U.S. Department of Energy
Office of River Protection
P.O. Box 450, MSIN H6-60
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SEP 1 5 2011

11-TPD-057

Ms. Jane A. Hedges, Program Manager
Nuclear Waste Program
State of Washington
Department of Ecology
3100 Port of Benton Blvd
Richland, Washington 99352

Dear Ms. Hedges:

COMPLETION OF HANFORD FEDERAL FACILITY AGREEMENT AND CONSENT ORDER (HFFACO) INTERIM MILESTONE M-045-91C, DUE SEPTEMBER 30, 2011

This letter documents completion of the HFFACO Interim Milestone M-0145-91C. This interim milestone requires that the U.S. Department of Energy, Office of River Protection implement the Data Quality Objectives (DQO) process, in consultation with the Washington State Department of Ecology (Ecology) to develop and provide Ecology a test plan to evaluate the chemistries as specified in RPP-RPT-43116, Revision 0, *Expert Panel Report for Hanford Site Single-Shell Integrity Project*.

The enclosed test plan, RPP-PLAN-50077, *Test Plan to Evaluate the Propensity for Corrosion in Single-Shell Tanks*, was completed with Ecology's involvement and consultation (Enclosure 1). The test plan references the chemical testing DQO document, RPP-49674, *Single-Shell Tank Corrosion Chemistry Data Quality Objectives*, which is enclosed for your reference (Enclosure 2).

If you have any questions, please contact me, or your staff may contact, Jeremy M. Johnson, at (509) 376-1866.

Sincerely,

Scott L. Samuelson, Manager
Office of River Protection

TPD: JMJ

Enclosures (2)

cc w/encl: See Page 2

SEP 1 5 2011

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Enclosure 1

11-TPD-057

RPP-PLAN-50077
Test Plan to Evaluate the Propensity for Corrosion in Single-Shell Tanks

Consisting of 22 pages, including coversheet.

DOCUMENT RELEASE FORM

(1) Document Number: RPP-PLAN-50077		(2) Revision Number: 0	(3) Effective Date: 08/15/2011
(4) Document Type:	☐ Digital Image ☐ Hard copy ☒ PDF ☐ Video	(a) Number of pages (including the DRF) or number of digital images	21
(5) Release Type	☒ New ☐ Cancel	☐ Page Change	☐ Complete Revision
(6) Document Title:	Test Plan to Evaluate the Propensity for Corrosion in Single-Shell Tanks		
(7) Change/Release Description:	New Release		
(8) Change Justification:	N/A		

(9) Associated Structure, System, and Component (SSC) and Building Number:			
(a) Structure Location: 241-A, AX, B, BX BY, C, S, SX, T, TX, TY, U		(c) Building Number: 241	(e) Project Number: N/A
(b) System Designator: Waste Storage Tank		(d) Equipment ID Number (EIN): NA	

(10) Impacted Documents:	(a) Document Type	(b) Document Number	(c) Document Revision
	N/A		

(11) Approvals:

(a) Author (Print/Sign): K. D. Boomer — Date: 08/08/2011

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J. L. Castleberry	H3-30	R. S. Rast	E6-47
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J. J. Luke	H6-05	T. J. Venetz	E6-47
F.R. Miera	E6-32		

Release Stamp: AUG 0 9 2011 DATE: STA: 15 HANFORD RELEASE ID: 65

(13) Clearance	(a) Cleared for Public Release	(b) Restricted Information?	(c) Restriction Type:
	☒ Yes ☐ No	☐ Yes ☒ No	N/A

(14) Clearance Review (Print/Sign): NANCY A FOUAD/Nancy A Fouad — Date: 8/9/2011

A-6003-881 (REV 3)

Test Plan to Evaluate the Propensity for Corrosion in Single-Shell Tanks

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EDT/ECN:	DRF	UC:	N/A
Cost Center:	N/A	Charge Code:	N/A
B&R Code:	N/A	Total Pages:	21

Key Words: Single-Shell Tank, Corrosion, Single-Shell Tank Integrity Project Expert Panel, Liquid-Air Interface, Pitting, Stress Corrosion Cracking

Abstract: One of the concerns with respect to SST integrity is the presence of aggressive species that may attack the tank liners increasing the release of waste to the environment. To identify these species, the expert panel looked at the work developed to maintain the integrity of the DSTs, which have specific chemistry limits to control corrosion. These controls for the DSTs are presented in OSD-T-151-00007, Operating Specifications for the Double-Shell Storage Tanks. The expert panel recommended that these conditions be used as guide for the SST testing because the tanks which have been managed under these limits have shown no signs of promoting general, localized, or environmentally assisted cracking (EAC).

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AUG 0 9 2011
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Nancy A Fouad 8/9/2011
Release Approval Date

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RPP-PLAN-50077, Rev. 0

Test Plan to Evaluate the Propensity for Corrosion in Single-Shell Tanks

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August 2011

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

Contract No. DE-AC27-08RV14800

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Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
CPP	Cyclic Potentiodynamic Polarization
DOE	United States Department of Energy
DST	Double-Shell Tank
DNV	Det Norske Veritas Laboratory, Columbus, OH
EAC	Environmentally Assisted Cracking
Ecology	Washington State Department of Ecology
E_{pit}	The potential at which stable pit initiate on the forward scan of a CPP.
E_{prot}	The potential at which pits (if they occur) passivate and stop growing on the reverse scan of a CPP.
FY	Fiscal Year
HFFACO	Hanford Federal Facility Agreement and Consent Order
LD	Liner Degradation
LAI	Liquid-Air Interface
DST	Double-Shell tank
NO_2^-/NO_3^- Ratio	Nitrite to Nitrate Ratio
OCP	Open Circuit Potential
ORP	Office of River Protection
PSQ	Principle Study Question
SCE	Saturated Calomel Electrode
SCC	Stress Corrosion Cracking
SEM	Scanning Electron Microscope
SRS	Savannah River Site
SSR	Slow Strain Rate
SST	Single-Shell Tank
SSTIP	Single-Shell Tank Integrity Project
TPA	Tri-Party Agreement
WRPS	Washington River Protection Solutions LLC

1.0 INTRODUCTION

One of the main functions of the River Protection Project is to store the Hanford Site tank waste until the Waste Treatment and Immobilization Plant and other supplemental treatment systems are ready to receive and process the waste. Waste from the older Single-Shell Tanks (SSTs) is being retrieved and transferred to the newer Double-Shell Tanks (DSTs). However, the process of retrieving this waste will take a considerable amount of time due to operational considerations (e.g., DST space requirements). All SSTs are past their design life, and some will be expected to contain waste for 20 years beyond the previously agreed date of 2018.

Therefore, the integrity of the SSTs must be maintained until the wastes have been retrieved. To aid in maintaining the SST integrity, Washington River Protection Solutions LLC (WRPS) initiated the Single-Shell Tank Integrity Project (SSTIP) and commissioned a SSTIP Expert Panel to provide advice on the formation of the project. The expert panel made 33 recommendations to the SSTIP which are documented in RPP-RPT-43116, *Expert Panel Report for Hanford Site Single-Shell Tank Integrity Project*.

WRPS prepared RPP-PLAN-45082, *Implementation Plan for the Single-Shell Tank Integrity Project* (Implementation Plan), which discusses the expert panel recommendations adopted by the SSTIP. The United States Department of Energy (DOE) and the Washington State Department of Ecology (Ecology) used the expert panel's report and the Implementation Plan to develop the Hanford Federal Facility and Consent Order (HFFACO) Tri-Party Agreement (TPA) M-045-91 Milestone Series. This milestone series was added to the HFFACO by the M-45-10-1 TPA Change Package.

1.1 PURPOSE

This test plan addresses the requirements of TPA Milestone M-45-91C which states the following:

> "DOE shall implement the DQO process, in consultation with Ecology, to develop and provide Ecology a Test Plan to evaluate the chemistries as specified in RPP-RPT-43116, Rev 0, *Expert Panel Report for Hanford Site Single-Shell Integrity Project.*"

DOE must provide Ecology this Test Plan by September 30, 2011. TPA Milestone M-045-91C was derived from two of the SSTIP expert panel's recommendations that addressed Liner Degradation (LD).

> ***Recommendation LD-3, Examine "non-compliant" wastes at 25 °C:*** *The Panel recommends selected "non-compliant" SST waste simulants be examined at 25 °C. "Non-compliant" wastes are those that fail to meet specific temperature, nitrite, nitrate, and hydroxide concentration criteria. The examinations will provide information on the propensity for pitting, cracking, and corrosion at the liquid-air interface (LAI) or corrosion of the liner in the vapor space. This testing should be coordinated with the double-shell tank (DST) testing program.*[1]

[1] This testing will be done at 30 °C because it is easier to control experimentally than 25 °C.

Recommendation LD-5, Determine Ammonia Corrosion Control Concentration: *Ammonia in sufficient concentrations has the potential to inhibit liner corrosion. The panel recommends laboratory testing to determine the concentration of ammonia required to control corrosion in the liquid phases of the solid and supernatant layers, at the LAI, and on the exposed liner in the vapor spaces. This testing should be coordinated with the DST testing program.*

The expert panel's concern for SST liner integrity is based on the presence of aggressive chemical species that may attack SSTs liners and cause corrosion. Corrosion of the SSTs liners could increase the release of waste to the environment from the SSTs. To preliminarily identify the presence of aggressive species within the SST waste, the expert panel reviewed the DST specific chemistry corrosion control limits and conditions. The DST Corrosion controls limits and conditions are found in OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks.*

The expert panel has not recommended the control of corrosion in the SSTs through the use of the DST operating specifications. Rather, the expert panel has asked the SSTIP to build on the knowledge gained through the development of the DST operating specifications and ongoing testing to evaluate the risks to the SSTs. A primary reason for this recommendation by the expert panel is that the DSTs, managed under these operating specifications, have shown no sign of promoting general, localized, or environmentally assisted cracking (EAC) corrosion.

Ongoing testing for the DSTs has drawn on the expertise of many individuals and sources from academia and industry. Testing has shown that ammonia inhibits corrosion in the DSTs, especially at the Liquid-Air Interface (LAI) and vapor spaces. If aggressive species are identified, a second series of tests will be conducted to see whether the current levels of ammonia in the SSTs inhibit the attack on the steel liner.

1.2 BACKGROUND

The SSTs were built between 1943 and 1964. Table 1 lists the materials of construction by tank farm for the SSTs.

Table 1. Steel Tank Liner Materials of Construction

Tank Farm	ASTM Steel Type
241-B, C, T, U, BX	A7-39
241-TX, BY	285-46
241-S	283-46T
241-TY	283-49T
241-SX, A	A283-52T
241-AX	A201, Grade A

Corrosion testing of SST liner steel has been performed multiple times and for many decades. However, this past SST corrosion testing focused on corrosion rates at higher temperatures and storage conditions that no longer exist in the SSTs. A compilation of these historical reports and

a summary of results of the past SST corrosion testing can be found in ARH-ST-111, *Compilation of Hanford Corrosion Studies*.

To support the SSTIP testing program, the DOE Office of River Protection (ORP) completed the Data Quality Objective (DQO) process in consultation with Ecology. This process was documented in RPP-49674, *Single-Shell Tanks Corrosion Chemistry Data Quality Objectives*.

The systematic decision-making process expanded the expert panel's recommendations, examining the SST liners for their propensity to corrode. The DQO process identified three types of corrosion that may occur and the test criteria for determining whether these forms of corrosion would require further investigation. The most likely forms of corrosion to which the Hanford SSTs are susceptible are the following:

- general corrosion,
- localized corrosion, and
- EAC identified as Stress Corrosion Cracking (SCC).

General corrosion will be examined through the use weight loss coupons. Localized corrosion, which could be either pitting corrosion or LAI corrosion, will be examined using Cyclic Potentiodyamic Polarization Testing (CPP). The testing for SSC will use Slow Strain Rate (SSR) testing.

The information presented in this test plan is a point-in-time representation of an ongoing testing program for the SSTs. As more information is obtained, the SSTIP may determine new testing and compositions from the advice of the expert panel. This test plan will not be updated as part of this process, but all testing will be available in publicly released documents. Testing is currently underway in the 222-S Laboratory and in the Det Norske Veritas (DNV) Laboratory in Columbus, Ohio. Other testing, at off-site laboratories, will be initiated in Fiscal Year (FY) 2012 as necessary. Completion of this test program to evaluate the propensity for corrosion in SSTs is expected to occur by the end of FY 2014.

2.0 WASTE TANK CHEMISTRY DETERMINATIONS

"Non-compliant" SSTs or SST waste layers were initially identified using DST chemistry specifications. Table 2 gives the chemistry control limits (OSD-T-151-00007) for the DST wastes that have a temperature less than 167 °F (75 °C), which is the lowest temperature range for the DST specifications. These criteria identified 33 waste layers, which reside in 23 SSTs. Additional criteria have been recommended to augment the criteria for testing the SST waste layers at the DST chemistry control limits at 30 °C:

- Nitrite Inhibition Limit – Previous work has shown that if the nitrite to nitrate ratio (NO_2^-/NO_3^- ratio) is above 0.15 and below a temperature 50 °C, then there is concern for SCC (RPP-ASMT-47754). Although SCC has not been demonstrated for the NO_2^-/NO_3^- ratio > 0.15 at temperatures below 50 °C, there has not been an effort to investigate the effects of this ratio at the lower temperature that occur in most of the SSTs. The addition of this criterion identified six layers in three tanks for inclusion in the testing.

- SRS Testing – Other chemistry limits either used at the SRS or as part of the optimization of the DST chemistry limits may be used to identify potentially aggressive layers (WSRC-IM-2003-00010). At this time no additional layers have been identified for testing using this criterion.

- Temperature – If any waste layers are identified at temperatures higher than 30 °C, the waste layers will be tested at that temperature instead of 30 °C. This adjustment for temperature is necessary because the temperature can have an impact of the chemical reactions that influence the corrosion of the steel. In most chemical reactions, an increase in temperature is accompanied by an increase in reaction rate. A rough rule-of-thumb suggests that the reaction rate doubles for each ten degree Celsius rise in temperature. Although this rule has many exceptions, it is important to take into consideration the influence of temperature when analyzing why materials fail. Two tanks have been identified as needing testing at 40 °C: 241-B-101 and 241-S-104.

From the additional criteria listed above, a total of 39 waste layers in 26 tanks require testing and two tanks require testing at 40 °C. Table 3 identifies these tanks and waste layers. The table also includes the temperature in the waste layers, testing basis, and material of construction of the steel liners in the tank. The DST specification listed under testing basis is the existing chemistry operating specification limits shown in Table 2.

Testing will be conducted with samples prepared from the steel alloys listed in Table 3. However, these alloys may not be from the same period production. Newer materials from the same alloys have improved chemistry control versus the legacy steels used to the construct the tanks. This difference can skew testing results and not identifying the actual propensity for corrosion to occur in the SSTs. If legacy steels are available for testing, legacy steels will be used. However, since legacy steel availability is limited, the specimens from modern alloys will be used in most of the testing.

Table 2. General Chemistry Control Limits Applicable to Double-Shell Waste Tanks for Waste Temperatures < 167 °F (75 °C)

For $[NO_3^-]$ Range	Variable	Limits
$[NO_3^-] \leq 1.0\underline{M}$	$[OH^-]$	$0.010\underline{M} \leq [OH^-] \leq 8.0\underline{M}$
	$[NO_2^-]$	$0.011\underline{M} \leq [NO_2^-] \leq 5.5\underline{M}$
	$[NO_3^-] / ([OH^-] + [NO_2^-])$	< 2.5
$1.0\underline{M} < [NO_3^-] \leq 3.0\underline{M}$	$[OH^-]$	$0.1\ ([NO_3^-]) \leq [OH^-] < 10\underline{M}$
	$[OH^-] + [NO_2^-]$	$\geq 0.4\ ([NO_3^-])$
$[NO_3^-] > 3.0\underline{M}$	$[OH^-]$	$0.3\underline{M} \leq [OH^-] < 10\underline{M}$
	$[OH^-] + [NO_2^-]$	$\geq 1.2\underline{M}$
	$[NO_3^-]$	$\leq 5.5\underline{M}$

Chemistry specifications for Double-Shell Tank corrosion control are found in OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*.

Table 3. Out-of-Specification and Nitrite Limit Tanks

Tank [a]	Layer(s)	Temperature (°C)	Testing Basis	Steel Alloy
241-B-101	Solid	38.8	DST Specification	A7
241-B-102	Solid, Supernatant	18.1, 18.1	DST Specification	A7
241-B-103	Solid	17.3	DST Specification	A7
241-B-104	Solid	21.5	DST Specification	A7
241-B-105	Solid	18.6	DST Specification	A7
241-B-106	Solid, Supernatant	22.9, 17.6	DST Specification	A7
241-B-107	Solid	16	DST Specification	A7
241-B-108	Solid	21.2	DST Specification	A7
241-B-109	Solid	20	DST Specification	A7
241-B-203	Solid, Supernatant	16.5, 20.2	Nitrite Limit	A7
241-B-204	Solid, Supernatant	16.7, 19.0	Nitrite Limit	A7
241-BX-110	Solid, Supernatant	22, 19.9	DST Specification	A7
241-C-110	Solid, Supernatant	20.8, 23.8	Nitrite Limit	A7
241-S-104	Solid	38.4	DST Specification	A283
241-T-102	Solid, Supernatant	17.8	DST Specification	A7
241-T-108	Solid	16.2	DST Specification	A7
241-T-109	Solid	22.6	DST Specification	A7
241-T-110	Solid, Supernatant	18, 18.6	DST Specification	A7
241-T-201	Solid, Supernatant	20.6, 19.2	DST Specification	A7
241-TX-104	Solid, Supernatant	20.6, 20.6	DST Specification	A285
241-TX-116	Solid	21.1	DST Specification	A285
241-TX-117	Solid	21.1	DST Specification	A285
241-TY-101	Solid	18.6	DST Specification	A283
241-U-106	Solid, Supernatant	29.6, 24.4	DST Specification	A7
241-U-203	Solid, Supernatant	19.1, 18.8	DST Specification	A7
241-U-204	Solid, Supernatant	18, 18	DST Specification	A7

[a] The tanks that are assumed leakers are shaded in gray.

3.0 TECHNIQUES AND TESTING

From the DQO, three types of corrosion testing were identified for evaluation: general corrosion, localized corrosion (which may consist of either of pitting or LAI corrosion), and SCC. The American Society for Testing and Materials (ASTM) has developed a procedure for testing each type of corrosion, which are identified in the following sections.

The corrosion testing addressed in the DQO is conducted in two phases. The first phase addresses the different types of corrosion while the second phase addresses the ammonia as a corrosion inhibitor (see Figure 1). If it is determined that the evaluation of actual tank waste is required, the DQO will be revised to explicitly address that action.

The following Principle Study Questions (PSQs) were discussed and accepted by the DQO planning team.

1. Do the single-shell tank waste layers show a propensity for corrosion that will have an impact on retrieving tank waste and/or continued storage?
2. Is a corrosivity problem resolved by the addition of ammonia up to the calculated ammonia in the waste layer?

The DQO planning team developed the following alternative actions:

- Sample and analyze actual tank waste,
- No action required,
- Accelerate waste retrieval,
- Use a different retrieval technology, and
- Chemically or physically inhibit corrosivity of the waste.

Testing of the waste simulants varies for each of the recommended procedures. In general, the test regime will follow this overall approach:

- Waste simulants representative of the waste layers identified in SSTs will be prepared for testing. These simulants may be prepared as a bounding composition to cover wastes layers of similar composition (e.g., high nitrate and low pH).

- Steel specimens will be tested per the selected ASTM standard. For the weight loss tests, coupons will be exposed for six, twelve, and 18 months. For electrochemical testing, the tests will be conducted per the prescribed criteria, which are normally a few days to a week in duration.

- Both the electrochemical and the weight loss coupon testing will be carried out at the tank temperature.

- The need for replicate testing will be guided by the testing standard. The coupons general corrosion testing will be done in triplicate. The electrochemical testing for CPP and SSR testing will be repeated as necessary to confirm the results obtained and to establish the critical potential range of the results reported.

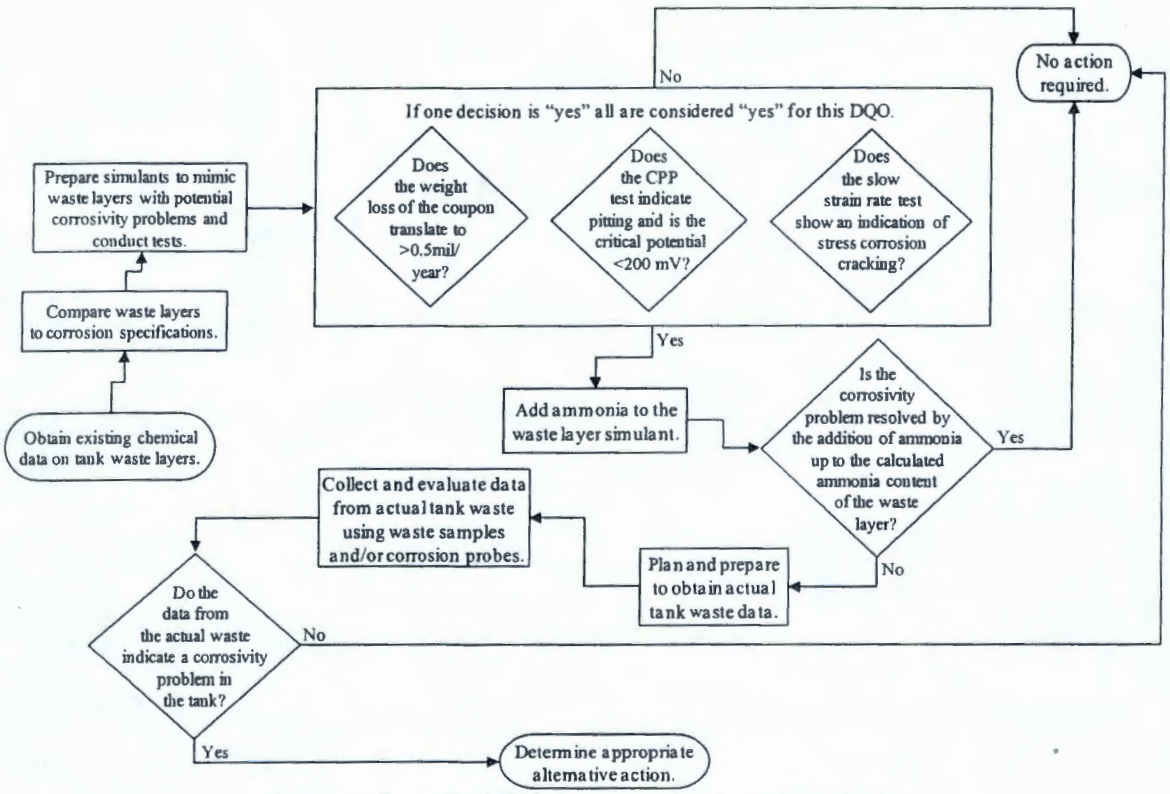

Figure 1. Single-Shell Tank Corrosion Test Logic Flow Chart

3.1 GENERAL CORROSION WEIGHT LOSS COUPONS

General corrosion tests, using weight loss coupons, will also be performed in the 222-S Laboratory. The testing procedure will follow ASTM G31-72(2004), *Standard Practice for Laboratory Immersion Corrosion Testing of Metals*. Weight loss coupons will be conducted with three coupons per waste simulant. The coupons will be immersed in the solution for the weight loss testing and placed in the headspace and at the liquid-air interface.

The immersed coupons will provide the weight loss data. Due to the slow action of hydroxide in corrosion, the weight loss coupons will be exposed for a period of up to 18 months and sampled at the 6, 12, and 18-month time frames. This procedure is similar to the approach used in the 1980s at the Pacific Northwest Laboratory (PNL 5488). Weight loss equivalent to 0.5 mils per year will be used to select waste compositions that require further investigation for general corrosion per the DQO (i.e., testing with actual waste samples).

In addition, the coupons placed in the vapor space and at the LAI interface will be examined for pitting, LAI corrosion, and vapor space corrosion. These other forms of attack will be reported qualitatively. The pitting and LAI corrosion results will be compared with the electrochemical testing results from CPP.

Figure 2. Weight Loss Coupon for Partially Immersed Sample

3.2 LOCALIZED CORROSION-ELECTROCHEMICAL CORROSION

Electrochemical corrosion studies will be performed to determine the pitting propensity, corrosion rate, and electrochemical parameters such as open circuit potential (OCP), corrosion potential, and corrosion current. This testing will be conducted at the 222-S laboratory and at DNV Laboratory that has conducted the DST testing in Columbus, Ohio. Tests will be performed in accordance with ASTM G61-86, *Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, and Cobalt-Based Alloys,* as well as ASTM G31–72 (2004), *Standard Practice for Laboratory Immersion Corrosion Testing of Metals.*

The pitting behavior of passive materials can be characterized by using a CPP technique. An electrode of the material of interest is anodically polarized in this test, i.e., the potential is

electronically increased at a pre-determined scan rate from its OCP. Figure 3 shows a typical apparatus for this testing.

Materials that are susceptible to pitting will eventually exhibit an abrupt increase in current from the low passive current. This current corresponding potential is called the "pitting potential" or the "breakdown potential," which is designated as E_{pit} in Figure 4. The subsequent current increase is caused by breakdown of the passive film and rapid growth of localized corrosion in the form of, for instance, pittings, LAI attack, or crevice corrosion.

In a CPP experiment, the scan direction is reversed after some extent of localized corrosion growth as indicated by a particular measured apex current. The curve for a material undergoing localized corrosion will exhibit a hysteresis loop as shown in Figure 4. Pits or crevices will continue to grow at potentials below which they initiated. As the potential is decreased further, the attack in the localized corrosion site will usually cease suddenly, resulting in a rapid and large decrease in the measured current. This potential is defined as the "protection potential" or "re-passivation potential," which is designated as E_{prot}.

This critical potential can also be determined from the point at which the reverse scan crosses the forward scan or the zero-current potential, which are usually similar in value. A 200 mV potential difference between the re-passivation potential and OCP will be used for evaluation of the results as the criteria for further investigation of pitting corrosion, which has been previously used by the Expert Panel Oversight Committee (EPOC) for the DST testing.

To augment this potential difference, the EPOC has recommended a new standardized approach for evaluating pit corrosion. This approach evaluates the degree of the propensity for pitting based on the re-passivation potential versus the open circuit potential. The approach defines five categories per RPP-ASMT-50092, *The Double-Shell Tank Corrosion Monitoring and Testing Expert Panel Oversight Committee Meeting Held May 18-20, 2011*. This approach accounts for the appearance of pits on test specimens, which are due to the technique used.

Figure 3. Cyclic-Potential Polarization Test Apparatus

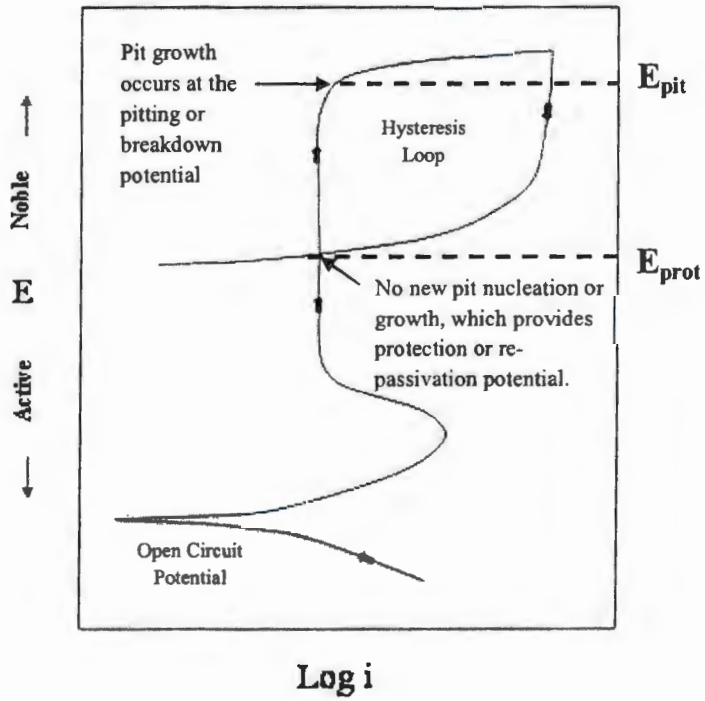

Figure 4. Anodic Polarization Curve for an Alloy Susceptible to Pitting

3.3 STRESS CORROSION CRACKING

Experiments for SCC will be carried out using a SSR test as per ASTM G129-00 (2006), *Slow Strain Rate Testing to Evaluate the Susceptibility of Metallic Materials to Environmentally Assisted Cracking*. This practice covers procedures for the design, preparation, and use of axially loaded, tension test specimens and fatigue pre-cracked (fracture mechanics) specimens for use in slow strain rate (SSR) tests to investigate the resistance of metallic materials to EAC.

The 222-S Laboratory does not have the capability to perform the SSR testing. The DST project uses the DNV Laboratory in Columbus, Ohio to perform this testing. SSR testing is ongoing at the DNV Laboratory. Other methods can be used to test for SCC using either U-Bend stress coupons or C-Ring stress test specimens . These tests will be in agreement with three ASTM standards:

- ASTM 30-97, *Practice for Making and Using U-Bend Stress Corrosion Test Specimen*
- ASTM 38-01, *Practice for Making and Using C-Ring Stress Corrosion Test Specimen*
- ASTM G31-72, *Practice for Laboratory Immersion Corrosion Testing of Materials*

These testing procedures listed above do not produce results consistent with SSR testing used for DST testing, so their use would have to account for this inconsistency. The expert panel members may recommend some select U-bend or C-ring tests with tank waste. For all methods employed in this investigation, the metallographic analysis will follow an agreed upon ASTM protocol, such as ASTM G 161-00, *Standard Guide for Corrosion–Related Failure Analysis* and ASTM E3-01 (Reapproved 2007), *Standard Guide for Preparation of Metallographic Specimens.*

Figure 5 shows a cylindrical tensile specimen, which will be tested at a constant extension rate of 10^{-6} in/in-s (unless otherwise noted). To perform the tests, a specimen will be placed into a Teflon test cell and the load applied using pull rods that entered the cell through sliding seals. After insertion of the specimen and pull rods into the load frame, the solution of interest will be introduced and heated to the desired temperature. Tests will either be conducted at open circuit or at an applied potential using saturated calomel electrode (SCE) maintained at room temperature using a Luggin probe/salt bridge that will be filled with the test environment solution. A platinum flag will be used as a counter electrode. All SSRT experiments will be performed under quiescent (no gas purging) conditions.

Post-test analysis will consist of stereographic optical examination at 20 – 40x. Additional analyses using higher magnification optical microscopy, metallographic cross sectional analysis, and scanning electron microscopy (SEM) will be used to examine the fracture surface.

The determination of SCC is made by expert examination of the test specimens. The test results from the SSR testing include stress/strain curves of the specimens as they are pulled to failure. These tests will be performed and analyzed by corrosion subject matter experts at the testing lab and reviewed by the expert panel. Figure 6 shows this type of curve for some of the specimens tested using 241-AN-107 waste simulants versus a standard stressed in air. The longer the specimen can be pulled prior to failure, the more ductile the material and the less likely for SCC to be the cause of the failure. The specimens are also visually examined for signs of SCC. Figure 7 shows specimens without and with signs of SCC.

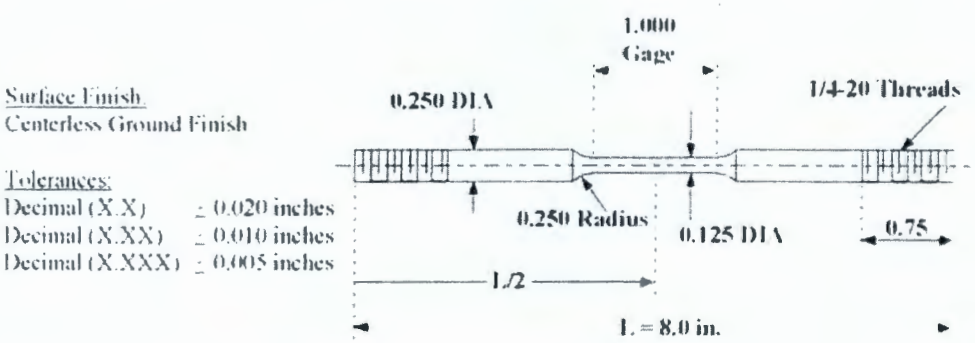

Figure 5. Slow Strain Rate Test Specimen

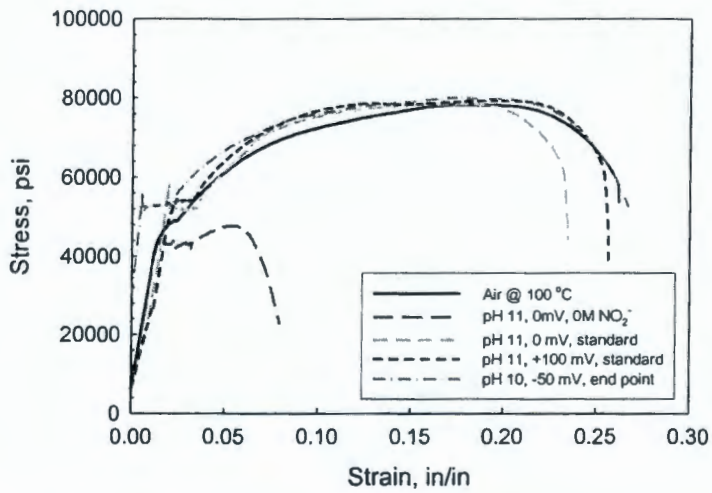

Figure 6. Slow Strain Rate Testing Stress versus Strain Results

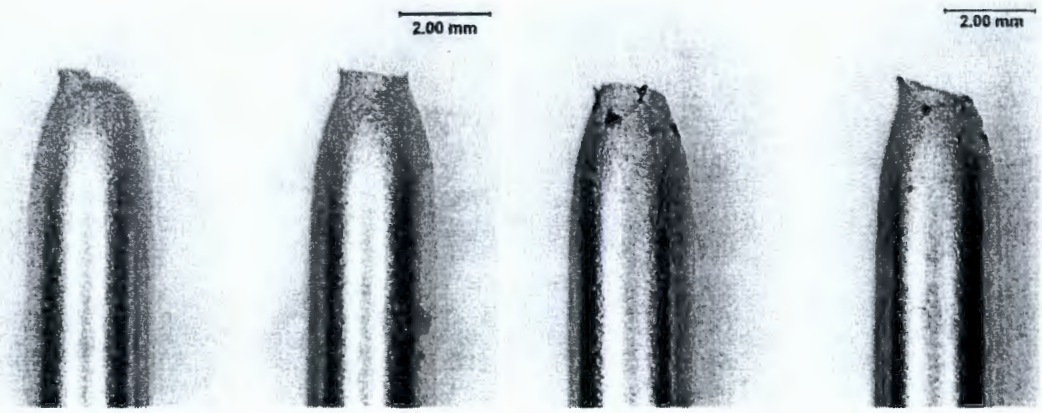

Figure 7. Slow Strain Rate Testing Specimen Strained to Failure with no Stress Corrosion Cracking on the Left and with Stress Corrosion Cracking on the Right

4.0 AMMONIA AS AN INHIBITOR

For test specimens that show the propensity for pit and LAI corrosion, additional testing will be conducted to examine the ammonia inhibition of the corrosion in the aggressive layers. This study will be conducted in two parts using CPP techniques described in Section 3.2. First, a simple simulant will be prepared by choosing aggressive nitrite-nitrate ratios with suitable hydroxide content or pH.

Other components will be introduced at concentrations that are near, but less than aggressive limits (Congdon, 1988). These components will include phosphate, sulfate, silicate, fluoride and other ions as recommended by the expert panel. The effect of ammonia will be studied by systematically introducing ammonia to determine the critical concentration necessary for corrosion inhibition. Once the concentration limit is determined, the pH will then be reduced to lower values to investigate whether the ammonia-induced passivation holds true.

The second part of this study will be similar to the first part, but with selected aggressive waste segments identified in the work performed in Section 3.2. Selection of the wastes will be discussed with the expert panel representatives before work is performed. This work would be guided by the DQO logic presented in Figure 1, which focuses on obtaining more representative data prior to taking actions to reduce the propensity of corrosion in a tank.

5.0 DATA QUALITY

The quality assurance (QA) for the corrosion testing is controlled by ATS-MP-QA, *222-S Laboratory Facility Quality Assurance Program Plan for Industrial Hygiene Analyses*. In addition, all of the QA requirements in the ASTM documents listed above will be followed. Test plan LAB-PLN-10-00001will be revised, and any specific QA requirements or deviations from QA plan ATS-MP-QA and the ASTM documents will be discussed in the test plan. If actual tank waste data are required and sampling is required, any additional QA requirements for sampling and analyses will be added to DQO document. If other than Hanford laboratories are used, they will use equivalent standards either by reference or have QA requirements flowed down through contract provisions.

6.0 REFERENCES

ARH-ST-111, 1975, *Compilation of Hanford Corrosion Studies*, Atlantic Richfield Hanford Company, Richland, Washington.

ASTM 30-97, *Practice for Making and Using U-Bend Stress Corrosion Test Specimen,* American Society of Testing and Materials, West Conshohocken, Pennsylvania.

ASTM 38-01, *Practice for Making and Using C-Ring Stress Corrosion Test Specimens,* American Society of Testing and Materials, West Conshohocken, Pennsylvania.

ASTM E3-01 (Reapproved 2007), *Standard Guide for Preparation of Metallographic Specimens*, American Society of Testing and Materials, West Conshohocken, Pennsylvania.

ASTM G31-72 (2004), *Practice for Laboratory Immersion Corrosion Testing of Materials,* American Society of Testing and Materials, West Conshohocken, Pennsylvania.

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

ASTM G129-00 2006 (Reapproved 2006), *Slow Strain Rate Testing to Evaluate the Susceptibility of Metallic materials to Environmentally Assisted Cracking*, American Society of Testing and Materials, West Conshohocken, Pennsylvania.

ASTM G161-00, *Standard Guide for Corrosion–Related Failure Analysis*, American Society of Testing and Materials, West Conshohocken, Pennsylvania.

PNL-5488, 1985, *Prediction Equations for Corrosion of A-537 and A-516 Steels in Double Shell Slurry, Future Purex, and Hanford Facilities Wastes*, Pacific Northwest Laboratory, Richland, Washington.

OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks,* Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-43116, 2009, *Expert Panel Report for Hanford Site Single-Shell Tank Integrity Project*, Rev. 0,Washington River Protection Solutions, LLC, Richland, Washington.

RPP-ASMT-47754, 2010, Double-Shell Tank Corrosion Monitoring and Testing Expert Panel Oversight Committee Held August 17&18, 2010, Washington River Protection Solutions LLC, Richland, Washington.

RPP-RPT-50092, 2011, The Double-Shell Tank Corrosion Monitoring and Testing Expert Panel Oversight Committee Meeting Held May 18-20, 2011, Washington River Protection Solutions LLC, Richland, Washington.

RPP-49674, 2011, *Single-Shell Tanks Corrosion Chemistry Data Quality Objectives*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

WSRC-IM-2003-00010, CSTF Corrosion Control Program, Program Description Document, Aiken, South Carolina.

Enclosure 2

11-TPD-057

RPP-49674
Single-Shell Tanks Corrosion Chemistry Data Quality Objectives

Consisting of 17 pages, including coversheet.

DOCUMENT RELEASE FORM

(1) Document Number: RPP-49674		(2) Revision Number: 0	(3) Effective Date: 6/21/2011
(4) Document Type:	☐ Digital Image ☒ Hard copy ☒ PDF KW 6/29/11 ☐ Video	(a) Number of pages (including the DRF) or number of digital images 15	
(5) Release Type	☒ New ☐ Cancel	☐ Page Change	☐ Complete Revision
(6) Document Title:	Single-Shell Tanks Corrosion Chemistry Data Quality Objectives		
(7) Change/Release Description:	New Document		
(8) Change Justification:	N/A		

(9) Associated Structure, System, and Component (SSC) and Building Number:			
(a) Structure Location: N/A		(c) Building Number: N/A	(e) Project Number: N/A
(b) System Designator: N/A		(d) Equipment ID Number (EIN): N/A	

(10) Impacted Documents:	(a) Document Type	(b) Document Number	(c) Document Revision
	None		

(11) Approvals:

(a) Author (Print/Sign): D. L. Banning D L Banning Date: 6-21-11

(b) Reviewer (Optional, Print/Sign): T. J. Venetz T J Venetz Date: 6/22/11 Date: Date: Date: Date: Date:

(c) Responsible Manager (Print/Sign): J. G. Reynolds J G Reynolds Date: ~~06/21/2~~ 06/21/11

(12) Distribution:

(a) Name	(b) MSIN	(a) Name	(b) MSIN	Release Stamp
See distribution list				JUN 29 2011 DATE: STA: 15 HANFORD RELEASE ID. 24

(13) Clearance	(a) Cleared for Public Release	(b) Restricted Information?	(c) Restriction Type:
	☒ Yes ☐ No	☐ Yes ☒ No	

(14) Clearance Review (Print/Sign): Kelly L Wheeler Kelly L Wheeler Date: 6/29/2011

A-6003-881 (REV 3)

DISTRIBUTION SHEET

To: Distribution	From: Tank Waste Inventory and Characterization.	Page 1 of 1
Document/Project Title/Work Order: RPP-49674, Rev. 0, Single-Shell Tanks Corrosion Chemistry Data Quality Objectives		Date: June 21, 2011
		EDT No.: N/A
		ECN No.: N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
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SINGLE-SHELL TANKS CORROSION CHEMISTRY DATA QUALITY OBJECTIVES

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U.S. Department of Energy Contract DE-AC27-08RV14800

EDT/ECN:	DRF	UC:	N/A
Cost Center:	2GB00	Charge Code:	
B&R Code:	N/A	Total Pages:	15

Key Words: Data Quality Objectives, DQO, Corrosion, Corrosion Mitigation, Single-Shell Tanks, Sampling, Analysis, SST, Waste Chemistry, Corrosion Testing, Single-Shell Tank Integrity Projec, Recommendations LD-3 and LD-5.

Abstract: This document describes the data quality objective requirements needed to support the testing program required to address recommendations LD-3 and LD-5 provided by the Single-Shell Tank Integrity Expert Panel. The type, quantity, and quality of the data needed to make the decisions affecting the integrity of the single-shell tanks are discussed.

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JUN 29 2011
DATE:
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Release Stamp

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RPP-49674
Revision 0

SINGLE-SHELL TANKS CORROSION CHEMISTRY DATA QUALITY OBJECTIVES

D. L. Banning
Washington River Protection Solutions LLC

Date Published
June 2011

washington river protection solutions

Post Office Box 850
Richland, Washington

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

Approved for public release; distribution unlimited

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LIST OF TERMS

Abbreviations and Acronyms

CCP	cyclopotentiodynamic polarization
DQO	data quality objective
DST	double-shell tank
LAI	liquid-air interface
PSQ	principle study questions
SCC	stress corrosion cracking
SST	single-shell tank
SSTIP	Single-Shell Tank Integrity Project
QA	quality assurance

1.0 INTRODUCTION

One of the main functions of the River Protection Project is to store the Hanford Site tank waste until the Waste Treatment Plant and other supplemental treatment systems are ready to receive and process the waste. Waste from the older single-shell tanks (SST) is being retrieved and transferred to the newer double-shell tanks (DST). However, the process of retrieving this waste will take a considerable amount of time due to operational considerations (e.g., DST space requirements) and some SSTs are expected to contain waste for more than another 20 years. Therefore, the integrity of the SSTs must be maintained until the waste from all of the SSTs has been retrieved. To aid in maintaining the SST integrity, Washington River Protection Solutions LLC initiated the Single-Shell Tank Integrity Project (SSTIP) and commissioned a Single-Shell Tank Integrity Expert Panel (Panel) to provide advice on the formation of the project.

To help maintain the integrity of the DSTs, specific chemistry limits have been established to control corrosion of the DSTs and are presented in OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*. Because these chemistry limits have shown no sign of the propensity for general, localized, or environmental corrosion, the Panel recommended that these conditions be used as guide for the SST testing.

The implementation plan for SST integrity (RPP-PLAN-45082, *Implementation Plan for the Single-Shell Tank Integrity Project*) discusses the Panel recommendations for the SSTIP. This Data Quality Objective (DQO) addresses the following Panel recommendations that were selected to examine the SST liners for their propensity for corrosion. See Section 4.1 for a small change in recommendation LD-3.

- **Recommendation LD-3: Examine Non-Compliant Wastes at 25 °C**
  The Panel recommends examining selected "non-compliant" SST waste simulants at 25 °C to ascertain the propensity for pitting and stress corrosion cracking (SCC). The corrosion rates might be so slow at this temperature that examination could eliminate new pits or SCC as credible concerns. Waste simulants should also be tested to determine the propensity for causing corrosion at the liquid air interface (LAI) and on the steel walls in the vapor space. This testing work should be carefully coordinated with the DST testing program that is already underway.

- **Recommendation LD-5: Determine Ammonia Corrosion Control Concentration**
  The Panel recommends that laboratory tests be carried out to assess the effectiveness of ammonia as an inhibitor of corrosion in the liquid phases of the solid and supernatant layers, at the LAI and on the exposed walls in the vapor spaces. A laboratory investigation is needed to establish the relationship between the concentrations of ammonia in the vapor that are needed to control these kinds of corrosion. Again, this testing work should be carefully coordinated with the testing program that is already underway with the DSTs

This document describes the DQO process undertaken as required per Milestone M-045-91C in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al.). This interim milestone requires U.S. Department of Energy to implement the DQO process, in consultation

with State of Washington Department of Ecology, to develop and provide Ecology a Test Plan to evaluate the chemistries as specified in RPP-RPT-43116, *Expert Panel Report for Hanford Site Single-Shell Integrity Project*, by September 30, 2011. The purpose of this DQO effort is to ensure collection of the appropriate data to support the testing required by Panel recommendations LD-3 and LD-5

The DQO process was implemented in accordance with TFC-ENG-CHEM-C-16, *Data Quality Objectives for Sampling and Analyses* and the U.S. Environmental Protection Agency EPA QA/G4, *Guidance on Systematic Planning Using the Data Quality Objectives Process*. As stated in these documents, the DQO process is iterative. Therefore, changes to this DQO document will be made during the project if data are obtained that change the requirements or if additional data are needed. As the SST corrosion chemistry testing proceeds and data are obtained, specific data requirements can be added or deleted from the document as required.

In addition to this DQO document, other documents (e.g., test plans) will be prepared to guide the overall testing program.

2.0 PROBLEM STATEMENT

Step one of the DQO process encourages decision makers to consider the broad context of the problem so that important issues are not overlooked. The objective of a problem statement is to clearly define the problem (the reason data are required) so the focus of the project will be unambiguous.

The current condition of waste in the SSTs consists of varying layers in different phases of consistency and chemical composition. Current information indicates certain waste layers are non-compliant with the requirements criteria specified for corrosion control chemistry limits currently being used in the DST system.

The following problem statement was accepted by the DQO planning team during the DQO meeting.

> In order to determine the propensity for liner degradation in SSTs, data regarding corrosivity of current waste layer compositions are needed.

3.0 DECISION STATEMENTS

Step two of the DQO process defines decision statements that combine principle study questions (PSQs) with alternative actions that may be taken. The PSQs identify key unknown conditions or unresolved issues that reveal the solution to the problem. Alternative actions are the possible actions that might be taken once the PSQs have been resolved.

The corrosion testing covered by this DQO is conducted in two phases. The first phase addresses the propensity of the various waste layers to cause corrosion. The second phase addresses the ammonia as a corrosion inhibitor (see Figure 3-1). If it is determined that the evaluation of actual tank waste is required, this DQO will be revised to explicitly address that action.

The following PSQs were discussed and accepted by the DQO planning team during the DQO meeting.

1. Do the single-shell tank waste layers show a propensity for corrosion that will have an impact on continued storage and/or retrieving tank waste?
2. Is a corrosivity problem resolved by the addition of ammonia up to the calculated ammonia in the waste layer?

The alternative actions developed by the DQO planning team are:

- Sample and analyze the corrosivity of actual tank waste,
- No action required,
- Chemically or physically inhibit corrosivity of the waste,
- Accelerate waste retrieval, and
- Use a different retrieval technology.

The first two alternative actions shown above are possible actions that could be taken depending on the results of SST waste layer simulant corrosion testing (including the second phase of the test; the addition of ammonia). The last three alternative actions and the "no action required" alternative action would be considered after evaluating the actual tank waste data (see Figure 3-1) or if actual tank waste data could not be obtained, these alternative actions would be considered using only the results from the test data.

Considering the format of decision statements, the following two decision statements were developed. The first decision statement addresses corrosion testing (phase 1 and 2) while the second decision statement addresses potential actions if actual tank waste data are obtained. However, if actual tank waste data cannot be obtained, the alternative actions in the second decision statement will be considered in the first decision statement.

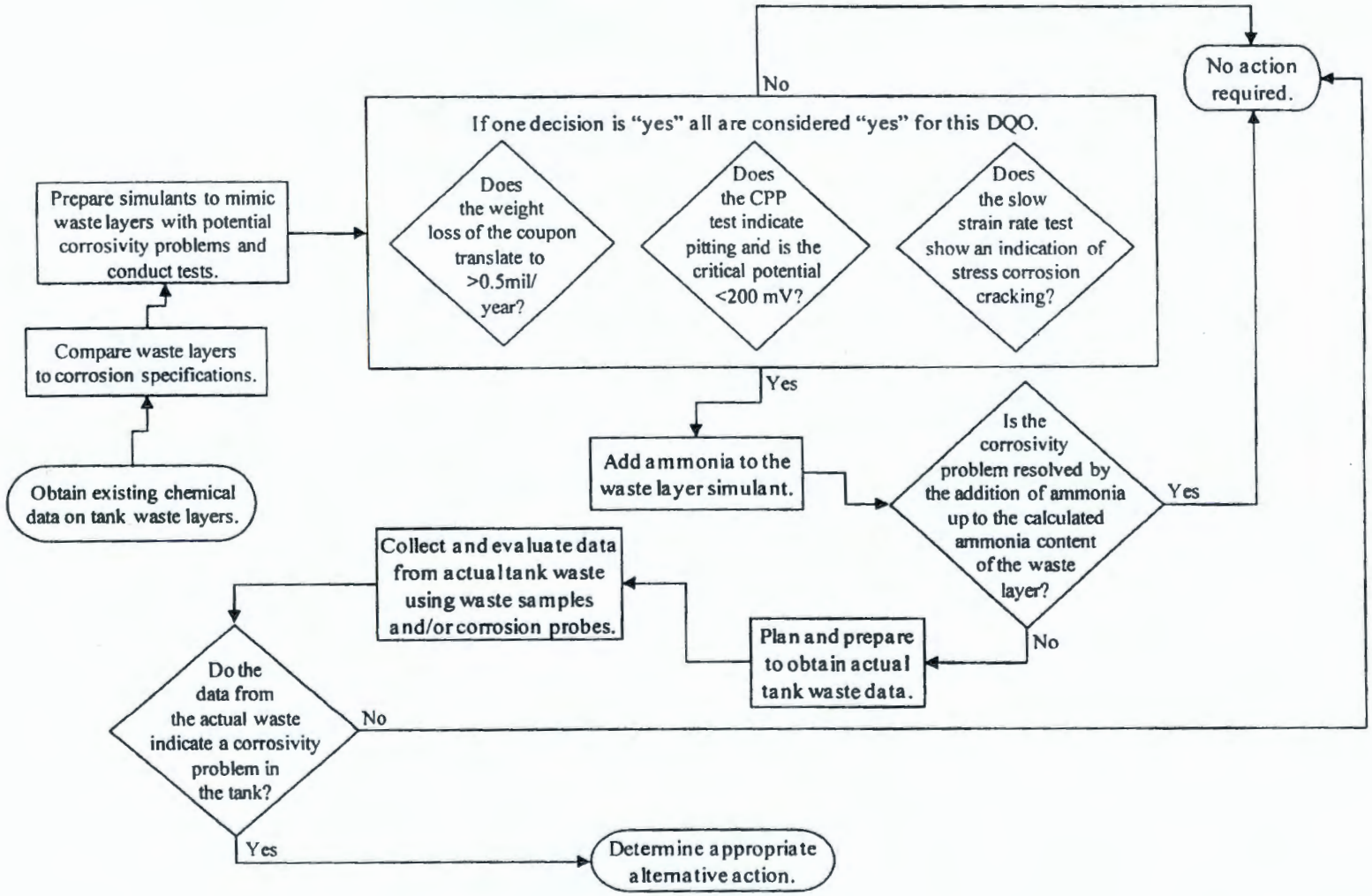
1. Determine whether any single-shell tank waste layer simulant is detrimental to the tank liner and requires sampling and analysis of actual tank waste or requires no action.

2. Determine whether any actual single-shell tank waste layer is detrimental to the tank liner and requires no action, chemically or physically inhibiting the corrosivity of the waste, a different retrieval technology, or accelerated waste retrieval of the waste in a tank.

If it is determined from the corrosion tests that actual tank waste data should be obtained, this DQO will be revised.

Figure 3-1 shows the general logic flow chart for the SST corrosion test.

Figure 3-1. SST Corrosion Test Logic Flow Chart



4.0 DATA INPUTS

The purpose of step three of the DQO process is to identify and collect the proper informational inputs needed to address the problem statement and resolve the decision statement. The DQO planning team discussed and accepted the following data inputs.

1. Chemical composition of waste layers (existing data),
2. Weight loss of coupons,
3. Corrosion potential [from cyclopotentiodynamic polarization (CPP) voltage and current],
4. Strain rate test data,
5. Sensitivity analyses of existing OH^- data,
6. Ammonia concentration (added to the simulants) compared to the expected ammonia concentration, and
7. Sensitivity analyses of ammonia inhibiter.

The first five data inputs are required for phase 1 of the corrosion testing. The next two data inputs (data input requirements 6 and 7) are required for phase 2 of the corrosion testing. Phase 2 addresses the addition of ammonia (if required) to the simulants (see Figure 3-1).

The waste simulants will be prepared using chemical data for existing waste layers (data input number 1) that could have a propensity to cause corrosion. The corrosion tests will be conducted on these simulated waste layers.

Data inputs 2 through 4 will be part of the phase 1 testing, obtained from conducting the corrosion tests (see Section 4.1) on the waste simulants. Data input 6 will also be obtained from conducting the corrosion tests (see Section 4.1), but will be part of the phase 2 testing.

In addition to the actual testing discussed in Section 4-1, two sensitivity analyses will be performed [data input 5 during phase 1 (for hydroxide) and data input 7 during phase 2 (for ammonia)].

If actual tank waste data are collected and evaluated, this DQO will be revised and additional data input requirements will be added. This data could include information from actual waste sampling or inserting corrosion probes into the SST waste.

4.1 TEST DATA

As indicated in Figure 3-1, three corrosion tests will be conducted on waste simulants. The majority of this testing will be conducted at 25 °C (see recommendation LD-3 in Section 1.0). However, during the DQO session, it was noted that some waste layers are at temperatures above 25 °C. It was agreed that tests would be conducted at the higher temperatures for these waste layers. A fourth test will be conducted, if required, by adding ammonia to the simulant to determine the expected ammonia concentration in the waste will inhibit the corrosion process. The following information summarizes the corrosion testing that will be conducted on the waste simulants. Additional information on the testing can be found in LAB-PLN-10-00001, *Test Plan*

for the Examination of Simulated Non-Compliant Waste from Hanford Single-Shell Tanks. This test plan will be revised or a new test plan will be prepared to govern the ongoing corrosion tests.

1. Electrochemical Corrosion: Electrochemical corrosion studies will be performed to determine the pitting propensity, corrosion rate, and electrochemical parameters such as open circuit potential, corrosion potential, and corrosion current. Tests will be performed in accordance with ASTM G61-86, *Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, and Cobalt-Based Alloys*. The CPP measurements are done by measuring the current-voltage relationship between two electrodes that are immersed in an electrolytic solution. Information about the propensity for pitting corrosion to occur and corrosion rate can be determined from this current voltage relationship. As stated above, the electrolytic solution will be stimulated waste tank solutions. The electrodes will be an inert carbon electrode and a working electrode constructed out of carbon steel that best represents tank construction materials. The working electrode has a known surface area and is only used for one measurement. The CPP measurements incrementally increase the potential of the working electrode until a predefined maximum current is reached. After a maximum current is reached, the voltage is incrementally decreased and current response is measured.

   The propensity for corrosion in the electrochemical corrosion test is determined by the shape of the CPP curve and the critical potential. When the shape of the CPP curve indicates pitting corrosion and the critical potential is < 200 mV, the tank liner may be at risk for elevated corrosion rates by the chemistry of the simulated waste being tested.

2. Passive Coupon Testing/Weight Loss Coupon Testing: Three coupons will be immersed in simulated tank solutions and tested for time periods of 6, 12, and 18 months. The three coupons will be exposed in an environmentally sealed container in the vapor space, liquid phase and at the LAI. The coupons will give information on the corrosion attack for the given time periods and locations. Corrosion products formed on the coupons during testing will be removed after testing and the weight loss of the coupon determined. Additional information may be attained such as the type of corrosion that may occur (e.g. pitting).

   Corrosion for this test will be determined through the weight loss of the coupons over the time frames listed above. If the weight loss of the coupon translates to corrosion occurring at a rate >0.5 mils/year, then an unacceptable corrosion rate has occurred.

3. Stress Corrosion Cracking: Experiments to determine the susceptibility for stress corrosion cracking may be carried out using several techniques. The technique planned for this test is the slow strain rate testing performed according to ASTM G129-00, *Slow Strain Rate Testing to Evaluate the Susceptibility of Metallic Materials to Environmentally Assisted Cracking*. The data collected can be used to determine whether the simulants promote stress corrosion cracking.

   The coupons are visually examined to determine how the fractures form (through the metal grains or between the grains) in the stressed coupons.

4. Ammonia as a corrosion inhibitor: Ammonia gas (NH_3) and ammonium (NH_4^+) are continually generated by various processes in the tank. Radiolysis of nitrogen (N_2) and nitrogen containing compounds (e.g., nitrate) is one pathway in which this happens. Ammonia is also generated through nonradiochemical processes. An example is the degradation of nitrogen containing compounds such as ethylenediaminetetraacetic acid (EDTA), which was used as a chelating agent in the process chemistry. Ammonia is known to be an inhibitor of corrosion. Testing will be performed to determine if there is a threshold where corrosion is inhibited by ammonia and what the threshold is. This can then be considered in the chemistry control program where the amount of ammonia is monitored in conjunction with other control parameters.

   If a waste simulant fails one of the first three corrosion tests listed above, ammonia will be added to the waste simulant to determine if the expected quantity of ammonia in the waste layer represented by the waste simulant will sufficiently inhibit the corrosion. This will be accomplished by conducting the first three tests a second time. An appropriate amount of ammonia will be added to the simulants in the second set of tests.

4.2 QUALITY CONTROL

The quality assurance (QA) for the corrosion testing is controlled by ATS-MP-1015, *222-S Laboratory Facility Quality Assurance Program Plan for Industrial Hygiene Analyses*. In addition, all of the QA requirements in the ASTM documents listed above will be followed.

As mentioned above, test plan LAB-PLN-10-00001will be revised and any specific QA requirements or deviations from QA plan ATS-MP-1015 and the ASTM documents will be discussed in the test plan.

If actual tank waste data are required and sampling is required, additional QA requirements for sampling and analyses will be added to this DQO document.

5.0 STUDY BOUNDARIES

Step four in the DQO process defines the spatial and temporal boundaries for the required sampling and analyses needed to make the necessary decisions. The spatial boundaries define the physical area to which the decisions will apply and where the samples should be taken. The temporal boundaries describe the timeframe the data will represent, and when the samples should be taken. In addition, this portion of the DQO addresses any sampling constraints.

This DQO will be in effect until the corrosion testing on the waste simulants is completed and the decisions made from the results. The corrosion testing will be conducted at the 222-S Laboratory. The revision of test plan LAB-PLN-10-00001 will discuss any specific testing requirements and constraints.

If the decision to obtain data from actual tank waste is made, this DQO will be revised to address the timing of the sampling, location of the actual waste samples or corrosion probes, and any constraints on the actual waste data collection.

6.0 DECISION RULES

Step five of the DQO process includes development of decision rules, which define the actions to be taken as a result of exceeding an action limit. Decision rules are expressed as "if then" statements that incorporate, as available, the parameter of interest, the scale of decision making, the action limit, and the actions that would result from resolution of the decision rule. For this DQO, the decisions are not based on a comparison to direct action limits, but on a subjective examination of the total data set by subject matter experts (see Figure 3-1).

Figure 3-1 shows five decision points in the logic flow chart. However, the first three tests are considered one decision because if one test fails unacceptable corrosion will be considered to be occurring in the waste layer represented by the waste simulant. In addition, the last decision point, collecting and evaluating data from actual tank waste, is not presently covered by this DQO. Therefore, the two decision rules shown below address the problem statement and decision statement discussed in Section 2.0 and Section 3.0 respectively. The two decision rules are sequential.

1. If the weight loss of the test coupon translates to >0.5 mil/year of wall thickness, or the CPP test indicates pitting and the critical potential is <200 mV, or the slow strain rate test shows an indication of stress corrosion cracking, then continue the test with the addition of ammonia; otherwise, no action is required.

2. If a corrosivity problem is resolved by the addition of ammonia up to the calculated ammonia content of that waste layer, then no action is required; otherwise, plan for actual tank waste data collection.

If actual tank waste data collection is conducted, an additional decision rule will be added to cover the decision to be made from collecting and evaluating the actual tank data.

7.0 ERROR TOLERANCE

The purpose of Step Six of the DQO process is to specify quantitative performance criteria for the decision rules expressed as probability limits on potential errors in decision making. The probability limits on decision errors specify the level of confidence required in conclusions drawn from the data. If applicable, these decision performance criteria will be used in step seven of the DQO process to optimize the design for obtaining data, and generate a resource-effective sampling design. However, the data obtained under this DQO are not collected in a form that allows common error determination of the sample data. The actual data from the evaluation of the corrosion coupons will be translated to corrosion estimates and no additional statistical evaluations for uncertainty will be conducted.

For the electrochemical corrosion tests, the actual value of the readings (electrical resistance and voltage) will be used to evaluate the amount of corrosion occurring in the waste simulants. In the same way, the observed type of cracking and actual measured weight loss of the passive coupons will be used to evaluate the corrosion taking place in the waste simulants.

8.0 SAMPLING DESIGN

The purpose of step seven of the DQO process is to identify a resource-effective sampling design that generates data expected to satisfy the decision performance criteria, as specified in the preceding DQO Process steps. This step provides a general description of the activities necessary to obtain the data required to satisfy the decision performance criteria. The data collection for the corrosion tests are summarized below and will be governed by a test plan.

The electrochemical corrosion tests will be conducted according to ASTM G61-86. The measurements are obtained by measuring the current-voltage relationship between two electrodes that are immersed in the waste simulant. The electrodes will be an inert carbon electrode and a working electrode (coupon) constructed out of carbon steel that best represents tank construction materials. The measurements incrementally increase the potential of the working electrode until a predefined maximum current is reached. After a maximum current is reached, the voltage is incrementally decreased and current response is measured.

Data from the tests are collected continuously using a potentiostat that transmits the data to a computer. The computer programming provides information on open circuit potential, corrosion potential, and corrosion current. The shape of the curve from the current-voltage relationship and the critical potential is used to determine the propensity for corrosion.

Data from the passive coupon test is simply the difference in the weight from the time a coupon is inserted into the waste simulant and the time it is removed. Three coupons will be immersed in simulated tank solutions and tested for time periods of 6, 12, and 18 months. The three coupons will be exposed in an environmentally sealed container in the vapor space, liquid phase and at the LAI. After the coupons are removed the, corrosion products formed on the coupons during testing will be removed and the weight loss determined.

The stress corrosion cracking tests are conducted by stretching a coupon that is submerged in the waste simulant and will be conducted according to ASTM G129-00. The coupon is stretched at a uniform rate until failure is reached. The force is monitored to determine the quality of the test. However, the corrosion is determined through the visual examination of the cracks that form in the coupon (cracks forming through the metal grains or around the metal grains).

If the ammonia test is conducted, ammonia will be added in the amount expected in the simulated waste layer and the corrosion tests discussed above will be conducted again.

If it is determined that data from actual tank waste is required, this DQO document will be revised to address the new sampling requirements. The sampling design will address the tank waste samples or the requirements for the placement of corrosion probes in the tank waste.

9.0 REFERENCES

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

ASTM G129-00 2006 (Reapproved 2006). *Slow Strain Rate Testing to Evaluate the Susceptibility of Metallic materials to Environmentally Assisted Cracking*, American Society of Testing and Materials, West Conshohocken, Pennsylvania.

ATS-MP-1015, *222-S Laboratory Facility Quality Assurance Program Plan for Industrial Hygiene Analyses*, as revised, Washington River Protection Solutions LLC, Richland, Washington.

Ecology, EPA, and DOE, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA QA/G-4, 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, U.S. Environmental Protection Agency Quality Assurance Management Staff, Washington, D.C.

LAB-PLN-10-00001, 2010, *Test Plan for the Examination of Simulated Non-Compliant Waste from Hanford Single-Shell Tanks*, Rev. 0, Washington River Protection Solutions LLC, Richland, Washington.

OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*, as revised, Washington River Protection Solutions LLC, Richland, Washington.

RPP-PLAN-45082, 2010, *Implementation Plan for the Single-Shell Tank Integrity Project*, Rev 0, Washington River Protection Solutions LLC, Richland, Washington.

RPP-RPT-43116, 2009, *Expert Panel Report for Hanford Site Single-Shell Tank Integrity Project*, Rev. 0, Washington River Protection Solutions LLC, Richland, Washington.

TFC-ENG-CHEM-C-16, *Data Quality Objectives for Sampling and Analyses*, as revised, Washington River Protection Solutions LLC, Richland, Washington.