Double-Shell Tank Integrity Program – 15533

K.D. Boomer*, J.S. Garfield**, J.L. Castleberry*, D.G. Baide*, and J.M. Johnson***
*Washington River Protection Solutions LLC.
Richland, Washington 99352
**AEM Consulting LLC.
***U.S. Department of Energy, Office of River Protection

ABSTRACT

Waste at Hanford is stored in 149 single-shell tanks and 28 double-shell tanks (DSTs). Concerns related to aging radioactive waste storage facilities throughout the US DOE complex led to Brookhaven National Laboratory (BNL) developing guidelines for structural integrity programs for tank systems (BNL-52527, *Guidelines for Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks*). The committee of experts who developed these guidelines is commonly known as the Tank Structural Integrity Panel (TSIP). The US DOE has subsequently adopted these guidelines, and requires site operators to have a program consistent with them (DOE M 435.1, *Radioactive Waste Management Manual*).

The Washington River Protection Solutions, LLC (WRPS) manages the tanks for the US DOE Office of River Protection (ORP) under the Tank Operations Contract (TOC). The US DOE-ORP contractual agreement with the TOC (11-NSD-010) includes a requirement to “maintain the tank structural integrity program as described in RPP-7574, *Double-Shell tank Integrity Project Plan*”. The DST integrity is maintained with a variety of activities such as ultrasonic and visual inspections, chemistry controls, corrosion monitoring and structural analyses methods.

The recent loss of tank 241-AY-102 has led to the formation of the High-Level Waste Integrity Assessment Panel to evaluate the DST integrity project (DSTIP) and to recommend improvements to the DSTIP. This panel continues the DOE practice of seeking expert advice to guide the formulation and continuous assessment of tank integrity activities. The panel has concluded its work and WRPS has developed a series of tasks to implement their recommendations.

INTRODUCTION

The mission of the US DOE River Protection Project (RPP) is to store, retrieve, treat, and dispose of the highly radioactive waste stored in the Hanford Site tanks in an environmentally-sound, safe, and cost-effective manner. The waste is contained in 149 single-shell tanks (SSTs), 27 double-shell tanks (DSTs), and one DST that has leaked into the annulus between the primary and secondary liner. There is no indication that this leak has reached the environment. The DSTs are supported by ancillary systems and equipment, which allow the movement of the waste into, within, and out of the tank system. The 242-A Waste Evaporator facility, for the concentration of waste, is also a part of the Hanford Tank Farm waste processing and storage facilities.

The 28 DSTs were constructed between 1968 and 1986 in six tank farms. Their design improved structural integrity and accessibility for inspection. However, since the DSTs and ancillary equipment service is required to exceed their design life before the DST waste is removed and sent to the Waste Treatment and Immobilization Plant (WTP), means must be taken to ensure that the DST system can meet the RPP mission goals.

To ensure the structural and leak integrity of the DSTs, the DST Integrity Project (DSTIP) employs chemistry control to minimize the propensity for corrosion in the DSTs, inspects the tanks to detect degradation of the system integrity, and assesses structural integrity of the tanks. In addition, the project ensures inspection and maintenance of ancillary equipment along with periodic inspection of the 242-A Evaporator. Fig. I shows the overall scope of the DSTIP.

The DSTIP activities include the following principal elements:

- DST integrity assessments: (e.g., ultrasonic and video examinations) and documentation of results for use in periodic re-inspections.
- DST corrosion control: sampling and adjustments for corrosion mitigation, optimization studies to quantify the best waste chemistry parameters to minimize corrosion, and development and installation of in-tank corrosion probes for DSTs with new or revised corrosion control limits.
- DST structural analysis and studies for thermal, operating, and seismic loads.
- Periodic testing, evaluation, and certification of DST ancillary equipment and waste transfer piping (valve pits, transfer piping, etc.), which support the operation of the DST system.
- Periodic testing and certification of the 242-A Evaporator Facility.

In fiscal year (FY) 2006, the DSTIP completed the field work and documented the integrity assessment of the DSTs and ancillary equipment as Hanford Federal Facility Agreement and Consent Order Milestone 48-14. An Independent Qualified Registered Professional Engineer (IQRPE) certified this assessment and provided recommendations for future integrity work [1]. The second such assessment is due in FY 2016.

As a comprehensive program to ensure the continued viability of the DSTs to support the Hanford mission, the DSTIP activities also include facilitating Expert Panel workshops on all technical aspects of DST use and life extension, providing guidance for modeling of DST waste and operational characteristics. To ensure continued improvement of the technical bases, the DSTIP receives programmatic steering and advice from an Expert Panel Oversight Committee.

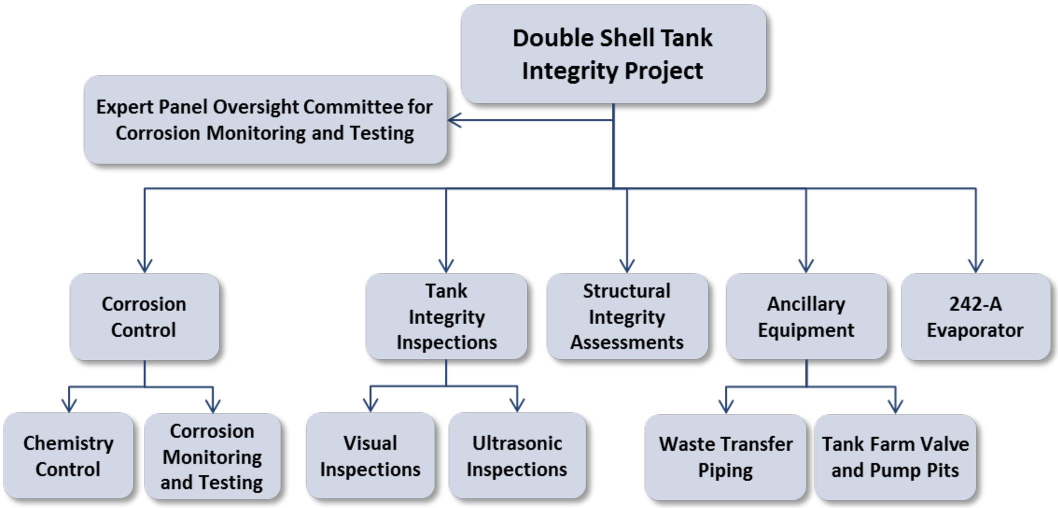


Fig. I. Double-Shell Tank Integrity Project Plan Scope

The Double-Shell Tank System

The US DOE constructed 28 DSTs of which 27 tanks have maintained their integrity. Tank 241-AY-102 (AY-102) has leaked for the primary tank into the floor of the secondary liner and as such isn’t fit for use. The US DOE is conducting operations to recover the waste from tank AY-102 and transfer it to DSTs. The 27 DSTs are supported by ancillary equipment (e.g., transfer piping, valve pits), which allow the movement of the waste into, within, and out of the tank system. The DST System also includes the 242-A Evaporator which removes water from the waste.

The need for additional tank space and the need to support an increased radionuclide heat load led to a decision by the U.S. Atomic Energy Commission (predecessor to the U.S. Energy Research and Development Administration, and subsequently the DOE) in the 1960s to initiate construction of DSTs with improved design, materials, and construction. The construction of the DSTs began in 1968 with the sixth farm being completed in 1986. All of the DSTs have a nominal million-gallon waste capacity, with design lives ranging from 20 to 50 years.

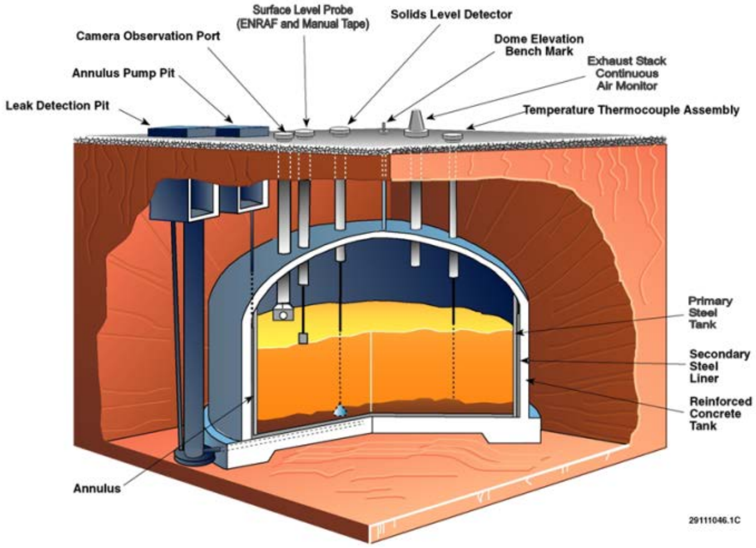


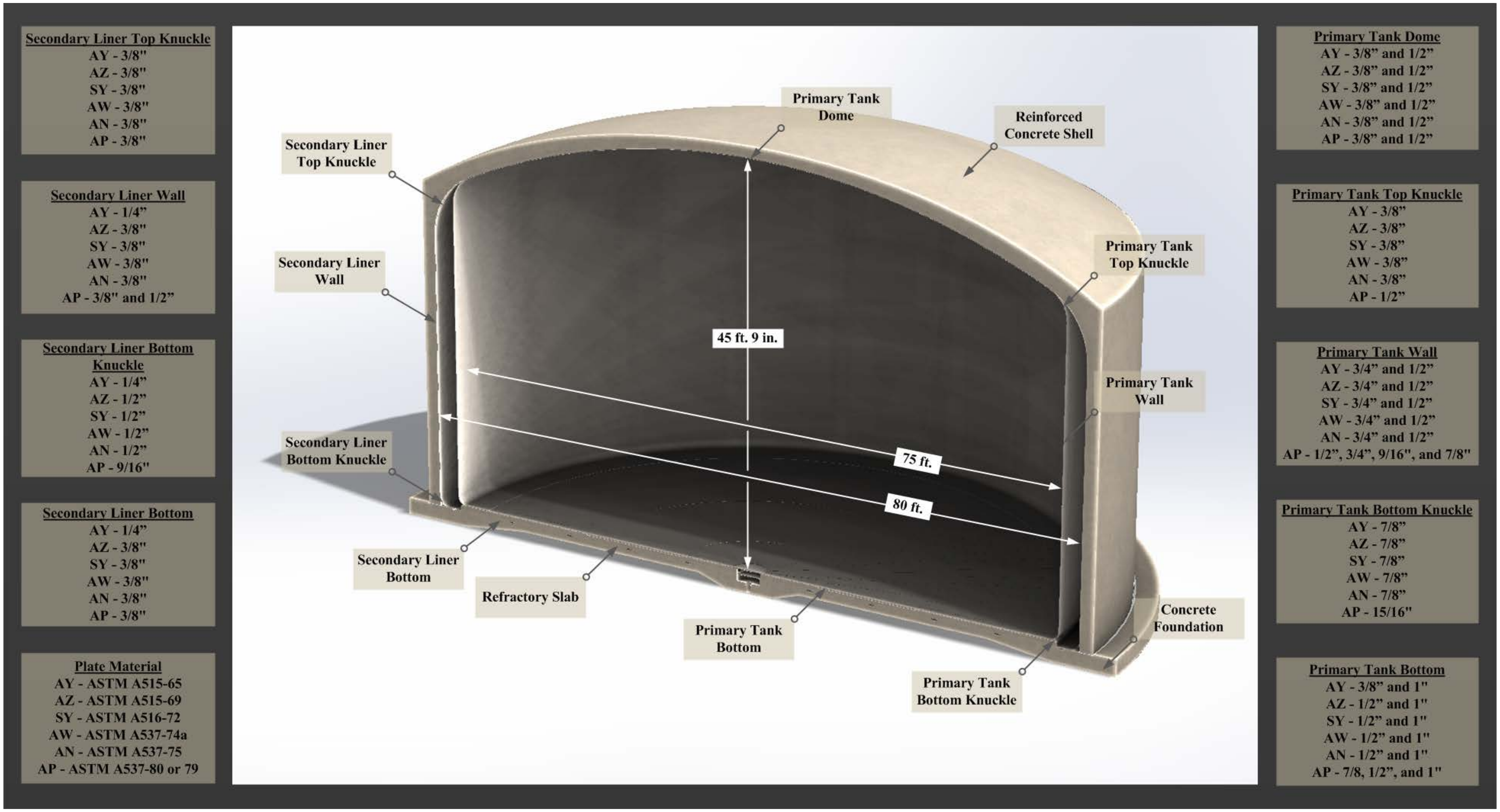
Fig. II. Double-Shell Tank Elements

DSTs consist of a primary steel tank inside of a secondary steel liner, which are made to same carbon steel specification in each tank farm (e.g., American Society of Mechanical Engineers A-515, A-516, or A-537). The secondary steel liner is encased by a reinforced concrete shell. The primary tank rests on a refractory concrete slab, used to thermally insulate it from the secondary liner and concrete foundation during post-weld heat treatment, which reduced residual stresses from fabrication and the propensity for SCC failures. The refractory slab also provides air circulation/leak detection channels under the primary tank bottom plate. An annular space of 76.2 cm (2-1/2 ft), exists between the secondary liners and primary tanks, allowing for visual examination of the tank wall and secondary liner annulus surfaces. The annular space also allows for visual surface and ultrasonic volumetric inspections of the primary tank walls and secondary liners. See Fig. II and Fig. III for the typical configuration of the DSTs.

The DSTs design allows the detection of any potential leaks from the primary tank. Leaking waste would be held in the secondary containment, allowing for corrective action long before there could be any release of waste to the environment. Table I covers the construction dates, year of initial service, and the expected design life at time of construction.

Table I. Double-Shell Tank Construction and Age as of 2015.

Tank Farm	Number of Tanks	Construction Period	Construction Project	Initial Operation	Design Life	Current Age
241-AY	2	1968 – 1970	IAP-614	1971	40	44
241-AZ	2	1970 – 1974	HAP-647	1976	20	39
241-SY	3	1974 – 1976	B-101	1977	50	38
241-AW	6	1976 – 1979	B-120	1980	50	35
241-AN	7	1977 – 1980	B-130, B-170	1981	50	34
241-AP	8	1982 – 1986	B-340	1986	50	29
Total	28					



Secondary Liner Top Knuckle
AY - 3/8"
AZ - 3/8"
SY - 3/8"
AW - 3/8"
AN - 3/8"
AP - 3/8"

Secondary Liner Wall
AY - 1/4”
AZ - 3/8"
SY - 3/8"
AW - 3/8"
AN - 3/8"
AP - 3/8" and 1/2”

Secondary Liner Bottom Knuckle
AY - 1/4”
AZ - 1/2”
SY - 1/2”
AW - 1/2”
AN - 1/2”
AP - 9/16"

Secondary Liner Bottom
AY - 1/4”
AZ - 3/8"
SY - 3/8"
AW - 3/8"
AN - 3/8"
AP - 3/8"

Plate Material
AY - ASTM A515-65
AZ - ASTM A515-69
SY - ASTM A516-72
AW - ASTM A537-74a
AN - ASTM A537-75
AP - ASTM A537-80 or 79

Primary Tank Dome
AY - 3/8” and 1/2”
AZ - 3/8” and 1/2”
SY - 3/8” and 1/2”
AW - 3/8” and 1/2”
AN - 3/8” and 1/2”
AP - 3/8” and 1/2”

Primary Tank Top Knuckle
AY - 3/8”
AZ - 3/8”
SY - 3/8”
AW - 3/8”
AN - 3/8”
AP - 1/2”

Primary Tank Wall
AY - 3/4” and 1/2”
AZ - 3/4” and 1/2”
SY - 3/4” and 1/2”
AW - 3/4” and 1/2”
AN - 3/4” and 1/2”
AP - 1/2”, 3/4”, 9/16", and 7/8"

Primary Tank Bottom Knuckle
AY - 7/8”
AZ - 7/8”
SY - 7/8”
AW - 7/8”
AN - 7/8”
AP - 15/16"

Primary Tank Bottom
AY - 3/8” and 1"
AZ - 1/2” and 1"
SY - 1/2” and 1"
AW - 1/2” and 1"
AN - 1/2” and 1"
AP - 7/8, 1/2”, and 1"

Fig. III. Double-Shell Tank Configuration

DOUBLE-SHELL TANK INTEGRITY PROJECT STRATEGY

The DSTs, each with a nominal capacity of one million gallons, are the primary assets of the DST System. While the other elements of the system are required for operation, the loss of DST space has a significant effect on the ability to meet mission requirements. As such, the DSTIP focuses on ensuring the integrity of the 27 DSTs. This relationship was recently demonstrated by the recovery act project to replace eight transfer lines in the 241-SY tank farm for $16 million, which is considerably less than the cost of a new tank.

To ensure the structural and leak integrity of the DSTs, the DSTIP employs chemistry control to minimize the propensity for corrosion in the DSTs, inspects the tanks to detect degradation of the system integrity, and assesses structural integrity of the tanks. In addition, the project ensures inspection and maintenance of ancillary equipment along with periodic inspection of the 242-A Evaporator.

During DST design and construction, steps taken to prevent SCC included material selection, tank wall thickness, and post-weld heat treatment. Hanford personnel selected higher strength steels to build the DSTs as compared to that used for SST construction. The thicknesses of the primary tank walls were increased over the steel plate used in previous construction, to minimize operational stresses. To reduce residual weld stresses from construction [e.g., stresses in the heat-affected zone (HAZ)], the tanks were post-weld heat treated up to 593 °C (1100 F).

The chemistry control requires that favorable ratios between inhibiting compounds and aggressive species be maintained. The DSTIP has developed chemistry controls for waste in the DSTs to limit the propensity for corrosion to occur. In addition to this chemistry control program, the DSTIP conducts nondestructive examination (NDE) of the primary tanks and the secondary liners with Ultrasonic Testing (UT) and visual inspections to detect corrosion that may be occurring.

In addition to this baseline set of programs, the DSTIP is performing chemistry optimization testing, along with corrosion monitoring, to fully understand and improve corrosion mitigation in the DSTs. Chemistry optimization studies have built on years of testing at Savannah River and Hanford to further identify the chemical composition ranges that minimize the propensity for localized corrosion. In-tank corrosion monitoring looks for indications of incipient corrosion from in-tank sensors and provides for data correlation between laboratory testing parameters and actual tank chemistry environments.

Concerns related to aging radioactive waste storage facilities throughout the DOE complex led to Brookhaven National Laboratory (BNL) developing guidelines for structural integrity programs for tank systems [2]. The committee of experts who developed these guidelines is commonly known as the Tank Structural Integrity Panel (TSIP). The DOE has subsequently adopted these guidelines, and requires site operators to have a program consistent with them [3]. The DOE-ORP contractual agreement with the TOC includes a requirement to “maintain the tank structural integrity program as described in RPP-7574” [4].

Structural integrity is defined in the TSIP guidelines as including leak tightness (barriers to release of waste) and structural adequacy (strength against collapse or failure from normal and abnormal loads). The TSIP guidelines advocate a systematic ongoing approach to assessing structural integrity as a basis for identifying necessary management options to ensure leak tightness and structural adequacy over the life of the mission.

The assessment of the DST system was completed in March 2006 [1]. In conducting this evaluation, the IQRPE reviewed the DSTIP documentation pertaining to DST integrity and prepared several supplemental reports to document this evaluation. The IQRPE made a total of 78 recommendations upon completion of the 2006 DST assessment. Document RPP-RPT-50440, *2006 Double-Shell Tank Integrity Assessment Recommendation Dispositions,* is a compilation of the actions taken to close the 78 recommendations [5]. Most of the actions were completed and the recommendations closed. However, 15 of the closed recommendations have follow-up activities [5].

Over the course of the DSTIP, advice and direction has been sought from numerous panels of outside experts brought in to review the various aspects of DST integrity and operations. These panels date back to the BNL panel on seismic analysis for HLW tanks. Ongoing work is focused on the bottom three items. The Expert Panel Oversight Committee (EPOC) is guiding work on chemistry optimization and vapor space corrosion.

Double-Shell Tanks Aging Mechanisms

Numerous methods of degradation can reduce the integrity of carbon steel and concrete structures. For the primary tank and secondary liners, the three primary types of degradation that can occur are the following:

- Thinning of the walls by general corrosion that could lead to structural failure
- Pitting of the walls that could lead to through-wall leaks
- Stress corrosion cracking that could lead to through-wall leaks
- Liquid-air interface (LAI) corrosion that could lead to accelerated thinning and pitting of the tank wall at an existing or previous waste surface

The TSIP guidelines identify a number of aging mechanisms that have the potential to cause degradation in tank systems. Their significance depends on tank specific conditions and plausible failure modes. The TSIP guidelines recommend that “in order to produce a realistic and cost-effective program” only those aging mechanisms that would be expected to cause significant degradation for the tank specific conditions and that affect the likely failure modes should be included in the tank structural integrity evaluation.

The DST life extension panel indicated that localized pitting and concentration cell corrosion caused by the formation of localized regions of aggressive waste are the most threatening degradation mechanisms for the DST primary tanks [6].

DOUBLE-SHELL TANK INTEGRITY INSPECTIONS

In addition to the daily monitoring of the leak tightness of the DSTs, the DSTIP inspects the DSTs visually to examine the surface of the tanks and with UT to examine volume of metal. The

DSTIP has also continued the development of NDE techniques such as Tandem Synthetic Aperture Focusing Technique and Electromagnetic Acoustic Transducer.

Leak Tightness

The DST liquid levels in the primary tank are monitored daily using ENRAF[1] Nonius Series 854 surface level gauges. Leak detection probes in the DST annuli are routinely monitored. The primary tank surface level Enraf and the three annulus leak detection on ENRAFs make up the Ecology-approved leak system.

Visual Examination

The DSTs are examined visually for conditions indicating structural and leak integrity deterioration both inside the primary tank (above the waste level) and on the annulus surfaces of the primary tank and secondary liner, using remote video equipment. Visual examinations will be performed every three years. Visual examinations of selected regions will be performed when ultrasonic testing of the primary tank walls identifies conditions or indications requiring additional assessments.

The Extent of Condition evaluation recommended increased annulus visual inspection frequencies for all twenty-eight DSTs, varying from annually to once every three years, following completion of a ≥ 95% inspection of the viewable area in the annulus [7]. The frequency depends on the extent of similarity between the tanks construction and operating histories and those of tank AY-102.

Ultrasonic Testing Examination of Double-Shell Tank Primary Tank Sidewalls

The DSTIP uses ultrasonic testing (UT) with remote robotic crawlers to examine the DST primary tank sidewalls for thinning, pitting, and cracking. This type of inspection provides a volumetric examination of the metal examined. The TSIP guidelines criteria for thinning, pitting, and cracking, and DSTIP reporting criteria are provided in Table II.

The examinations are performed using a crawler that holds the transducers to conduct the examination. The crawler is a remotely controlled device and delivers the ultrasonic transducers to the tank walls. The crawler used during most Pulse-echo ultrasonic inspection (P-scan) imaging is shown below in Fig. IV. The traveling bridge on the crawler can be outfitted with various ultrasonic transducer configurations. The crawler system is deployed through a 24-inch annulus inspection riser using customized deployment tools. Water is used as the couplant (to maintain contact between the transducer and metal) and it is continuously fed to all transducers at a rate needed to maintain an acceptable signal.

---

[1] ENRAF is a trademark of Honeywell International Inc., Morristown, New Jersey

Table II. Ultrasonic Testing Evaluation Guidelines and Reportable Values.

Parameter	TSP Acceptance Criteria	DSTIP Reportable Value
Thinning	20% thickness	10 % thickness
Pitting	50% thickness	25% thickness
Cracking	> 30.5 cm (12 in.) 20% of thickness ≤ 30.5 cm 12 in.) 50% of thickness	Any Linear Indication greater than 15.2 (6 in.) in length and .25 cm (0.1 in.) in depth.

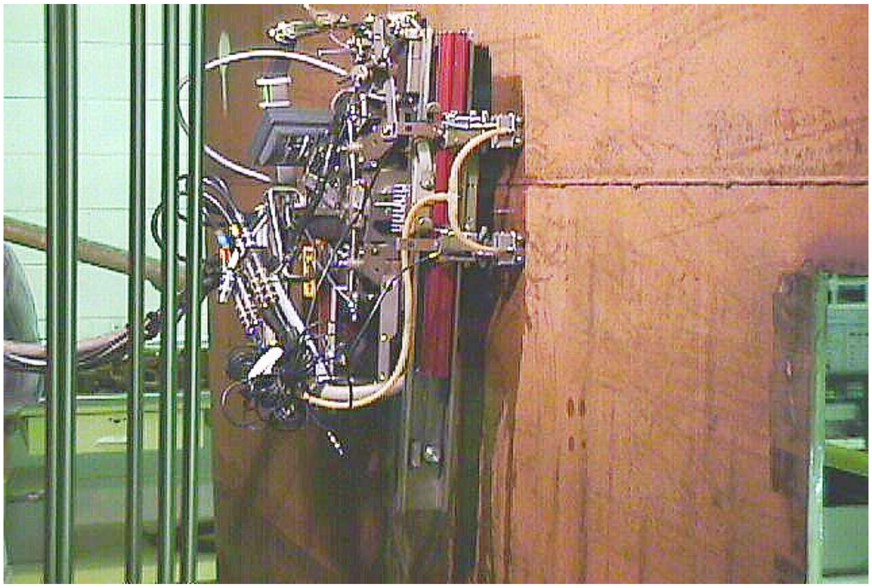


Fig. IV. P-scan Crawler System on Tank Mock-up.

DOUBLE-SHELL TANK WASTE CHEMISTRY CORROSION CONTROL

The *Tank Farms Waste Transfer Compatibility Program* [8] is a safety program that provides a formal process for evaluating waste transfers and chemical additions through the preparation of documented Waste Compatibility Assessments (WCA). The primary purpose of the program is to ensure that sufficient controls are in place to prevent the formation of incompatible mixtures as the result of waste transfer operations. The program defines a consistent means of evaluating compliance with Administrative Controls, safety, operational, regulatory and programmatic criteria and specifies considerations necessary to assess waste transfers and chemical additions.

The *Operating Specifications for the Double-Shell Tanks* [9] requires that the waste be maintained within specification for hydroxide and nitrite concentration for a given nitrate ion concentration. The management of tank chemistry for corrosion is shown in Fig. V.

Chemical changes can occur during waste storage. Hydroxide concentrations in tank waste are affected by ongoing chemical reactions with organics in the waste and carbon dioxide in the vapor space. These reactions generally deplete the free hydroxide concentration with time. Reaction rates for these hydroxide consumption mechanisms increase with increasing temperature. Hydroxide depletion caused by reaction with carbon dioxide is generally more pronounced near the waste surface. Double-shell tank chemistry controls are specified in terms of limits on nitrate, nitrite, and hydroxide concentrations [9].

The chemistry control limits are determined from testing conducted to investigate stress corrosion cracking (SCC), pitting, and vapor space corrosion (VSC). Work during FY 2010 and 2011 focused primarily on the influence of organics, the nature of liquid-air interface (LAI) corrosion, SCC, and pitting propensity at temperatures below 50°C. Although there may be some risk for pitting in these mixed tank environments, results do not imply that these mixed chemistries pose any significant threat for SCC except at low pH (11.0), high temperature (60°C), high plastic strain, and high potential (0 mV vs. SCE). These conditions are unlikely to develop during normal DST operations.

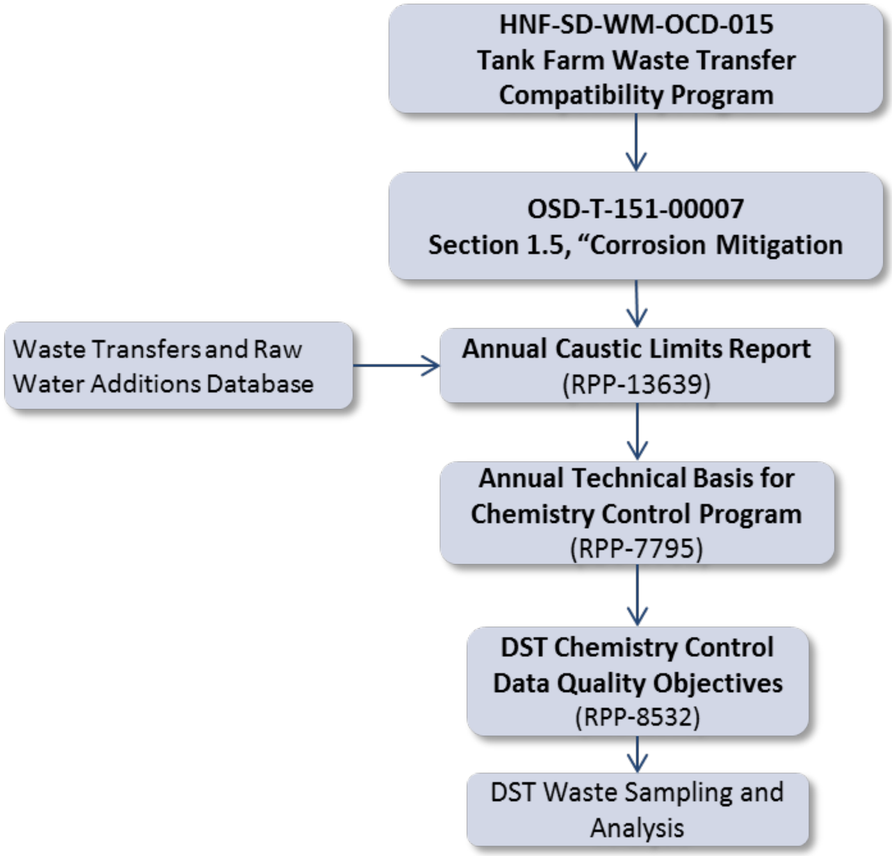


Fig. V. Corrosion Mitigation Logic Diagram

Corrosion Monitoring in Double-Shell Tanks

In 1996, under a Department of Energy technology initiative, the TOC launched an effort to improve the Hanford DST corrosion monitoring program. Proof-of-principle testing conducted at Oak Ridge National Laboratory and Pacific Northwest National Laboratory for the initial corrosion monitoring systems developed under this program [10]. A 3-channel prototype corrosion probe was designed, constructed and deployed in tank 241-AZ-101 in August 1996 based on these studies.

Six similar corrosion monitoring systems were installed in Hanford DSTs over the next ten years. These systems were first of a kind instruments that implemented the Electrochemical Noise (EN) and Linear Polarization Resistance (LPR) techniques to monitor the onset of SCC and pitting (should they occur) and uniform corrosion rate in real time in the DSTs. These systems proved to be difficult to maintain and operate on a long term basis. None of these original systems are still in service.

In 2007, the design and purpose of the DST corrosion monitoring systems were revised to improve reliability and data quality. The resulting design, known as the Multi-Probe Corrosion Monitoring System (MPCMS), shifted focus away from collecting in-situ, real-time corrosion data, to facilitating the periodic collection of corrosion potential, corrosion rate [via Electrical Resistance (ER) sensors], and coupon weight-loss data. The MPCMS uses a long fixed probe to locate electrodes and coupons at various elevations in the DST. The fixed probe also contains removable coupon racks that can be pulled for analysis without removing the fixed probe.

The first MPCMS was installed in tank 241-AN-107 in 2006. Five additional systems of similar design were installed by the end of 2010. Each MPCMS contains a variety of primary reference electrodes [e.g., Saturated Calomel Electrodes (SCEs), Silver/Silver-Chloride (Ag/AgCl) electrodes, Copper/Copper-Sulfate (Cu/$CuSO_4$) electrodes, etc.] for use in making corrosion potential measurements. Each MPCMS also contains ER sensors in each waste layer in the tank. All six of the MPCMSs are still in operation.

The MPCMS design has proven to be expensive to fabricate and install and, more importantly, does not facilitate troubleshooting, repair, or replacement of in-tank components in the event of failure. In response to these challenges, a new corrosion monitoring system design, known as the Retractable Corrosion Monitoring Probe (RCMP) was developed in 2012.

The mechanical design of the RCMP is significantly different than all previous DST corrosion monitoring systems, using a cable reel and retractable replaceable probe head instead of a long fixed probe to position a set of reference electrodes at various elevations in the tank. The first RCMP was installed in Tank 241-AW-105 in August, 2013 and in 241-SY-101 in August, 2014.

The RCMP is designed to be installed only in the supernatant (or possibly into the top of the sludge layer) in the tank. The RCMP probe head is not heavy enough to penetrate a substantial distance into the sludge. However, work by the EPOC has demonstrated that it is possible to measure DST corrosion potential from any elevation within the waste, making it unnecessary for the probe head to penetrate into the sludge.

Waste Corrosion Potential Measurement

In FY 2002, a laboratory procedure was developed to perform consistent electrochemical corrosion testing on DST waste obtained from core samples. The test procedure is designed to evaluate the corrosion potential of the carbon steel wall in the knuckle-region of the DST where the sludge is in contact with the wall. Sample collection, sample extrusion, and the electrochemical corrosion testing are performed while maintaining the waste under anaerobic conditions like those found in the bottom of the tank. The tests are used to determine corrosion rates and assess whether carbon steel similar to that used in the DST construction is susceptible to aggressive corrosion mechanisms when in contact with the waste under tank storage conditions. Cyclic potentiodynamic polarization (CPP) measurements can be performed to evaluate the propensity of the steel undergoing pitting in the waste environment.

Vapor Space Corrosion

Concern for DST vapor space corrosion (VSC) arose from notable VSC in some Savannah River Site tanks and some apparent VSC tank wall thinning at Hanford. An Expert Panel workshop was held in July of 2006 to discuss VSC and LAI corrosion of DSTs at the Hanford and Savannah River Sites [11]. The recommended approach to the investigation of the phenomenon started with a literature search followed by thermodynamic modeling of species present in the vapor that deposit on the tank surface.

As such, a VSC program is underway to:

a. Identify vapor components that are likely to be the main concern in causing or contributing to VSC (e.g., ammonium nitrate) and those that may inhibit such corrosion (e.g., ammonia)
b. Explore the effects of waste chemistry changes (e.g., pH) on VSC and/or derive experimental or analytical methods to analyze the importance to VSC
c. Explore any methods and approaches that might allow accelerated laboratory testing for VSC and LAI corrosion, such as is presently being accomplished for waste chemistry testing by slow strain rate tests (e.g., effect of present and changed tank waste chemistry)

DOUBLE-SHELL TANK STRUCTURAL ANALYSIS

The established basis and protocol for the DST Dome Survey Program is documented in RPP-25782 [12]. The goal of this program is to monitor the elevation of the tank and tank dome deflection to determine if settlement or if excess deflection of the tank dome is occurring. All survey data should be reviewed by the responsible engineer and evaluated for tank settlement and dome deflection. Measurable deflections greater than 0.02-ft. (¼ inch) are investigated. Tank dome deflection of up to approximately ½ inch is within acceptable dome load limits [13].

MONITORING OF DOUBLE-SHELL TANK ANCILLARY EQUIPMENT AND WASTE TRANSFER SYSTEM

The DST waste transfer system (WTS) conveys waste between the tanks and process facilities. All waste transfer lines are designed with a secondary containment system capable of detecting and collecting releases and accumulated liquids in the event of a primary line failure. Included in the waste transfer system are pump pits, valve pits, pumps, jumpers, valves, actuators, piping, and hose-in-hose transfer lines.

A typical central pump pit consists of a waste transfer pump, a jumper connecting the pump discharge to the pit wall nozzles, a drain, and leak detection. The valve pits consist of multiple jumpers, a drain, and leak detection. The waste transfer pumps in the DST system are most commonly vertical turbine pumps with rigid intake; however, there are some submersible pumps. The valve pits must be cleaned and have their coatings re-inspected by a qualified National Association of Corrosion Engineers (NACE) coating inspector at the following periodicities for the pits [1].

Deployment of a Fitness-For-Service (FFS) strategy for the WTS has resulted in a variety of activities to monitor failure mechanisms [14]. That body of work defines a basis for service life, which will be documented in the *Tank Farm Waste Transfer System Fitness-for-Service Erosion and Corrosion Bases* [15].

242-A EVAPORATOR

Materials used for the 242-A Evaporator components and piping includes austenitic stainless steels (ASTM A240, Type 304L) and low alloy carbon steels (primarily ASTM A53 and A106). Austenitic stainless steels are subject to pitting in the presence of chloride ions, especially at low pH. Pitting corrosion was concluded to be unlikely because of the high pH, dynamic operation, and low chloride concentrations [16].

FUTURE WORK

In October 2012, Washington River Protection Solutions, LLC (WRPS) determined that the primary tank of AY-102 was leaking. WRPS contracted a panel of experts from industry and academia (High-Level Waste Integrity Assessment Panel, HIAP) to provide advice and recommendations for the DSTIP.

The HIAP reviewed the DST integrity issues in two meetings with an emphasis on corrosion and degradation mechanisms. The initial meeting was in September 2013 and discussed the tank AY-102 leak assessment. The second meeting was in April 2014 and discussed the extent of condition reviews from the leak assessment along with an overall program review. At both meetings, HIAP focused on three concerns:

- No Early warning – Determine why the existing DSTIP did not predict a primary tank failure or provide early warning of the pending failure.
- Program improvements – Recommend activities to either predict a primary tank failure or increase the probability of early warning.
- Forensic recommendations – The board is planning to provide additional recommendations regarding forensic assessment of tank AY-102 to facilitate a conclusion on why the leak occurred.

The HIAP comments have been documented in the *Second Workshop of the High Level Waste Integrity Assessment Panel: Extent of Condition and Balance of Program* which emphasized investigation of the bottom plate of the primary tank [17]. WRPS has prepared a response to the HIAP concerns coupled with recommendations for project action to strengthen in the DSTIP in the *Double-Shell Tank Integrity Improvement Plan* [18]. The purpose of this DST Integrity Improvement Plan is to translate the HIAP recommendations to specific project activities that are technically and practically responsive.

CONCLUSION

The DOE has developed a robust DSTIP over the past two decades. Guided by nationally and internationally recognized experts the project continues to seek improvements in its integrity activities and technology. The recent leak from AY-102 has led to a set of new recommendations to improve tank integrity that ORP and WRPS are pursuing.

REFERENCES

1. Brown, M. H. (2008). RPP-28538, *Volume 1: IQRPE Double-Shell Tank System Integrity Assessment, HFFACO M-48-14*, Rev. 5, Washington River Protection Solutions LLC., Richland, Washington.
2. Bandyopadhyay et al. (1997). BNL-52527, *Guidelines for Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks*, Brookhaven National Laboratory, Upton, New York.
3. Letourneau, M. 1999. DOE M 435.1, *Radioactive Waste Management Manual*, U.S. Department of Energy.
4. Boomer et al. (2010). RPP-7574, *Double-Shell Tank Integrity Program Plan*, Rev. 3, Washington River Protection Solutions LLC, Richland, Washington.
5. Gunter, J. (2013). RPP-RPT-50440, *2006 Double-Shell Tank Integrity Assessment Recommendation Dispositions*, Rev. 1, Washington River Protection Solutions LLC., Richland, Washington.
6. Bush et al. (2001). PNNL-13571, *Expert Panel Recommendations for Hanford Double-Shell Tank Life Extension*, Pacific Northwest National Laboratory, Richland, Washington.
7. Washenfelder, D. J. (2012). WRPS-1204931, *Double-Shell Tank 241-AY-102 Primary Tank Leak Extent of Condition Evaluation and Recommended Annulus Visual Inspection Intervals*, Washington River Protection Solutions LLC, Richland, Washington.
8. Uytioco, E. M. (2014). HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*, Rev. 37, Washington River Protection Solutions LLC, Richland, Washington.
9. Rast, R. (2013). OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*, Washington River Protection Solutions LLC, Richland, Washington.
10. Edgemon, G.L. (1996). WHC-SD-WM-TI-772, *Technical Basis for Electrochemical Noise Based Corrosion Monitoring of Underground Nuclear Waste Storage Tanks*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
11. Terry et al. (2006). RPP-RPT-31129, *Expert Panel Workshop on Double-Shell Tank Vapor Space Corrosion Testing*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
12. Mackey, T. C. (2007). RPP-25782, *DST Dome Survey Program*, Rev. 0A, CH2M HILL Hanford Group, Inc., Richland, Washington.
13. Jensen, C. E. (2005). RPP-RPT-25608, *Hanford Double-Shell Tank Thermal and Seismic Project—Increased Concentrated Load Analysis*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
14. Engeman J. K. and Garfield, J.S. (2014). RPP-PLAN-52788, *Waste Transfer System Fitness-for-Service Implementation Plan*, Rev. 0, Washington River Protection Solutions LLC, Richland, Washington.
15. Engeman, J. K. (To be issued). RPP-RPT-52791, *Tank Farm Waste Transfer System Fitness-for-Service Erosion and Corrosion Bases*, Washington River Protection Solutions LLC, Richland, Washington.
16. Oliver, T. J. (2008). RPP-RPT-33306, *IQRPE Integrity Assessment Report for the 242-A Evaporator Tank System*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

17. Martin, T. M. (2014). RPP-ASMT-57582, *Second Workshop of the High Level Waste Integrity Assessment Panel: Extent of Condition and Balance of Program,* Washington River Protection Solutions LLC, Richland, Washington.
18. Garfield et al. (2014). RPP-PLAN-57352, *Double-Shell Tank Integrity Improvement Plan,* Rev. 0, Washington River Protection Solutions LLC, Richland, Washington.