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Corrosion Evaluation for Tank 241-AP-106 Re-purposing

B. J. Wiersma

August 2019

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EXECUTIVE SUMMARY

Tank AP-106 will be an integral part of the Direct Feed Low Activity Waste (DF-LAW) activity. This tank is an underground, carbon steel, double shell tank (DST). Before it can be utilized, the Cs-137 concentration levels in the waste must be reduced significantly. The AP-106 re-purposing process will manage normal waste tank additions procedures such that waste acceptance criteria objectives for Cs-137 removal are achieved. As this process was being developed, concerns regarding tank integrity during and after the process to Tank AP-106 and associated tanks (i.e., AP-102, AN-101, and AP-108) were addressed. The degradation mechanisms identified include: general and pitting corrosion, caustic stress corrosion cracking, galvanic corrosion, and microbiologically induced corrosion (MIC).

Recommendations were provided to minimize the exposure of the tank to corrosive conditions (see Section 6.0). These recommendations included chemistry adjustments at defined steps in the process that will maintain the waste in compliance with the corrosion control program. Additionally, sampling and inspection (see Sections 6.0 and 7.0, respectively) recommendations that will assess the final condition of the tank environment and the tank were presented.

The greatest risk for this process involves the handling of large quantities of Columbia River water (i.e., greater than 450,000 gallons) within the AP-106, associated tanks and supporting infrastructure (i.e., transfer line piping). As long as this water is blended into the supernate in a timely fashion, and the waste is adjusted appropriately with corrosion inhibitors, the final condition is expected to be within compliance. Recommendations were also made to address process interruptions that could result in exposure of the tank walls to aggressive conditions.

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LIST OF ABBREVIATIONS

CFD	Computational Fluid Dynamics
CPP	Cyclic Potentiodynamic Polarization
DF-LAW	Direct Feed – Low Activity Waste
DNV-GL	Det Norske Veritas-Germanischer Lloyd
DO	Dissolved Oxygen
DST	Double Shell Tanks
DWPF	Defense Waste Processing Facility
LSI	Langelier Saturation Index
MIC	Microbiologically Induced Corrosion
OSD7	Operating Specifications Document [1]
PNNL	Pacific Northwest National Laboratory
SCC	Stress Corrosion Cracking
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
TDS	Total Dissolved Solids
WRPS	Washington River Protection Solutions

Corrosion Evaluation for Tank 241-AP-106 Re-purposing

1.0 Background

The AP-106 re-purposing process will attempt to manage "stratification" of waste in the tank in order to accomplish waste acceptance criteria objectives for Cs-137 removal. One of the boundaries for this process is to avoid environmental conditions that may compromise tank integrity. An initial review of the process concept identified that degradation mechanisms such as pitting corrosion, caustic stress corrosion cracking, and galvanic (or concentration cell) corrosion needed to be evaluated [2]. Since that initial review, the re-purposing process has been refined and has attempted to address the issues either by modifying the steps such that the risk of exposing the tank steel to a corrosive environment are minimized or corrosion testing has been performed to address unknown conditions. This document will:

1) Review the materials and construction details for the waste tanks and transfer lines;
2) Review the waste chemistry and in-service inspection history;
3) Summarize the steps of AP-106 re-processing;
4) Describe the corrosion mechanisms and their risk;
5) Review corrosion testing applicable to the process;
6) Recommended control measures to mitigate corrosion in AP-106 and the tanks that will receive the decant waste;
7) Recommended verification of the integrity of AP-106.

2.0 Materials of Construction for the Waste Tanks and Transfer Lines

Four double shell tanks (DST) will be involved in the process. AP-106 is the tank that is being re-purposed. Decants from this tank will be transferred to tanks AP-102, AP-108, and AN-101. Details on each of the structures are contained in extent of condition reviews that were recently completed [3] [4]. The primary tank wall for each was constructed of A537 carbon steel. Each tank received a post-weld heat treatment for stress relief. Two of the tanks (AP-102, and AN-101) were soaked for 3 hours at a minimum temperature of 1000 °F. The primary tank walls of AP-106 and AP-108 were above this temperature as well, however, the tank bottom thermocouples near the center of the tank were greater 950 °F, but less than 1000 °F, for more than 2.5 hours (note: this meets the ASME code minimum values for stress relief). Thus, it was determined at the time of construction that adequate stress relief was performed on each of the tanks in the process. Although these conditions meet code standards, this does indicate that a higher degree of vulnerability from the standpoint of residual stress could exist in the region of the center of the tank bottom.

The only other construction anomaly occurred during the hydrostatic testing of Tank AN-101. Raw river water remained in the tank for up to 8 months. No report on the hydrostatic leak test was uncovered [3] and therefore the condition of the tank primary is not known. However, additional information on Tank AN-107, a tank constructed at the same time, may provide some insight on the aggressiveness of the raw water. The hydrostatic test water remained in this tank for up to 5 months. Pits on the order of 20-30 mils deep and 0.25-inch wide (i.e., broad and shallow) were observed in the tank. It is not known whether the full depth of the pits was due to the raw water. These pits were determined to be minor, that is the depth was less than the maximum acceptance depth of 32 mils. The rationale of the engineers at the time was that the presence of well inhibited waste would keep the pits from growing significantly. Pits of similar size have been observed during pre-service and in-service inspection of the tanks at SRS [5]. Thus, this seems to be a reasonable conclusion. As a result of these observations, inhibited water was used to hydrotest the tanks in the AP tank farm. The construction records indicated that nitrite and hydroxide were to be added to the hydrotest water. This approach would have minimized pitting of the tank.

Columbia river water comes in from either 282E or 282W basins to a service water building in the AP tank farm. The piping going into the service water building is likely carbon steel and has been in-service for several years. Then raw water goes from the service water building to the AP tank farm flush pit. The flush pit piping is all carbon steel except for a small hose section. Then water flows from the flush pit to the AP tank farm valve pit. In the valve pit, there are stainless steel jumpers that connect to the carbon steel line SN-516 that goes to AP-106. A review of the transfers between the tanks indicated both the tanks and the transfer line piping associated with the near vicinity of AP-106 is constructed of carbon steel.

3.0 In-service Assessment of the DST Tanks and Transfer Lines

Tank chemistry sampling records and in-service ultrasonic inspection records were reviewed to assess whether excessive corrosion damage has occurred during service. Records indicate that all four tanks are currently in compliance with the current and the proposed chemistry control requirements [6] [7] [8] [9]. The chemistry of the solids layer for Tank AN-101 has not been determined by sampling. However, estimates indicate that the waste was compliant with corrosion chemistry limits when it was received during the C-tank farm retrievals. Although sampling of the tanks is infrequent, based on the records it is reasonable to assume that the tanks have been compliant for an extended period of time. Therefore, significant in-service degradation is not anticipated to have occurred.

This conclusion is verified by the results of the in-service ultrasonic inspection of the tanks. No reportable indications of service induced wall thinning, pitting or cracking have been observed for AP-102, AP-108, and AN-101 [10] [11] [12]. Tank AP-106 will be inspected this summer prior to initiating the process [13]. On the other hand, significant degradation of the exterior of the secondary liner in several of the AP and AN tanks (particularly AP-102) has been observed [10]. This wall loss in the annulus floor, however, would not necessarily preclude the use of the primary tank, however, should be accounted for if an emergency situation were to occur.

4.0 AP-106 Re-purposing Process

The revised process utilizes a “water cap” approach in order to separate the high activity supernate. Figure 1 shows the steps in the process and a brief outline of the steps is presented [14].

Step 1: Decant Tank AP-106 to Tank AP-102. The waste level in AP-106 will be reduced to 24” or approximately 65,000 gallons. No change to the chemistry or temperature of AP-106 will occur, although an evaluation of the decant solution on AP-102 will need to be performed. The initial composition of the AP-106 waste is shown in Table 1.

Step 2: Approximately 75,000 gallons of Columbia River water will be added to the top of the waste in AP-106, which will bring the waste level to 51” or 140,000 gallons. The addition will take approximately 30 hours. The tank will not be mixed at this stage. After 3-4 days the waste will be decanted to Tank AP-102 at a rate of 200 gallons/min. The transfer pump is at the 12.7-inch level” level and will operate for approximately 9 hours. The waste will be pumped down to approximately 14” to avoid damaging the pump. The composition of the remaining waste and the waste that is transferred to AP-102 is shown in Table 1.

This composition assumes that the waste becomes well mixed as the transfer proceeds. On the other hand, if no mixing occurs, all that would remain in the tank is essentially water. It is likely that the actual concentration will be bounded by these two extremes. The evaluation for AP-102 should account for these extremes.

Step 3: The chemistry of the waste remaining in AP-106 will be adjusted to meet the proposed update to the Operational Specifications Document (OSD7) specification [1]. The present plan calls for the addition of 4000 gallons of an inhibited solution of 10 M sodium hydroxide and 2.5 M sodium nitrite. Then 8000 gallons of 8 M sodium nitrite will be added. The chemical additions to AP-106 from the tanker truck will require 2-3 days. Approximately 33" or 91,000 gallons of Columbia River water will be added to the tank over a period of 1.5 days. The water will be added through the pump column or the drop leg to enhance mixing as much as possible. Within 1-3 days, the pump will be turned on in re-circulation mode in order to blend the inhibitors, water and remaining supernate. The pumps will re-circulate the waste for 3 days to blend the waste so that the layers become homogenous. The estimated concentration after the chemical adjustment is shown in Table 1. A sample will be taken at this point. Variable depth samples are recommended as discussed below. The waste will be decanted to Tank AP-108 until the level in AP-106 reaches approximately 14".

Step 4: The activities for this step also depend on the success of Step 2 and 3. Approximately 102,000 gallons of Columbia River water will be added to AP-106 to raise the level of the tank to 51". This addition will take approximately 43 hours. Recirculation of the tank waste will begin within 1-3 days and have a duration of 3 days. The estimated composition of the waste at this stage is shown in Table 1. Results from the sample taken in step 3 may be used to adjust the anticipated compositions. The waste will be decanted from AP-106 to Tank AN-101 until the level in AP-106 reaches approximately 18".

Step 5: At this stage, approximately 40,000 gallons or 14" of a 10 M sodium hydroxide and 2.5 M sodium nitrite solution will be injected beneath the supernate layer via the lower drop leg. This addition will be completed in 5-days. The maximum delivery temperature for the caustic will be specified such that the temperature at the tank bottom will not exceed 100 °F. At the completion of the addition, Columbia River water will be added to the top of the waste to raise the level of the tank to approximately 60". The river water addition will take approximately 31 hours.

The compositions of the various layers at this stage are difficult to estimate given that mixing is a complex issue. From the Pacific Northwest National Laboratory (PNNL) caustic injection Computational Fluid Dynamics (CFD) model [15], the caustic solution is anticipated to be diluted to 60% of initial concentration on the tank bottom, and 45% at the pump inlet (12.7" from the tank bottom). However, the caustic layer thickness cannot be estimated at this time.

The tank contents will then be decanted to AP-102 until the level in AP-106 reaches 18". The decant process is expected to initiate 1-3 days after the water add and take approximately 10 hours to complete.

Step 6: Step 6 will establish the final state of AP-106. Approximately 120,000 gallons of Columbia River water will be added to AP-106. The level in the tank will exceed 60", the highest level during the re-purposing process. The waste will be recirculated within 1-3 days of the water addition. After 3 days variable depth samples will be obtained as recommended. Preliminary corrosion chemistry results are anticipated within 2-4 days. If necessary, chemical additions of either nitrite or nitrite and hydroxide should be staged so that additions can begin promptly. Three to four days after the additions are made, if needed, the tank will be re-circulated for 3 days. A surface sample should be taken to verify that the waste is compliant with the proposed OSD7 specification.

Table 1 Estimated Compositions at Different Steps of AP-106 Re-Purposing.

Step	Hydroxide (M)	Nitrite (M)	Nitrate (M)	Chloride (M)	Fluoride (M)
1	0.43	1.03	1.22	0.089	0.013
2	0.20	0.48	0.57	0.04	0.01
3	0.34	0.66	0.16	0.01	0.002
4	0.09	0.18	0.04	0.0031	0.0004
5	0.037	0.096	0.017	0.001	0.0002
6	0.037	0.096	0.017	0.001	0.0002

5.0 Potential Corrosion Issues

The process for re-purposing tank 241-AP-106 (AP-106) has several areas of concern for corrosion control. These were highlighted in an e-mail from B. J. Wiersma on 3/24 [2].

- The impact that the addition of raw water would have on the tank, with regard to general and pitting corrosion (step 2 and 5. Note that water is added to the top of the waste).
- The dilution of inhibitors during dilution and decant cycles with regards to pitting corrosion (Step 4; Note during steps 3 and 6 inhibitor adjustments are being made in addition to raw water additions, whereas in step 4 there is no specific activity for inhibitor adjustment.).
- The susceptibility of the tank bottom to corrosion during the caustic additions, specifically stress corrosion cracking and/or galvanic corrosion. (Step 5)
- The chemistry compliance of the receiver tanks. (Step 1, 2, 3, 4, and 5; there is no decant in step 6)

Each of these is discussed briefly.

5.1 Corrosion Due to Raw Water Additions

Raw water from the Columbia River is stored in large concrete reservoirs. This water will be utilized to form the water cap for AP-106 re-purposing in several of the steps. The chemistry of the water is summarized in the Table 2. Samples of the Columbia River water, taken in 2010, were the source of this data [16]. The river water is a neutral, soft water. A sample of the water from the concrete basin was taken in June 2019 and was analyzed for chloride, fluoride, nitrate, nitrite, calcium and dissolved solids. The chloride and calcium concentrations were essentially the same as the 2010 analysis. The nitrate, nitrite,

AP-106 Repurposing Concept:

Transfer: Partial pump down

Water Cap:
- Add water
- Form a layer on top of supernatant (no mixing)
- Decant

Dilution Cycle(2x):
- 1st: Add OH, NO2, and Water, Mix, Sample, Decant
- 2nd: Add Water, Mix, Decant

Caustic Displacement:
- Add caustic under the supernatant (no mixing)
- Add water on to of the supernatant (no mixing)
- Decant

Add Water, Mix, Sample:
- Add water (bottom)
- Mix

(If needed) Adjust Chemistry, Recirculate: Add NaNO2, Mix.

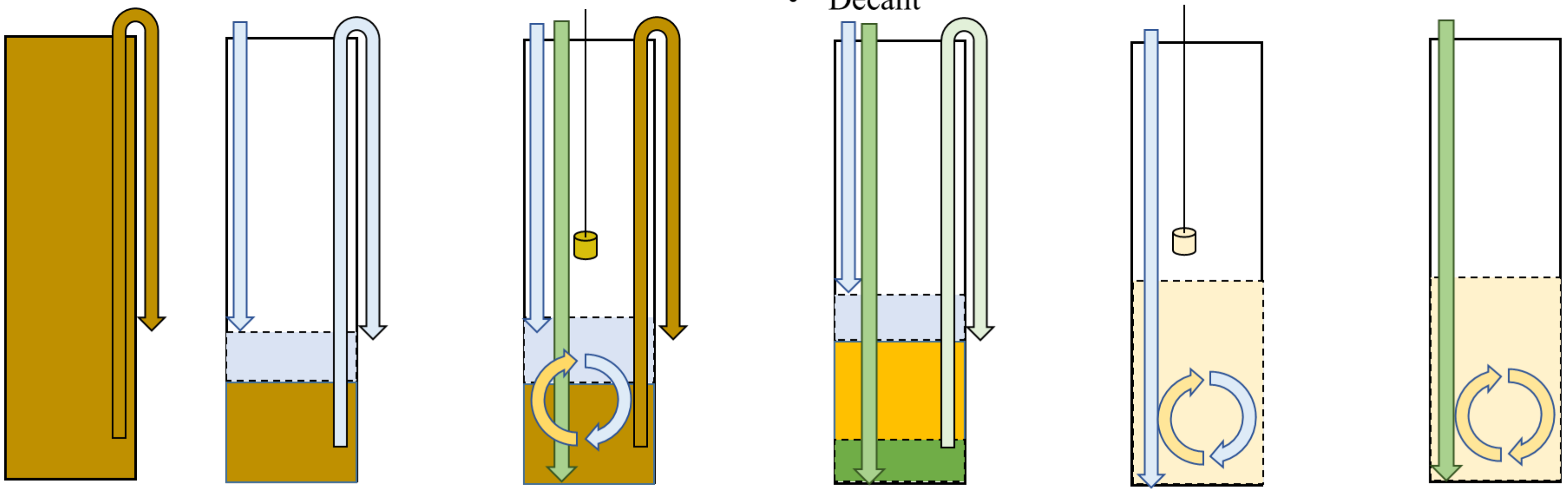


Figure 1 AP-106 Re-Purposing Schematic.

and fluoride concentrations were less than the detectable values (< 1 ppm). The dissolved solids concentration was also similar to the previous value (79 ppm vs. 104 ppm).

Soft waters tend to result in general corrosion of carbon steel because they do not form a scale on the surface [17]. The rate can be high initially, and then decrease as the corrosion layer product forms and diffusion through this layer begins to control the corrosion rate. The following model from the literature was investigated to determine whether the water composition could be correlated to the corrosion rates.

Table 2 Water Sample Analysis for Columbia River Water [16]

Parameter	Value	Units
TDS (max)	104	ppm
DO (max)	13	ppm
pH (min)	7.6	NA
Ca (Max)	20	ppm
Mg (Min)	5	ppm
Alk (min)	55	ppm
Sulfate (Max)	10	ppm
LSI	-0.72	NA
Nitrate	0.2	ppm
Chloride	1	ppm

The corrosion rate of steel exposed to water is dependent upon several factors such as the Langelier Saturation Index (LSI), dissolved oxygen (DO), total dissolved solids (TDS), and time (t) [18]. An empirical relationship between these four factors and the corrosion rate has been derived:

$$\text{Corrosion Rate} = [(\text{TDS})^{0.253} * (\text{DO})^{0.82}]/[(10^{\text{LSI}})^{0.0876} * (t)^{0.373}] \qquad (1)$$

where TDS and DO are in ppm, t is in days and the Corrosion Rate is in mpy. The LSI is a measure of the scaling capability of the water. A positive value indicates that a scale will form on the surface, whereas a negative LSI indicates that the water will not form a scale and therefore general corrosion will occur. The LSI is calculated from the following equation:

$$\text{LSI} = \text{pH} - \text{pH}_s \qquad (2)$$

where pH is the actual pH and pH_s is the calculated pH of calcium carbonate saturation. pH_s is calculated with the following equation:

$$\text{pH}_s = 11.017 + 0.197 \log(\text{TDS}) - 0.995 \log(\text{Ca}) - 0.016 \log(\text{Mg}) - 1.041 \text{ Log}(\text{Alk}) + 0.021 \log(\text{SO}_4) \qquad (3)$$

where Ca is the calcium concentration in ppm, Mg is the magnesium concentration in ppm, Alk is the total alkalinity (related to the carbonate/bicarbonate concentrations), and SO_4 is the sulfate concentration in ppm.

For comparison, at SRS, the water is very soft and has a slightly acidic pH [19]. Water sample data from wells at SRS are shown in Table 3. These values approximate averages of the water chemistry taken from several different wells. The LSI at SRS was -6.34, which is very corrosive.

Table 3 Groundwater Chemistry at SRS

Parameter	Value	Units
TDS (max)	30	ppm
DO (max)	10	ppm
pH (min)	5	NA
Ca (Max)	1	ppm
Mg (Min)	0.4	ppm
Alk (min)	1	ppm
Sulfate (Max)	10	ppm

Given this water chemistry, the corrosion rate steel may be calculated from the following equation:

$$\text{Corrosion Rate} = 6.21 * t^{-0.373} \qquad (4)$$

where t is in years. Equation 4 may be integrated with respect to time to determine the depth of penetration (T) in mils.

$$T = 9.9 * t^{0.627} \qquad (5)$$

This power law relationship between the depth of attack and the time is typical for carbon steel exposed to groundwater [20]. An estimate of the corrosion rate and the depth of penetration as a function of time is shown in Table 4.

Table 4 Estimates of Corrosion Rates in SRS Well Water

Time (Days)	Corrosion Rate (mpy)	Penetration (mils)
7	27.1	0.8
30	15.8	2.1
60	12.2	3.2
90	10.5	4.1
120	9.4	4.9
365	6.2	9.9

To test the model, the calculations were compared to results of short-term coupon tests that were performed on carbon steel samples exposed to SRS groundwater [21]. Exposure tests of steel samples to the ground water were performed over 31 to 104-day intervals. The general corrosion rate decreased from a high value of near 18 mpy at 31 days to approximately 10 mpy at 104 days. The corrosion was primarily general with mild pitting. The results shown in Table 5 indicate a high initial general corrosion rate that appears to be decaying with time. These results are compared to the corrosion rate calculated by Equation 4. Although it predicted slightly lower corrosion rates, than what was observed in the exposure tests (~2 mpy lower in general) it predicted the general trend and was therefore utilized to get an order of magnitude estimate. This correlation, along with simulant testing, will be utilized to estimate the general corrosion rate due to exposure of steel to the river water.

Table 5 Corrosion of Carbon Steel in SRS Groundwater Compared to Calculated Values

Time (days)	Corrosion Rate (mpy)	Calculated Corrosion Rate (mpy)
31	18.2	15.6
41	17.1	14.0
63	15.5	12
73	18.6	11.3
82	9.2	10.8
104	12.6	9.9

5.2 Dilution of Inhibitors

For step 4, water will be added to the tank via the pump or lower drop leg and then re-circulated. The waste was pre-conditioned with inhibitors (nitrite and hydroxide) in an effort to remain in compliance with the corrosion control program. If step 4 proceeds well, only one dilution will be necessary to achieve the desired decontamination factor. However, if more dilutions become necessary, it is possible to deplete the inhibitors (nitrite and hydroxide) to levels where pitting corrosion could become a concern, particularly at the liquid air interface [22]. To evaluate the corrosivity of the diluted solutions, CPP tests were performed on actual AP-106 waste that was sequentially diluted 5 times. This data is reported below in section 6.2.

The unknown during this stage is the effectiveness of the step 2 water cap/decant addition. Current material balance estimates suggest that for the bounding cases after the chemistry adjustment is made in step 3, the solution will be near compliance for Step 4 as well. Material balances should be reviewed prior to beginning Step 4 to verify this estimate.

5.3 Caustic Stress Corrosion Cracking

Failure of carbon steel structures handling high temperature caustic solutions (e.g., bayerite process) has been observed for several years [23]. The mechanism is typically observed at high temperatures (80 C and greater) and high hydroxide concentrations (3 M and greater) [23] [24]. The mechanism produces intergranular attack [25] [26]. The conditions for caustic cracking are those which permit the coexistence of unprotected steel and an incomplete protective film [25]. From the Pourbaix diagram [27] for iron, the principal the ferroate ion, $HFeO_2^-$, is produced at the active surface. As soon as its solubility product is exceeded, a passive ferrous ion film, such as magnetite, begins to form. This active to passive transition on slow anodic polarization curves appears as a potential region where the current decreases to a passive value [28]. Caustic cracking is discontinued at potentials more noble than the active to passive transition potential.

Parkins recognized that the presence of oxidizing species (e.g., nitrate) may result in the mitigation of caustic stress corrosion cracking [28]. Testing for Hanford simulated wastes [26] and in SRS simulated wastes [29] [30] demonstrated the effectiveness of these inhibitors. The types of tests performed included anodic polarization and slow strain rate tests. (Note: PNNL performed U-bend tests in simulated, high temperature caustic solutions to determine the present limits for caustic cracking. However, these tests did not provide similar mechanistic information [31]). Essentially the same conclusions were drawn from each set of tests. First, steel is spontaneously passivated in solutions where the corrosion potential is more positive than the active to passive transition region. Secondly, anodic dissolution kinetics are controlled by the hydroxide concentration with the corrosion rate increasing with concentration. Finally, nitrate and nitrite increase the rate of cathodic reaction and thus promote passivity with nitrite being the more effective passivating agent [26] [30].

However, many of these studies had been conducted at temperatures well above the anticipated value for the AP-106 re-purposing process (i.e., greater than 85 °C). Recent investigations indicated that caustic SCC may occur at temperatures as low as 70 °C [32]. Slow strain rate tests were conducted in FY19 at DNV-GL in a simulated AP-106 float solution (i.e., 10 M OH^-, 0.2 M NO_2^-, and 1.5 M NO_3^-) at 75 °C indicated susceptibility to SCC. Additionally, recent testing at DNV-GL performed at 75 °C in 10 M hydroxide simulants, with low nitrate and nitrite concentrations, indicated a propensity for SCC [33]. These temperatures are significantly greater than the anticipated value for AP-106 re-purposing (i.e., ~35 °C). Testing was subsequently performed in float simulant that was higher in nitrite and at a lower temperature (50 °C) to establish a suitable margin for the actual process. This testing is reported on below.

5.4 Concentration Cell (Galvanic) Corrosion

Steps 2 and 5 of AP-106 re-purposing rely on managing layers with different densities, compositions and corrosion characteristics with respect to the carbon steel. In the bounding case, two or three distinct separate layers form (See Figure 1). As a result of the concentration differences, a galvanic potential of the steel exposed to the caustic layer coupled to the steel exposed to the supernate may create a condition that enhances susceptibility to SCC or general/localized corrosion. This issue can be visualized by examining the intersection of the cathodic branch of the simulant/steel combination with the more noble OCP and the anodic branch of the simulant/steel combination with the more active OCP (see Figure 2). This figure is an example showing carbon steel in contact with a raw water simulant and an AP-106 supernate simulant, such as occurs in step 2. The potential at which the two branches intersect is the galvanic coupling potential and the current is the galvanic coupling current. If the coupling potential were to reside within the active to passive transition region, the material would be susceptible to SCC. Similarly, the galvanic coupling current could define a regime of relatively high general corrosion. Testing to define the anodic and cathodic branches in each of the wastes was combined with corrosion modeling to evaluate the tank wall potential distribution as a function of distance from the layer interfaces. These results will be discussed below.

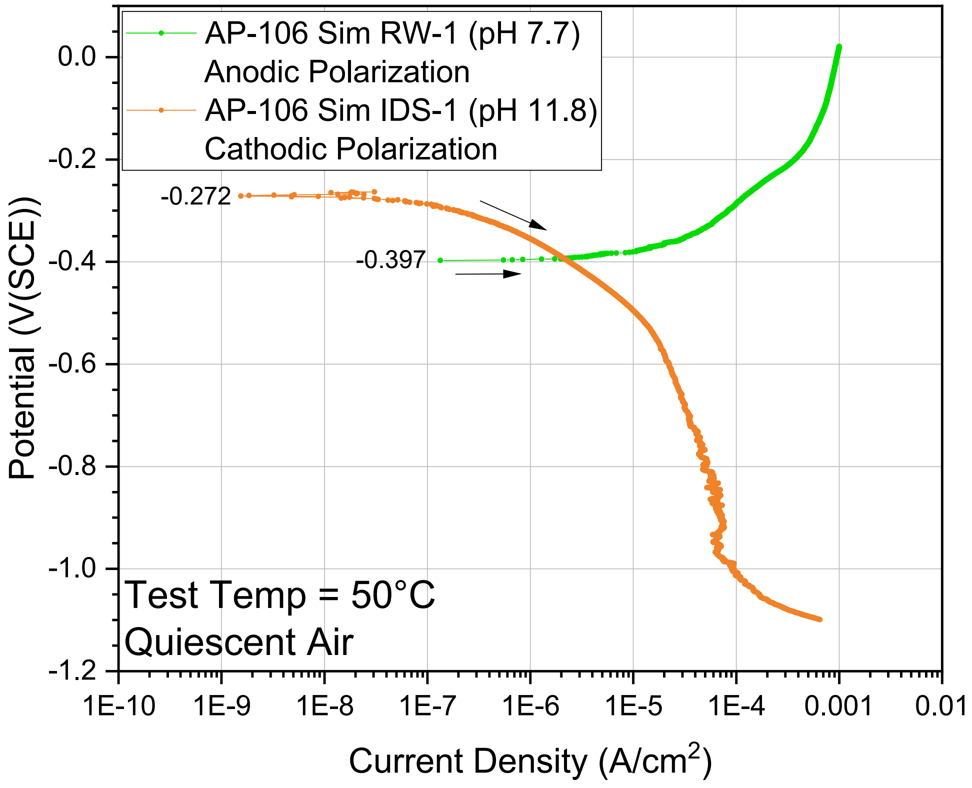


Figure 2 Galvanic Coupling Potential and Current Illustration. Anodic and cathodic polarization curves for A537 steel specimens tested in AP-106 Sim RW-1 (Raw Water, pH 7.7) and AP-106 Sim IDS-1 (Inhibited Diluted Supernate, pH 11.8) at 50°C in quiescent air.

6.0 Review of Recent Corrosion Testing and Modeling Efforts

6.1 Raw Water Corrosion Rates

An initial estimate of the steel corrosion rate and depth of penetration was made utilizing equations 1 through 5. For the estimate data from 2010 Columbia River water samples shown in Table 2. The total hardness was typically between 60-70. While not as soft as SRS well water, this also represents a relatively soft water. The LSI is negative, -0.72, meaning that it is slightly corrosive, although not nearly as much as the SRS ground water.

Given this information, equation 4 can be integrated with respect to time to determine the total depth of penetration, T, as a function of the time, t, in years.

$$T = 5.34 * t^{0.627} \qquad (6)$$

Table 6 shows the corrosion rate as a function of time and the estimated penetration (assumed to be mostly general corrosion). The Columbia River water is approximately half as corrosive as the SRS ground water. After 7 days there would be approximately 0.4 mils of wall loss, while after 30 days there would be approximately 1 mil of wall loss. This degree of wall loss is relatively insignificant. Given that the wall likely has a film of supernate that is relatively high in hydroxide, at least initially, it is also a fairly conservative estimate of the initial penetration.

Table 6 Calculated Corrosion Rates and Penetration as a Function of Time

Time (Days)	Corrosion Rate (mpy)	Penetration (mils)
7	14.6	0.4
30	8.5	1.1
60	6.6	1.7
90	5.6	2.2
120	5.1	2.7
365	3.3	5.3

DNV-GL conducted CPP tests in a raw water simulant that was utilized for AY-101 testing. The composition is shown below in Table 7. The tests were conducted at ambient temperature. The tests indicated spontaneous general corrosion occurs at the open circuit potential [34]. An estimate of the general corrosion rate made from the portions of the anodic and cathodic polarization branches indicates that the corrosion rate is between 5-10 mpy.

WRPS recently conducted immersion tests to determine corrosion rates for carbon steel in Columbia River water at ambient temperature [35]. These tests were performed for the recommended maximum length of exposure time that AP-106 will be exposed to the raw water, 30 days. Two sets of tests were performed. For the first set of steel samples, the surface was ground and polished and then immediately exposed to the river water. For the second set, the samples were immersed in caustic waste simulant and then immersed in the river water. The latter test was performed to assess the benefit of a caustic film, which will be present on the surface of the AP-106 primary wall.

Table 7 Dilute Raw Water Simulant Composition

Chemical	Concentration (M)
Sodium Hydroxide	0.0007
Sodium Nitrite	0.001
Sodium Nitrate	0.001
Sodium Chloride	0.001
Sodium Sulfate	0.001
Sodium Di-hydrogen Phosphate	0.001
Sodium Bicarbonate	0.001
TIC	0.001
pH	7.45

The corrosion rates for both tests are summarized in Table 8. The corrosion rate for the coupons with no pre-exposure was approximately 3 mpy, while for the coupons with pre-exposure to a waste simulant the corrosion rate was 2 mpy. These rates are comparable to what was predicted by the model and what was observed in the laboratory. The attack also seems to be more general than localized. These corrosion rates are greater than the typical corrosion rate for a DST exposed to a caustic waste (i.e., < 0.5-1 mpy). Although this is approximately an order of magnitude greater rate, the impact of this can be managed by minimizing the contact time between the raw water and the tank wall or piping system. The process as outlined above appears to minimize contact time (e.g., days) and thus significant wall loss would not be anticipated. Additionally, a film of supernate is likely present on the wall, which may serve to protect the wall initially during the process. However, as the process continues there may be less benefit from the film as it begins to wash away or be diluted.

Finally, river water stored in a relatively stagnant concrete basin at ambient conditions may develop microbial activity after a time. The presence of these microbes in the water may expose the carbon steel tank and transfer lines to an environment that results in microbiologically induced corrosion (MIC). Although, thus far only cooling water systems have demonstrated susceptibility to MIC at SRS [36], this is a mechanism that is acknowledged as possible in the tank farm facilities if water accumulates in low points. A review of the transfers between the tanks indicated both the tanks and the transfer line piping associated with the near vicinity of AP-106 is constructed of carbon steel. The piping will have multiple contacts with high pH, high radiation dose transfers during the process. Thus, sustained growth of bacteria would not be anticipated. The raw water is transferred in a hose as it travels between the concrete basin and the AP-106 valve pit. Bacteria may grow in this section of the pipe and eventually cause issues. On the other hand, this piping is not exposed to radioactive waste either and thus could be easily replaced should a leak occur.

Table 8 Results of Corrosion Tests Performed in Columbia River Water at Ambient Temperature [35]

Exposure	Coupon after exposure	Coupon after exposure and cleaning	Mass before exposure (g)	Mass after exposure and cleaning (g)	Calculated corrosion rate (mpy)
Raw Water Coupon 1			17.3980	17.3127	3.01
Raw Water Coupon 2			17.2830	17.2049	2.76
Raw Water (Simulant Dipped) Coupon 1			17.2875	17.2264	2.16
Raw Water (Simulant Dipped) Coupon 2			17.4367	17.3824	1.92

6.2 Dilution of inhibitor species

WRPS performed a series of real waste corrosion tests on grab samples from AP-106 [37]. Electrochemical corrosion tests were performed on the sample that was sequentially diluted (1:1 by volume) to determine the propensity for pitting corrosion to initiate during the stage 4 dilutions. The estimated concentrations after each dilution are shown in Table 9. No pitting was indicated by the tests after the first four dilution. A pitting result was obtained on dilution 5.

Table 9 Calculated Chemical Compositions after each Dilution in molarity.

	AP-106 Sample	Dilution 1	Dilution 2	Dilution 3	Dilution 4	Dilution 5
Compound	**M**	**M**	**M**	**M**	**M**	**M**
Hydroxide	0.41	0.21	0.10	0.051	0.026	0.013
Nitrite	1.02	0.51	0.26	0.13	0.064	0.032
Nitrate	1.22	0.61	0.31	0.15	0.076	0.038

These test results show that dilution will eventually induce pitting; this result coincides with reports of pitting in dilute solutions at SRS [22]. The chemistry in AP-106 is expected to exceed these values throughout most of the process. Chemistry adjustments made during step 3, and possibly step 6, should consider these results and ensure that the waste is well inhibited. The chemistry for Dilution 4 should be utilized as a bounding composition for AP-106 during the process. It should be noted however, that this chemistry does not meet the minimum required nitrite concentration for the proposed new chemistry limits [38]. At the conclusion of the process the nitrite concentration should be raised to a minimum of 0.2 M.

6.3 Caustic Stress Corrosion Cracking

Slow strain rate tests were performed at DNV-GL in four AP-106 float simulants at 50 °C, including the float solution that will be utilized for Step 5 of AP-106 re-purposing (i.e., 10 M sodium hydroxide and 2.5 M sodium nitrite) [39]. All simulants contained 10 M sodium hydroxide, while the sodium nitrite concentration was varied from 0.2 M to 2.5 M. SCC was not identified in any of these environments at short term OCP values. Additionally, two slow strain rate tests were performed at applied potentials in two of the simulants. Float simulant 1, which contained 0.2 M sodium nitrite, was tested at an applied potential (-850 mV vs. SCE) that is congruent with a long term OCP value (~30 days) and also lies within an active passive transition of the slow scan anodic polarization curve. No SCC was observed. Float simulant 4, which contained 2.5 M sodium nitrite, was also tested at an applied potential (-735 mV vs. SCE) that is congruent with the appearance of the active passive transition in the anodic polarization curve. No SCC was observed in this case either. The 30-day OCP value for float simulant 4 had drifted noble of the active passive transition, which is indicative of formation of the protective passive film of magnetite. Finally, the crack growth rate tests in float simulant 4 also seemed to indicate very low crack growth rates (i.e., a rate between the air fatigue growth rate and the corrosion fatigue growth rate). These results are a positive indication that the float simulant is a relatively benign environmental condition for the tank bottom with respect to SCC. Based on these results, it is recommended that the temperature of the caustic solution be less than 50 °C. Preliminary thermal analysis of the step 5 evolution indicates that the temperatures will be lower [40].

6.4 Concentration Cell (Galvanic) Corrosion

Electrochemical testing and corrosion modeling were performed to examine the bounding or extreme case as though there were no mixing [41]. The results of the anodic and cathodic polarization scans for the two-layer case (Step 2) are shown in Figure 2. The supernate region was cathodic, while the raw water region was anodic. The coupling current (or corrosion rate) was low and is not expected to be significantly greater than the corrosion rate observed in the raw water alone. Step 5 results in two interfaces for AP-106 that could result in concentration cells (see Figure 1). Figure 2 shows the galvanic coupling between the raw water and the supernate, while Figure 3 shows the galvanic coupling between the supernate and the caustic float solution. Figure 2 indicated that the raw water region provides the anodic current and the supernate supplies the cathodic current. The galvanic coupling current was low and the corrosion rate in the raw water region just above the interface is expected to be on the same order as the carbon steel exposed to raw water. Figure 3 indicates that the supernate supplies the cathodic current, while the caustic float solution provides the anodic current. The anodic current observed in the caustic float solution is greater than what was observed in the raw water case. However, this phenomenon is observed frequently during short term tests [30]. Once the passive layer forms the current density and hence corrosion rate decrease significantly.

Corrosion modeling was performed to visualize the spatial current and potential distributions for Steps 2 and 5. Figure 4 shows the potential and current distributions as a function of distance for Step 2. Note that the first 37.5 feet represent the radius of the tank bottom that is exposed to the supernate, the next 2 feet represent the tank wall that is exposed to the supernate layer, and the final 2.25 feet represent the tank wall that is exposed to the raw water layer. The potential distribution indicates that for the tank area submerged in the supernate, the potential does not vary greatly from the open circuit potential in supernate alone. Likewise, for the majority of the area submerged in raw water, the potential does not deviate significantly from the open circuit potential in raw water alone. The current distribution confirms this as the predicted corrosion rate in the anodic region raw water region (see red curve in Figure 4) is are relatively low in these areas (i.e., 5-10 mpy or less). The modeling does indicate that there is a small region above the interface, likely on the order of an inch or two, where the current or corrosion rate is high (i.e., on the order of 30 mpy). This result occurs due to the large cathode to anode area and relatively conductive solutions assumed in the model. It is important to realize that the model assumes that no mixing is occurring at this interface. The greater the degree of mixing, the less likely that the sharp interface will exist. Although there likely will be some separation occurring between the two layers, due to the way the water will be added, it is very unlikely that one will see the sharp interfacial region. Thus, corrosion rates similar to that observed for the raw water and the supernate are likely to be observed over most of the exposed surface. For the anticipated short-term exposure (i.e., less than 30 days) this is not expected to result in significant damage to the tank during Step 2.

Figure 5 represents the potential and current distributions as a function of distance for Step 5. In this situation, there are three layers. Note that the first 37.5 feet represent the radius of the tank bottom that is exposed to the caustic float solution, the next 1.25 feet represent the tank wall that is exposed to the caustic float solution, the next 1.5 feet represent the tank wall that is exposed to the supernate, and final 2 feet represent the supernate layer, and the final 2.25 feet represent tank wall that is exposed to the raw water layer. The potential distribution illustrates that the negative open circuit potential of the caustic float solution dominates the polarization characteristics of the three layers. The potential layer is relatively constant near the open circuit potential on the tank bottom and then polarizes anodically along the tank wall as it approaches the interface with the supernate. Both the supernate and the raw water are polarized in the cathodic direction slightly, however, the majority of these regions remain near the open circuit potential. The current distribution indicates that the corrosion rate in the caustic solution will be a maximum near the interface with the supernate of 6 mpy. The areal average of the corrosion rate for the tank bottom and the side wall that is exposed to the caustic float solution is on the order of 3 mpy. Both these corrosion rates are relatively low and given the anticipated short exposure times are not expected to create a significant degradation issue. The caustic layer indicates that the coupling potential is greater than the active to passive transition potential region for the caustic float solution. Thus, stress corrosion cracking would not be anticipated. Therefore, even in the bounding case, this is not anticipated to create a significant issue for either SCC or general corrosion. As with Step 2, it is important to realize that the model assumes that no mixing is occurring at this interface. The greater the degree of mixing, the less likely that the sharp interface will exist. Although there likely will be some separation occurring between the two layers, due to the way the water will be added, it is very unlikely that one will see the sharp interfacial region. Thus, corrosion rates similar to that observed for the caustic float solution, the raw water and the supernate are likely to be observed over most of the exposed surface.

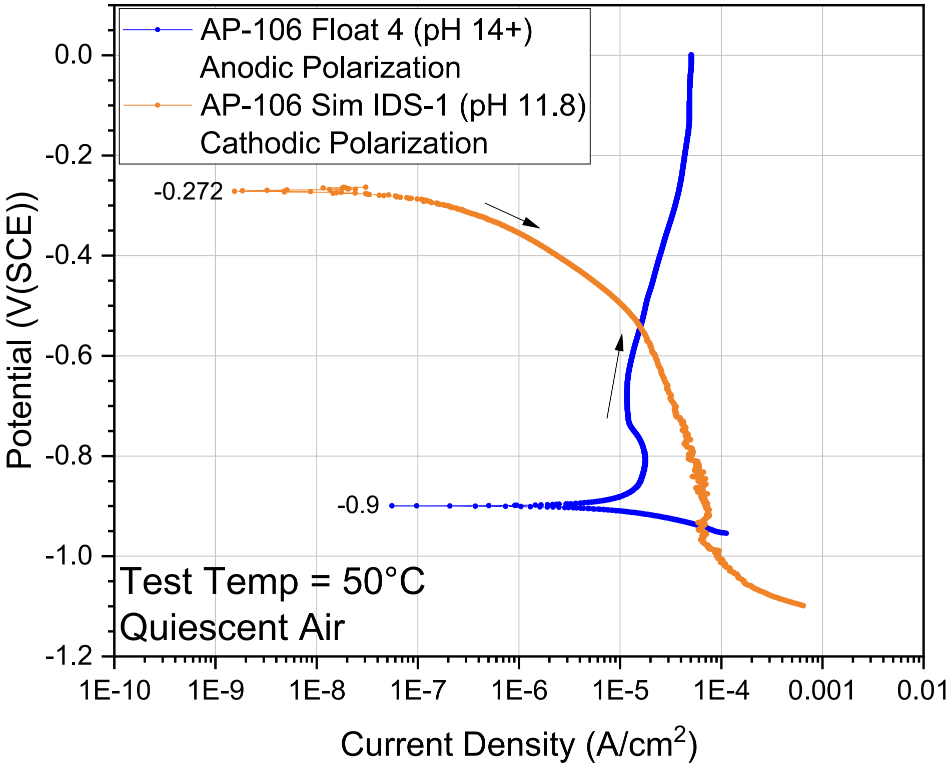
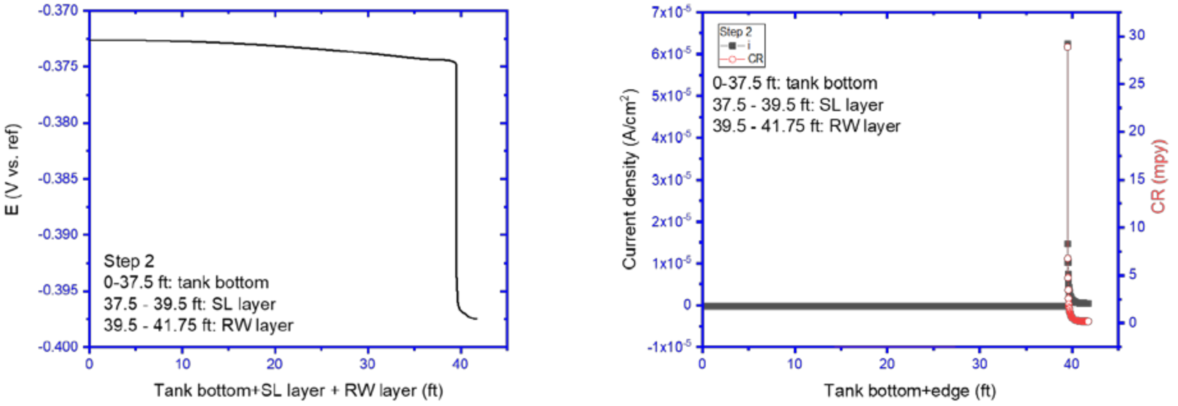
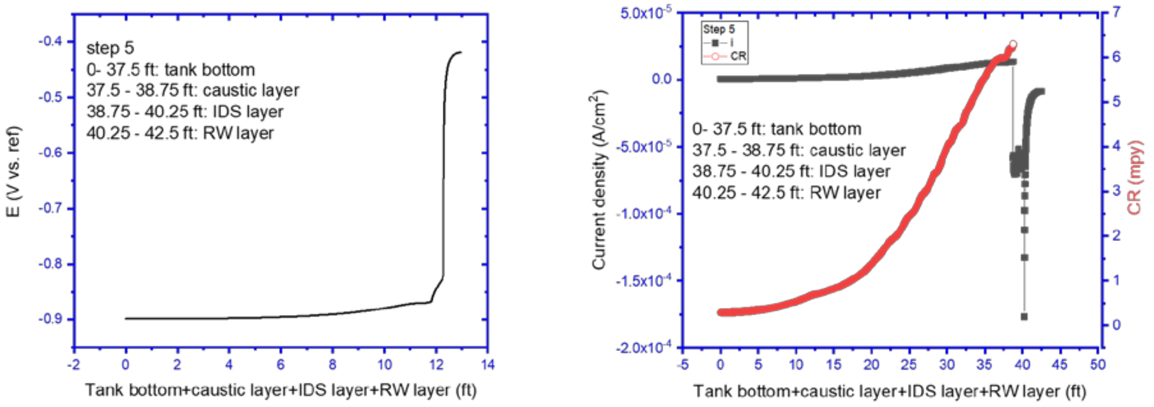


Figure 3 Anodic and cathodic polarization curves for A537 steel specimens tested in AP-106 Float 4 (pH 14+) and AP-106 Sim IDS-1 (Inhibited Diluted Supernate, pH 11.8) at 50°C in quiescent air.



(a) (b)

Figure 4 Potential (a) and current (b) distributions as a function of the distance from the center of the tank for Step 2.



(a) (b)

Figure 5 Potential (a) and current (b) distributions as a function of the distance from the center of the tank for Step 5.

7.0 Chemistry Compliance of Receiver Tanks

7.1 AN-101

Tank AN-101 will receive a 91,000-gallon waste transfer from AP-106 following Step 4 of the process. The composition in AP-106 following step 4 is difficult to estimate at this time following because there is an unknown amount of mixing in the previous re-purposing steps. However, the range of concentrations can be estimated by comparing the "no mixing" (i.e. only water in AP-106 prior to the Step 3 chemical additions) and "complete mixing" (i.e. AP-106 supernatant mixed completely with a previous water addition in Step 2) scenarios. This will be dilute supernatant with a specific gravity close to 1.0. The range of concentrations is shown in Table 10.

Table 10 Range of Supernate Chemistry in AP-106 Decant Waste to AN-101.

	OH (M)	NO2 (M)	NO3 (M	Cl (M)	F (M)	Pitting Factor
No Mixing	0.08	0.14	0.04	0.003	0.0004	8.82
Complete Mixing	0.09	0.18	0.04	0.003	0.0004	10.64
The pitting factor in the no mixing scenario uses the [NO3], [Cl], and [F] concentrations from the complete mixing scenario.						

As of 3/21/2019, AN-101 contained 194,000 gallons of supernatant. The most recent supernatant sample for AN-101 was taken 4/25/2016 [42]. Following that sample, the tank received a small transfer from AP-103 that was composed of 242-A Evaporator product and had a high hydroxide concentration. The projected chemistry for AN-101 after the AP-103 transfer is shown in Table 11.

Table 11 Projected Supernate Chemistry for Tank AN-101 [7].

OH (M)	NO2 (M)	NO3 (M	Cl (M)	F (M)	Pitting Factor
2.29	0.59	0.86	0.02	0.14	9.7

The difference in specific gravities between the two supernatants is greater than the 0.2 guideline used to estimate the propensity to mix. If there is no mixing between the streams, the bottom layer composition would likely be like that shown in Table 9. The upper layer would have a range of concentrations on the order of that shown in Table 10. Thus, the hydroxide concentrations in each layer would be well above the proposed OSD limit of 0.01 M. On the other hand, the nitrite in the dilute AP-106 supernatant layer would be between 0.14 and 0.18 M, which is lower than the proposed 0.2M nitrite lower limit.

However, it is likely that the transfer will mix to some degree with the existing AN-101 supernatant. As the supernatant transfer enters AN-101, the supernatant stream will create a jet as it enters the existing supernatant layer. That layer is 70" thick, and the transfer from AP-106 may penetrate to a sufficient depth that promotes mixing. If the tank were to be well mixed following the addition, both the hydroxide and nitrite concentrations would exceed the proposed OSD7 lower limits as shown in Table 12.

Table 12 Range of Supernate Chemistry for Tank AN-101 after the AP-106 Transfer During Step 4.

	OH (M)	NO2 (M)	NO3 (M	Cl (M)	F (M)	Pitting Factor
No Mixing	1.39	0.31	0.37	0.01	0.10	10.09
Complete Mixing	1.40	0.32	0.37	0.01	0.10	10.13

At present, the re-circulation pump is not qualified for operation and therefore mixing after the transfer will be by diffusion. Thermocouple data may be used to determine the degree of mixing. A surface sample will be recommended for this tank within 30 days to determine if layering has occurred.

7.2 AP-102

Tank AP-102 receives waste transfers during steps 1, 2, and 5 of the re-purposing process. During Step 1 of re-purposing is a transfer of 366,000 gallons of AP-106 supernatant to AP-102, which is corrosion control compliant and has a density of 1.25g/mL. The supernate chemistry of tank AP-106 at this stage is shown in Table 13.

Table 13 Supernate Chemistry of Tank AP-106 Prior to Step 1 of Re-purposing Process

OH	NO2	NO3	Cl	F	Pitting Factor
0.43	1.03	1.22	0.089	0.013	1.82

Given that the AP-106 and AP-102 supernatants have similar densities (1.25 vs. 1.22), it is expected that the tank will be well mixed following this transfer. The last sample from AP-102 was obtained in 2016 and the results are shown in Table 14. There have been transfers into this tank from other sources (e.g., AY-102) that were high in hydroxide and/or nitrite. The tank is well inhibited with respect to the proposed corrosion specifications.

Table 14 Supernate Chemistry of Tank AP-102 Prior to Step 1 of Re-purposing Process [8].

OH	NO2	NO3	Cl	F	Pitting Factor
1.04	1.08	0.88	0.03	0.08	5.5

Given that the initial volume in AP-102 was 216,000 gallons, the post-transfer estimated supernate chemistry of Tank AP-102 is shown in Table 15. The tank is anticipated to be well-inhibited after the transfer in step 1.

Table 15 Supernate Chemistry of Tank AP-102 After Step 1 of Re-purposing Process

OH	NO2	NO3	Cl	F	Pitting Factor
0.66	1.05	1.09	0.07	0.04	2.84

During step 2 approximately 75,000 gallons of water will be added on top of the remaining 66,000 gallons of supernatant in AP-106. The contents of that transfer are also not easily estimated as limited mixing between the existing supernatant and water may create a surface layer. The subsequent transfer of 101,000 gallons will initially transfer only supernatant and then an indeterminate mixture of supernatant and water. In the worst case, from the perspective of Tank AP-102 corrosion chemistry, the layers in AP-106 would remain unmixed, and 75,000 gallons of water would be transferred to AP-102. This would potentially leave a layer of Columbia River water at the top of AP-102. In the best scenario, from the perspective of Tank AP-102 corrosion chemistry, the contents of AP-106 would be mixed completely prior to transfer. The supernate chemistry of the waste in Tank AP-102 in this case would be as shown in Table 16. This assumes that a layer would form at the top of the supernatant. The composition would be compliant with the proposed OSD7 specification.

Table 16 Supernate Chemistry of Tank AP-102 After Step 2 of Re-purposing Process

OH	NO2	NO3	Cl	F	Pitting Factor
0.20	0.48	0.57	0.04	0.006	1.85

Step 5 of re-purposing will add 40,000 gallons of a caustic solution (10M NaOH with 2.5M $NaNO_2$) beneath 50,000 gallons of dilute AP-106 supernatant. Then 75,000 gallons of water will be added on top of the caustic/supernatant layers. The caustic solution is expected to have less than 50% mixing with the dilute supernatant. The water may or may not mix with the dilute supernatant on top of the caustic. Then, 116,000 gallons of this layered supernatant will be transferred to AP-102. Initially caustic or partially mixed caustic will be transferred, following by an unknown mixture of caustic, dilute supernatant, and water.

It is difficult to estimate the propensity of the Step 5 transfer to mix with the existing supernatant in AP-102 because the densities of these transfers are unknown. A worst case, from a corrosion perspective, would consider a layer of Columbia River water at the top of AP-102. On the other hand, if the supernate and the water layer were mixed, the composition would likely be as shown in Table 17. A waste with this composition would not likely mix completely with the supernate layer. Although this layer has a high pitting factor, the nitrite concentration is less than the required 0.2 M for the proposed OSD7 specification.

Table 17 Supernate Chemistry of Tank AP-102 After Step 5 of Re-purposing Process

OH	NO2	NO3	Cl	F	Pitting Factor
0.037	0.096	0.017	0.001	0.0002	11.6

Following the transfers, thermocouple data will be used to assess mixing in AP-102. The high heat load, due to the presence of the AY-102 solids may encourage mixing in AP-102. However, due to the potential of the dilute supernate (or water) present at the surface it is recommended that recirculation of the waste be performed within 30 days of the completion of the Step 2 and the Step 5 transfers to AP-102. At minimum a surface sample should be obtained to verify that this layer has been adequately inhibited.

7.3 AP-108

Tank AP-108 will receive approximately 102,000 gallons of dilute supernatant from AP-106 during Step 3 of the re-purposing process. This step involves the addition of 4000 gallons of a caustic solution (10M NaOH, 2.5M $NaNO_2$) and 8000 gallons of a nitrite solution (8M $NaNO_2$) to AP-106 in order to adjust the chemistry. River water will then be added to increase the tank level to 51" prior to the tank being mixed via recirculation. The composition in AP-106 is difficult to estimate following Step 3 because there is an unknown amount of mixing in the previous re-purposing step. However, the range of concentrations can be estimated by comparing the "no mixing" (i.e. only water in AP-106 prior to the chemical additions) and "complete mixing" (i.e. AP-106 supernate mixed completely with a previous water addition in Step 2) scenarios. These compositions are shown in Table 18.

Table 18 Estimates of AP-106 Supernate Chemistry Following Step 3.

Step 3	**OH**	**NO2**	**NO3**	**Cl**	**F**	**Pitting Factor**
No Mixing	0.29	0.53	0.16	0.01	0.00	8.82
Complete Mixing	0.34	0.66	0.16	0.01	0.00	10.64
The pitting factor in the no mixing scenario uses the [NO3], [Cl], and [F] concentrations from the complete mixing scenario.						

As of April 2019, Tank AP-108 has approximately 989,000 gallons of supernate above 112,000 gallons of saltcake. The AP-108 supernatant was most recently sampled in 2008, and at that time the supernate chemistry was as shown in Table 19.

Table 19 Tank AP-108 Supernate Chemistry in 2008 [43].

OH (M)	**NO2 (M)**	**NO3 (M)**	**Cl (M)**	**F (M)**	**Pitting Factor**
2.24	1.89	3.15	0.14	0.02	3.7

The tank was inactive until 2018, when AP-108 made a small transfer to AW-106 and received a transfer from AP-103. Given that the hydroxide concentration was much higher in AP-103 and the volume transferred was relatively small, the compositions in AP-108 will be assumed.

The specific gravity differences between the two supernatant is greater than 0.2, which indicates that the supernatants may not mix [44]. The transfer will be made via the 2” slurry transfer network that is typically used only for 242-A Evaporator product. The 2” slurry transfer line may terminate in the tank headspace or may terminate in a drop leg that is below the supernatant waste surface in AP-108.

If the dilute AP-106 supernatant is added on top of the current AP-108 supernatant, then it is likely that there will be limited mixing of the two supernatants and that a dilute surface layer will form in AP-108 that has a composition range similar to that shown in Table 17. If that is the case, then the dilute layer will be corrosion control compliant with the proposed specification. If the dilute AP-106 supernatant is added to AP-108 via a subsurface drop leg, then the dilute AP-106 supernatant will mix completely with the more concentrated AP-108 supernatant. This is due to the buoyant plume that will for as the dilute AP-106 supernatant floats to the surface of AP-108. Previous waste transfer experience is that this buoyant plume will completely mix with the existing supernatant either immediately or in the near term due to natural convection in the tank. In this case given the volume of AP-108 the waste composition would be expected to be closer to the values in Table 18. In either case, the condition in AP-108 following the transfer from AP-106 is expected to be acceptable in terms of analyte concentrations and pitting factor. However, given that the waste has not been sampled since 2008 a surface sample to verify corrosion control compliance is recommended.

8.0 Corrosion Mitigation During AP-106 Re-Purposing

The following corrosion mitigation measures are recommended for the safe execution of the AP-106 re-purposing process.

1) Minimize time of exposure to out-of-specification conditions; particularly to raw water additions. Set a time limit of 30 days on raw water exposure.

2) Stage inhibitors for addition in case process is interrupted. Estimate the amount of inhibitor needed based on what is known about the material balances. Because raw water is added at each step, inhibitors should be staged appropriately.

3) Sampling of AP-106:

Sampling may be performed in conjunction with those necessary to determine if the Cs-137 goals are being met.

Step 3:

- Sample after recirculation is complete.
- Perform a surface sample and 2 variable depths samples at appropriate levels.
- Inform analytical team of sample analysis needs so that they can be prepared to expedite results.
- Determine free hydroxide, nitrite, nitrate, chloride and fluoride concentrations.
- Measure temperature to ensure that it is less than 50 °C

Step 4:

- Ensure that waste chemistry for the dilution steps is compliant and within boundaries of WRPS testing [37].
- If the process becomes stalled for longer than 4 weeks and the process plans indicated that it will take longer than an additional 4 weeks, repeat Step 3 recommendations.

Step 5:

- If the process becomes stalled for longer than 4 weeks and the process plans indicated that it will take longer than an additional 4 weeks, repeat Step 3 recommendations. Chemistry adjustments shall be made, if necessary.
- The caustic float solution temperature should be minimized as much as practical. The caustic solution must be heated in the delivery truck to ensure that precipitates do not form during transfer to the tank. The solution temperature may also rise slightly as mixing with the supernate occurs. Ideally the float solution temperature should be less than 50 °C to reduce the risk of SCC. A high operating limit of 45 °C is recommended to provide adequate margin. Actions such as operating the tank annulus ventilation during the process should ensure that the tank bottom is adequately cooled.

Step 6:

- Repeat step 3 sampling activity.
- Make chemistry adjustment to supernate as necessary.

4) Sampling of Other Tanks:

- For each of the tanks (AP-102, AP-108, and AN-101) re-circulate the tank if possible to achieve homogeneity. If the re-circulation pump cannot be operated, steps should be taken to assess the waste for potential layering. A surface sample of the supernate in each tank should be obtained within 30 days of the last decant of a step. Alternatively, if a transfer from another tank with an inhibited waste from can be sent within 30 days, this may replace the need for a sample.
- Re-circulation of the waste in a tank is recommended within 30 days of the last transfer into the tank.

- If the process in AP-106 has been delayed, and the last decant was 90 days prior, a sample shall be taken in the associated tanks. Analysis of the sample should be expedited to assess the condition of the tank. After the last decant into a tank, a surface sample, at a minimum, is recommended. The sample shall be taken within 90 days of the last decant.

5) Evaluate the sample analyses from AP-102, AP-108, and AN-101 to determine if further corrosion evaluations need to be performed.
6) Develop contingency/recover plan for receiver tanks if the process stalls.

9.0 Structural Integrity Verification

Savannah River National Laboratory (SRNL) has provided a recommendation to Washington River Protection Solutions (WRPS) with regard to UT inspections before and after the process [13].

10.0 Conclusion

Recommendations were provided to minimize the exposure of the tank to corrosive conditions (see Section 6.0). These recommendations included chemistry adjustments at defined steps in the process that will maintain the waste in compliance with the corrosion control program. Additionally, sampling and inspection (see Sections 6.0 and 7.0, respectively) recommendations that will assess the final condition of the tank environment and the tank were presented.

The greatest risk for this process involves the handling of large quantities of Columbia River water (i.e., greater than 450,000 gallons). As long as this water is blended into the supernate in a timely fashion, and the waste is adjusted appropriated with corrosion inhibitors, the final condition is expected to be within compliance. Recommendations were also made to address process interruptions that could result in exposure of the tank walls to aggressive conditions.

11.0 References

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