# Visual Inspection Plan for Single-Shell Tanks and Double-Shell Tanks

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- **Yes**
- **No**

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  - **No**

## Description of Change and Justification

Added SST visual inspection information to section 3.4

## Approvals

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- **Official Use Only Exemption 4-Commercial/Proprietary (OUO-4)**
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- **Export Control Information (ECI)**
- **Official Use Only Exemption 6-Personal Privacy (OUO-6)**
- **Official Use Only Exemption 2-Circumvention of Statute (OUO-2)**
- **Official Use Only Exemption 7-Law Enforcement (OUO-7)**
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Visual Inspection Plan for Single-Shell Tanks and Double-Shell Tanks

J.K. Engeman

Washington River Protection Solutions, LLC.
Richland, WA 99352
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EDT/ECN: NA  UC: N/A
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Abstract: This inspection plan identifies the DST and SST remote visual inspection activities including the frequency, evaluation factors, equipment to be used, and record requirements.

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Approved For Public Release
## Visual Inspection Plan for Single-Shell Tanks and Double-Shell Tanks

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- **(5) Author (print/sign/date):** J.K. Engeman
- **(6) Resp. Mgr. (print/sign/date):** J.L. Castleberry
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Sent: Wednesday, March 18, 2015 9:45 AM  
To: Lawrence, Hugh K  
Subject: review

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Please review the attached doc.

Thanks,

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Visual Inspection Plan for Single-Shell Tanks and Double-Shell Tanks

J.K. Engeman
Washington River Protection Solution, LLC

Date Published
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Prepared for the U.S. Department of Energy
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EXECUTIVE SUMMARY

The mission of the River Protection Project (RPP) is to store, retrieve, treat, and dispose of the highly radioactive waste stored in the Hanford Site underground waste storage tanks in an environmentally-sound, safe, and cost-effective manner. The waste is contained in 149 single-shell tanks (SST) and 28 double-shell tanks (DST).

The SSTs, located in 12 tank farms, were constructed from 1943 and 1964. The SST Integrity Project was created to monitor and maintain the integrity of the SSTs. A panel of subject matter experts was established to gain a better understanding of the current structural integrity of the SSTs. The recommendations of the Single-Shell Tank Integrity Expert Panel are presented in RPP-RPT-45921, Single-Shell Tank Integrity Expert Panel Report. One of the recommendations was to perform a one-time visual inspection of all the SSTs to identify cracks in excess of 0.0625-in, staining, and rust on the tank dome, specifically in the curved haunch and top center sections of the tank dome.

The 28 DSTs, located in six tank farms, were constructed from 1968 to 1986. The primary tank within a secondary steel liner design of the DSTs provides improved protection from leakage and better accessibility for inspection. However, since the DSTs are expected to exceed their design life before the DST waste is removed and sent to the Waste Treatment and Immobilization Plant, the DST Integrity Project was tasked with ensuring that the DST system can meet the RPP mission goals.

Remote visual inspection is currently used to perform qualitative in-service inspections. These inspections provide a general overview of the condition of the tank. Remote inspection equipment is used for the in-tank SST inspections and the DST primary tank and annulus inspections. The DST inspections primarily focus on the condition of the tank steel and any noticeable signs of active aging mechanisms. The focus of the SST inspections is on the steel liner, any noticeable signs of historical aging mechanisms in the tank, the reinforced concrete dome, and the presence of cracking, rust stains, and spalling. The verification of concrete integrity through the use of visual inspection equipment can provide further confidence that the SST concrete domes are sound.

This inspection plan identifies the DST and SST remote visual inspection activities, including the frequency, evaluation factors, equipment to be used, and record requirements. This information serves as a guide for the inspection activities and assists with identifying the resources needed for the integrity projects. These activities are described in integrity project plans.

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<td>DST</td>
<td>double-shell tank</td>
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<td>LAI</td>
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<td>gal</td>
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<td>in.</td>
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<td>Mgal</td>
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1.0 INTRODUCTION

The mission of the River Protection Project (RPP) is to store, retrieve, treat, and dispose of the highly radioactive waste in Hanford Site underground waste storage tanks in an environmentally sound, safe, and cost-effective manner. Accomplishing the RPP mission requires Washington River Protection Solutions, LLC (WRPS), the Tank Operations Contractor, to provide and maintain adequate tank capacity for waste storage and waste feed delivery to the Waste Treatment and Immobilization Plant (WTP). The use of visual inspections of waste storage tank interiors and annulus space provides a qualitative indication of aging mechanisms present in the single-shell tanks (SST) and double-shell tanks (DST).
2.0 BACKGROUND

Hanford radioactive waste is currently stored in 149 SSTs and 28 DSTs. These tanks are supported by ancillary equipment (e.g., transfer piping, valve pits, and one catch tank) that enables the movement of the waste into, within, and out of the tank system. The SSTs were built in 12 farms between 1943 and 1964 and were designed to hold between 50,000 gal and 1 Mgal of waste.

Stress corrosion cracking (SCC) of the SST carbon steel liners was one of the factors causing the leakage of waste from the SSTs to the surrounding soil. This leakage led to a decision by the U.S. Atomic Energy Commission (predecessor to the U.S. Energy Research and Development Administration, and subsequently the U.S. Department of Energy) 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.

2.1 DESCRIPTION OF THE DOUBLE-SHELL TANK SYSTEM

The DSTs consist of a primary steel tank inside of a secondary steel liner, which is surrounded by a reinforced concrete structure. Between the bottom of the primary tank and secondary liner is 8-in. of refractory concrete. Both the primary tank and secondary liner are built of the same specification carbon steel. The primary tank of each DST was post-weld heat-treated to minimize the possibility of SCC failures.

2.1.1 Construction of the Double-Shell Tanks

The DSTs were constructed over a period of approximately 18 years (from 1968 to 1986), with a presumed design life of 20 to 50 years. Table 2-1 summarizes the DST construction dates, year of initial service, and the expected service life at time of construction. The DSTs were constructed to replace the SSTs, some which had leaked or were suspected of leaking. The SSTs had been constructed with only a projected 20-year life span. The DSTs were designed such that any potential leaks could be detected, the leaking waste could be held in the secondary containment, and corrective action taken long before there could be any release of waste to the environment.

Table 2-1. Double-Shell Tank Construction and Age as of 2014

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<th>Tank Farm</th>
<th>Number of tanks</th>
<th>Construction period</th>
<th>Construction project</th>
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1 The 241-xx farms and tanks are referred to herein without “241-” (e.g., AY Farm vs. 241-AY Tank Farm).
The DSTs have been certified by the Independent Qualified Registered Professional Engineer as fit for service. In October 2012, due to material seen in the annulus of Tank AY-102 during an inspection, the tank was identified as an assumed leaker (primary tank). Additional information on Tank AY-102 can be found in RPP-ASMT-53793, *Tank 241-AY-102 Leak Assessment Report*. Work continues to transfer all waste out of the SSTs into the DSTs (RPP-28538, *Double-Shell Tank Integrity Assessment Report*).

2.1.2 Description of the Double-Shell Tanks

Each DST consists of a primary carbon steel tank inside of a secondary carbon steel liner, which is surrounded by a reinforced-concrete structure. The primary steel tank rests atop an 8-in. insulating concrete slab, separating it from the secondary steel liner and providing for air circulation/leak detection channels under the primary tank bottom plate. An annular space of 2.5 ft exists between the secondary liner and primary tank, allowing for visual examination of the tank wall and secondary liner annular surfaces. The annular space also allows for ultrasonic volumetric inspections of the primary tank wall and secondary liner.

Each of the DSTs has between 59 and 126 risers penetrating the dome that provide access for video cameras, ultrasonic inspection devices, waste sampling devices, mixer pumps, and other equipment that require access to either the primary tank interior or annular space. Above each DST (extending from grade to various depths) are between three to five pits that house valves and pumps. This equipment allows transfer of waste fluids and sludge from SSTs to DSTs, from DSTs to other DSTs, or from DSTs to other facilities such as the WTP.

Figure 2-1. Double-Shell Tank Construction
Primary Tank

The primary tank of a DST is 75-ft in diameter, and measures approximately 46 ft-9 in. in height at the dome center. The bottom of the primary tank consists of a 1-in. thick steel plate, 4 ft in diameter in the center of the tank. The bottom plate thins to 0.375 in. at the interfacing weld and extends to a curved, formed section of a 0.875-in. thick plate (or for AP Farm 0.938 in.), commonly referred to as the “bottom knuckle.” The bottom knuckle consists of a horizontal plate, curved section, and vertical plate known as the “bottom transition plate,” also 0.875 in. in thickness. The primary tank vertical wall consists of either three or four vertical plates (courses). The courses are either 0.500 in. thick or for the bottom course in AP Farm, 0.750 in. thick. In the AY, AZ, and SY Farms, there are three plates that are approximately 10 ft in height, followed by a top transition plate that is approximately 3 ft in height. In the remainder of the farms, there are four plates that are approximately 8 ft in height. An inwardly curved section, referred to as either the “top knuckle” or “haunch,” joins the vertical wall with the roof section of the tank.

The entire primary shell rests atop an 8-in. thick insulating concrete slab that separates it from the secondary shell. A radial pattern of air distribution and drain slots is formed into the concrete to allow air circulation to cool the bottom of the tank and for any leakage from the primary tank to be directed into the annular space, where leak detection instrumentation is installed.

Secondary Liner

The secondary liner of a DST is 80 ft in diameter and approximately 40 ft high. The tank bottom consists of 0.25-in. thick steel plates and connects to a bottom knuckle, also 0.25 in. thick. The bottom knuckle of the secondary tank includes a small vertical plate that connects to the vertical wall plates of the secondary liner. Four vertical plates form the wall of the secondary liner of the DST, with a thickness between 0.25 in. and 0.375 in., which is topped by an inwardly curved secondary top haunch. The secondary haunch approaches the haunch of the primary tank at 460 in. A small gap, from 0.5 in. to 1 in. in AY Farm and from 0 in. to 1 in. in width in all of the other tank farms, exists between the two liners. The gap is overlapped by a series of 14-in. wide, 18-gauge flashing strips. These strips are tack-welded to the primary tank and extend approximately 4 in. past the secondary liner gap.

Concrete Structure

The concrete foundation of the DSTs is either 88 ft-6 in. (for AY Farm) or 89 ft-6 in. (for the remaining farms) in diameter, and is designed to uniformly distribute all loads. For the farms other than AP Farm, the center portion of the foundation is 2 ft thick and 6 ft in diameter. From the center, the bottom side of the foundation tapers to about a thickness of 1 ft, which then returns to 2 ft thick at the outer edge. The AP Farm has no taper, and the entire foundation is 2 ft thick. The foundations contain slots and drain lines to collect any leakage from the secondary tank. Any leakage from the bottom of the secondary liner is directed to a leak detection well.

The outside of the concrete structure is 83 ft in diameter and 1.5 ft thick, and rests on steel plates supported by the tank foundation. The dome of the concrete is 1.25 ft thick and is reinforced with steel rebar. Anchor bolts are threaded into studs welded to the secondary steel liner wall and the primary tank dome, after which the concrete is cast around the rebar and anchor bolts.
2.2 DESCRIPTION OF SINGLE-SHELL TANK SYSTEM

The SSTs consist of a single steel liner that is surrounded by a reinforced concrete structure. Unlike the DSTs, the steel liners of the SSTs terminate at a specified elevation above the maximum liquid level. This liquid level and maximum waste volume varies based on the geometry of the tank type. There are six different types of construction designs for the various SSTs. None of these designs contain a secondary containment or used post-weld heat treatment to minimize the possibility of SCC failures as performed during DST construction.

2.2.1 Construction of Single-Shell Tanks

The SSTs were constructed over a period of roughly 32 years (from 1943 to 1965), with a presumed design life of 20 years. Table 2-2 summarizes the SST construction dates, number, and type of tanks, design capacity, and current age. The SSTs were constructed to store radioactive waste produced by multiple processing facilities located in 200 East and 200 West Areas. While the DSTs were designed to detect and contain any potential leaks while in secondary containment, the SSTs were not designed with a secondary containment feature. There is no potential for leak detection prior to a leak into the environment.

<table>
<thead>
<tr>
<th>Tank farm</th>
<th>Number of tanks</th>
<th>Tank type</th>
<th>Capacity (gal)</th>
<th>Construction period</th>
<th>Initial operation</th>
<th>Current age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Farm</td>
<td>6</td>
<td>Type IVB</td>
<td>1,000,000</td>
<td>1953-1956</td>
<td>1956-1957</td>
<td>60</td>
</tr>
<tr>
<td>AX Farm</td>
<td>4</td>
<td>Type IVC</td>
<td>1,000,000</td>
<td>1963-1965</td>
<td>1965</td>
<td>49</td>
</tr>
<tr>
<td>B Farm</td>
<td>4 – 200-series</td>
<td>Type I</td>
<td>55,000</td>
<td>1943-1944</td>
<td>1952</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>12 – 100-series</td>
<td>Type II</td>
<td>530,000</td>
<td>1943-1944</td>
<td>1945-1947</td>
<td>69</td>
</tr>
<tr>
<td>BX Farm</td>
<td>12</td>
<td>Type II</td>
<td>530,000</td>
<td>1946-1947</td>
<td>1948-1951</td>
<td>66</td>
</tr>
<tr>
<td>BY Farm</td>
<td>12</td>
<td>Type III</td>
<td>758,000</td>
<td>1948-1949</td>
<td>1950-1951</td>
<td>64</td>
</tr>
<tr>
<td>C Farm</td>
<td>4 – 200-series</td>
<td>Type I</td>
<td>55,000</td>
<td>1944-1945</td>
<td>1947-1948</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>12 – 100-series</td>
<td>Type II</td>
<td>530,000</td>
<td>1943-1944</td>
<td>1946-1948</td>
<td>68</td>
</tr>
<tr>
<td>S Farm</td>
<td>12</td>
<td>Type III</td>
<td>758,000</td>
<td>1950-1951</td>
<td>1952-1953</td>
<td>64</td>
</tr>
<tr>
<td>SX Farm</td>
<td>15</td>
<td>Type IVA</td>
<td>1,000,000</td>
<td>1953-1955</td>
<td>1954-1959</td>
<td>61</td>
</tr>
<tr>
<td>T Farm</td>
<td>4 – 200-series</td>
<td>Type I</td>
<td>55,000</td>
<td>1943-1944</td>
<td>1952</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>12 – 100-series</td>
<td>Type II</td>
<td>530,000</td>
<td>1943-1944</td>
<td>1945-1947</td>
<td>71</td>
</tr>
<tr>
<td>TX Farm</td>
<td>18</td>
<td>Type III</td>
<td>758,000</td>
<td>1947-1948</td>
<td>1950-1952</td>
<td>66</td>
</tr>
<tr>
<td>TY Farm</td>
<td>6</td>
<td>Type III</td>
<td>758,000</td>
<td>1951-1952</td>
<td>1953</td>
<td>63</td>
</tr>
<tr>
<td>U Farm</td>
<td>4 – 200-series</td>
<td>Type I</td>
<td>55,000</td>
<td>1943-1944</td>
<td>1954-1956</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>12 – 100-series</td>
<td>Type II</td>
<td>530,000</td>
<td>1943-1944</td>
<td>1946-1949</td>
<td>68</td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.2.2 Description of Single-Shell Tanks

Each SST consists of a carbon steel liner surrounded by a reinforced-concrete structure. The steel liner rests atop a layer of grout and waterproofing membrane that separates it from the concrete structure. The size of the tanks varies between 20 ft to 75 ft in diameter and in height. The concrete structures vary in thickness based on the type of SST and the location on the tank structure. While the primary tank headspaces of the DSTs are completely enclosed by welded steel plates, the SST headspaces are enclosed by reinforced concrete.

The number of access risers into the SST headspace varies significantly based on the tank type, with the early constructed tanks having the least amount of access. Unlike the forced ventilation, which is used in the DST farms, the SSTs all currently ventilate using passive breather filters, which are periodically replaced. Forced ventilation was initially used on some of the later constructed high-heat SSTs (e.g., A and AX Farms). However, since all of the SSTs have been interim stabilized, the ventilation system was taken out of service after the pumpable liquid was removed from those tanks.

Types and locations of equipment vary for each tank type and tank farm. Figure 2-2 provides a generic overview of the waste layers and support equipment common to many of the SSTs. The configuration of each of the SSTs is maintained by the WRPS Retrieval Closure Project.

![Single-Shell Tank Construction Diagram](image-url)
Type I Single-Shell Tank

Type I tanks are commonly referred to as 200-series SSTs. These tanks are located in the B, C, T, and U Farms. The tanks are 20 ft in diameter, with storage capacities of 55,000 gal. The base slab is 7-in. thick reinforced concrete that is formed to match the dish-shaped steel liner, which extends to 18 in. of concrete toward the outer section of the footing. The vertical section of the concrete shell is 12 in. thick and extends approximately 24 ft-7 in. from the outside top of the footing to the underside of the 12-in. thick flat reinforced concrete roof. The inner steel liners were fabricated from 0.25-in. thick carbon steel plates. The liner extends up the sidewalls and ends 6 in. below the underside of the flat roof. Supporting ventilation and access structures were installed through and built on top of the flat roof. A generic representation of a Type I SST is provided in Figure 2-3.

Type II Single-Shell Tank

Type II tanks were typically constructed in conjunction with the Type I tanks. In addition to the farms containing Type I tanks, BX Farm is also made up of 12 Type II SSTs. These tanks are significantly larger than the Type I tanks, with 75-ft diameter steel liners and storage capacities of 530,000 gal. Figure 2-4 is a generic representation of a Type II SST.

The base slab of Type II SSTs is 6-in. thick reinforced concrete that is formed to match the dish-shaped steel liner, which extends to being 2 ft thick towards the outer section of the footing. The 12-in. thick sidewall extends 16 ft-8 in. from the footing to the spring line of the dome. It is at this point where the elliptical-shaped concrete dome begins. The concrete dome is made up of the haunch section, which is a heavily reinforced region of concrete that is designed to withstand the loads subjected on the dome. The haunch transitions to a 15-in. thick strip of reinforced concrete that completes the shape of the dome. The highest point of the elliptical-shaped dome extends 13.25 ft above the sidewall spring line, producing a total tank height of 32 ft-11 in. from the bottom of the tank foundation. Supporting ventilation and access structures were installed through and built on the haunch section of the tank dome.
The inner steeliners for the B, C, T, and U Farm Type II tanks were fabricated from 0.25-in. and 0.313-in. thick carbon steel plates. The tank bottom and sidewalls are 0.25-in. thick plate, while the curved knuckles are 0.313-in. plate. In BX Farm Type II tanks, a thicker steel plate (0.375 in.) was used along the tank bottom. The liner extends up the sidewalls and ends at the spring line for the concrete roof dome. This point is 19 ft above the tank bottom at the centerline of the tank. Stiffener deposits are welded to the inside surface of the liner at equal distance spacing. Lead flashing was embedded in the concrete wall and extended around the top stiffener ring to prevent liquids from getting behind the tank liner (Figure 2-5).

![Figure 2-5. Lead Flashing Construction](image)

**Figure 2-5. Lead Flashing Construction**

**Type III Single-Shell Tank**

Tanks located in TX, BY, S, and TY Farms are Type III, 758,000-gal capacity SSTs. The Type III tank is the next largest tank, with a 75-ft diameter steel liner, similar to the Type II SSTs. However, to increase the tank capacity, the Type III tank liner and dome are about 6 ft higher than the Type II tanks. The base slab is 6-in. thick reinforced concrete at the tank centerline and is formed to match the dish-shaped steel liner, which extends to being 3 ft thick towards the outer section of the footing. A generic representation of a Type III SST is shown in Figure 2-6.

![Figure 2-6. Type III Single-Shell Tank](image)
Unlike the Type II tank, which maintains a uniform slab thickness along the full length of the tank bottom, the Type III tank bottom is flat. The thickness of the base slab increases when moving towards the vertical sidewall because of the flat bottom of the concrete base. The 12-in. thick sidewall extends 22 ft-8 in. from the footing to the spring line of the dome. It is at this point where the elliptical-shaped concrete dome begins. The concrete dome is made up of the haunch section, which is a heavily reinforced region of concrete that is designed to withstand the loads subjected on the dome. The haunch transitions to a 15-in. thick strip of reinforced concrete that completes the shape of the dome. The highest point of the elliptical shaped dome extends 13 ft-4 in. above the sidewall spring line, producing a total tank height of 39 ft from the bottom of the dish section of the tank foundation. Supporting ventilation and access structures were installed through and built on the haunch and center sections of the tank dome.

The carbon steel liners were fabricated from varying thicknesses of steel plate. The tank bottoms and curved knuckles are 0.375-in. plate. The first row of vertical plates above the knuckle is 0.313-in. thick plate that transitions to 0.25 in. thick for the upper two vertical plates. The liner extends up the sidewalls and ends at the spring line for the concrete roof dome. This point is 24 ft-11.625 in. above the tank bottom at the centerline of the tank. Stiffener deposits are welded to the inside surface of the liner, including an angled ring to allow for the installation of a 12-in. wide piece of lead flashing at the top edge of the liner. This flashing was embedded into the concrete wall, sloped downward, and curled around the top stiffener ring to form a drip lip for reflux condensate from the dome.

**Type IVA Single-Shell Tank**

Type IVA SSTs are located in SX Farm and have a 1 Mgal capacity. The Type IVA tanks contain a 75-ft diameter steel liner, similar to the Type II and Type III SSTs; however, the Type IVA tanks domes and liner are about 7 ft higher than the Type III tanks. A generic representation of a Type IVA SST is shown in Figure 2-7.

The base slab of Type IVA SSTs is 8-in. thick reinforced concrete at the tank centerline and is formed to match the dish-shaped steel liner, which extends to being 23 in. thick toward the outer section of the footing. Similar to the Type III tank, the outer face of the Type IVA tank bottom is flat. The thickness of the base slab increases when moving toward the vertical sidewall because of the flat bottom of the concrete base. The reinforced concrete sidewall begins with a thickness of 2 ft, extending approximately 14 ft before it begins to taper down over the next 6 ft to a 15-in. thick sidewall. The 15-in. sidewall section is extended the remaining 11 ft-1 in. prior to reaching the spring line.

**Figure 2-7. Type IVA Single-Shell Tank**
It is at this point where the elliptical-shaped concrete dome begins. The concrete dome is made up of the haunch section, which is a heavily reinforced region of concrete designed to withstand the loads subjected on the dome. The haunch transitions to a 15-in. thick strip of reinforced concrete that completes the shape of the dome. The highest point of the elliptical shaped dome extends 13 ft-3 in. above the sidewall spring line, producing a total tank height of 46 ft-5.625 in. from the bottom of the tank foundation. Supporting ventilation and access structures were installed through and built on the haunch and various points of the tank dome.

The carbon steel liners were fabricated from 0.375-in. thick steel plate. The Type IVA SSTs do not have the curved knuckle design used in other types of SSTs. The dished tank bottom and vertical sidewall are joined by a weld where they intersect. The liner extends up the sidewalls and ends at the spring line for the concrete roof dome. This point is 32 ft-3.875 in. above the tank bottom at the centerline of the tank. Stiffener deposits are welded to the inside surface of the liner, including an angled ring to allow for the installation of a 16-in. wide, 0.25-in. thick steel plate at the top edge of the liner. This plate was embedded into the concrete wall, sloped downward, and tack-welded to the liner to form a drip lip for reflux condensate from the dome (Figure 2-8).

![Figure 2-8. Tank Plates](image-url)
Type IVB Single-Shell Tank

Type IVB SSTs are located in A Farm and have a 1 Mgal capacity. The Type IVB tanks have a 75-ft diameter steel liner, similar to the Type II and Type III SSTs; however, the Type IVB tanks are greater in height. A generic representation of a Type IVB SST is shown in Figure 2-9.

Unlike the Type IVA concrete base, which is dish-shaped, the Type IVB concrete base is flat to support the flat steel liner. The base slab is 6-in. thick reinforced concrete and extends out from the tank centerline to the 8-ft by 2-ft thick circular footing that is centered under the tank sidewall.

The reinforced concrete sidewall begins with a thickness of 2 ft, extending approximately 17 ft before it begins to taper down over the next 6 ft to a 15-in. thick sidewall. The 15-in. sidewall section is extended the remaining 9 ft-6.75 in. prior to reaching the spring line. It is at this point where the elliptical-shaped concrete dome begins. The concrete dome is made up of the haunch section, which is a heavily reinforced region of concrete that is designed to withstand the loads subjected on the dome. The haunch transitions to a 15-in. thick strip of reinforced concrete that completes the shape of the dome. The highest point of the elliptical shaped dome extends 13 ft-3 in. above the sidewall spring line, producing a total tank height of 47 ft-9.75 in. from the bottom of the tank footing. The access risers for Type IVB SSTs were installed in a similar manner to previous tank types; however, Type IVB SSTs used concrete reinforced pits around large diameter risers and forced ventilation instead of passive condensers.

The carbon steel liners were fabricated from 0.375-in. thick steel plate. The Type IVB SSTs do not have the curved knuckle design used in other types of SSTs. The tank bottom and vertical sidewall are joined at a 90-degree angle by a weld. The liner extends up the sidewalls and ends at the spring line for the concrete roof dome. This point is 32 ft-3.875 in. above the tank bottom at the centerline of the tank. Stiffener deposits are welded to the inside surface of the liner, including an angled ring to allow for the installation of a 12-in. wide piece of lead flashing at the top edge of the liner. This flashing was embedded into the concrete wall, sloped downward, and curled around the top stiffener ring to form a drip lip for reflux condensate from the dome.
Type IVC Single-Shell Tank

The Type IVC SSTs located in AX Farm were the last to be constructed prior to the beginning of construction of the first DST farm, AY Farm. Similar to the Type IVA/B SSTs, the Type IVC tanks also have a 1 Mgal capacity. The Type IVC tanks have a 75-ft diameter steel liner similar to the Type II and Type III SSTs; however, the Type IVB tanks are greater in height. A generic representation of a Type IVC SST is shown in Figure 2-10.

Similar to the Type IVB concrete base, the Type IVC concrete base is flat to support the flat steel liner. The base slab was increased in size from the Type IVB slab to 1 ft-6 in. thick reinforced concrete to allow for the installation of leak detection drain slots. These drain slots were installed to direct tank leakage into a sump where instruments would monitor for increasing liquid levels. The base slab extends out from the tank centerline to the 10-ft by 3-ft thick circular footing that is centered under the tank sidewall.

The reinforced concrete sidewall begins with a thickness of 2 ft extending approximately 19 ft-10 in. before it begins to taper down over the next 5 ft to a 15-in. thick sidewall. The 15-in. sidewall section is extended the remaining 7 ft-8 in. prior to reaching the spring line. It is at this point where the elliptical-shaped concrete dome begins. The concrete dome is made up of the haunch section, which is a heavily reinforced region of concrete that is designed to withstand the loads subjected on the dome. The haunch transitions to a 15-in. thick strip of reinforced concrete that completes the shape of the dome. The highest point of the elliptical-shaped dome extends 13 ft-3 in. above the sidewall spring line, producing a total tank height of 48 ft-11 in. from the bottom of the tank footing.

The access risers for Type IVC SSTs were installed in a similar manner to previous tank types; however, Type IVB SSTs used concrete-reinforced pits around large diameter risers and forced ventilation instead of passive condensers. Type IVC SSTs were also the first to have airlift circulators installed. These systems were installed to minimize the settling of high-heat solids, which were suspected of contributing to the failure of tank steel liners in other farms (e.g., A Farm).

The carbon steel liners were fabricated from 0.375-in. thick steel plate. The Type IVC SSTs have a curved knuckle, unlike the Type IVA and IVB SSTs. After the knuckle, the liner extends up the sidewalls and ends at the spring line for the concrete roof dome. This point is 32 ft-6 in. above the tank bottom at the centerline of the tank. Stiffener deposits are welded to the inside surface of the liner at specified intervals.
Type IVC tank construction drawings specified the installation of a piece of bent plate at the top edge of the liner. This bent plate was embedded into the concrete wall, sloped downward, and angled around the top section of the steel liner to prevent intrusion from tank dome condensate. Figure 2-11 shows the Type IVC SST supporting infrastructure.

Figure 2-11. Type IVC Single-Shell Tank Supporting Infrastructure
3.0 HANFORD VISUAL INSPECTIONS

Washington State Department of Ecology (Ecology) Publication 94-114, *Guidance for Assessment and Certifying Tank Systems that Store and Treat Dangerous Waste* (Ecology 1994), identifies external and visual inspection as acceptable tank examination methods. Visual examination of tanks by remote video camera has been demonstrated to provide valuable information for assessing tank conditions and to support deployment of remotely operated nondestructive examination (NDE) equipment.

3.1 BACKGROUND

Visual inspections of the DSTs and SSTs began in the early 1970s using still photography. The camera assembly and housing were lowered into the tank headspace and positioned to begin a series of photographs. The strobe lights located in the camera housing (Figure 3-1) were used to illuminate the tank wall surface just prior to capturing the photograph. The use of still photography proved to be an effective way of capturing the necessary detail over a large area in a relatively short period of time (Figure 3-2).

![Figure 3-1. Historical Still Photography Camera Assembly and Housing](image)

![Figure 3-2. Single-Shell Tank Headspace Still Photograph](image)
Still photography was used until 1993 when remote video cameras became commercially available for use in high-radiation environments. These camera systems allowed real-time inspections, the capability to focus and zoom-in on areas of interest, and the ability to easily revisit previous areas of interest (Figure 3-3).

While the inspections continued for the DSTs, periodic visual inspections were no longer performed in the SSTs. However, since SST inspections have restarted, the deployment of new systems is underway. The requirements for the new SST inspections are identified in Recommendation (SI-4) by the Single-Shell Tank Expert Panel documented in RPP-RPT-45921, Single-Shell Tank Integrity Expert Panel Report. In that recommendation, the use of visual inspection was selected as the preferred method to identify cracks in excess of 0.0625 in., staining, and rust on the tank dome, specifically in the curved haunch and top center sections of the tank dome.

### 3.2 DOUBLE-SHELL TANK VISUAL INSPECTIONS

The DSTs are examined visually for conditions both inside the primary tank (above the waste level) and on the annulus surfaces of the primary tank and secondary liner. These visual inspections use remote video equipment during planned periodic visual assessments. The present approach for conducting visual examinations of DSTs is to perform a video examination of each tank’s interior and annulus regions in conjunction with the tank’s ultrasonic examination inspection.

The DSTs are visually inspected using tank farms operating procedure TO-020-142, Video Examination of DST Interiors and Annuli. Visual examinations are conducted under the following conditions.

- Visual examinations will be performed, as much as possible, in conjunction with periodic scheduled ultrasonic testing, approximately every five years (not to exceed seven years between inspections).
- Visual examinations of selected regions will be performed when ultrasonic testing of the primary tank walls identifies conditions or indications requiring additional assessments.
- The primary tank interior will be visually inspected following complete pump-down of the tank to view previously inaccessible surfaces that have not been documented for at least five years.

The primary tank’s interior visual examination (including the dome space) is performed through one of the primary tank’s risers. The primary tank annulus sidewall and secondary liner annulus visual examinations are performed via four of the annulus risers.
Additional coverage and inspection frequency are being evaluated for implementation. The visual baseline information is documented in the Tank Integrity Inspection Guides (TIIG). The TIIG contains photographic information of notable indications (areas of interest) and specifies their location on each DST, and also shows the tank regions examined by ultrasonic testing.

To develop a TIIG, a variety of information is used, including previous inspection results, construction drawings, certified vendor information, and other relevant information. The information provided by the construction drawings provides the ability to pinpoint the location of the vertical welds along the primary and secondary walls of the DST. This mapping process is then linked with the steel plate data to form the TIIG.

Figure 3-4 represents an example of the inspection map section of the TIIG, and Figure 3-5 represents an illustration of the information in the guide section of a TIIG. The figures are annotated with descriptions for each item. These example figures can be used as a template for understanding the TIIGs. Each item of interest has been mapped and is given a unique tank specific photo identification number, which enables the region to be identified and explained in the TIIG.

The TIIGs for each tank farm are compiled into a single document. These documents are updated within a calendar year from when a tank primary or annulus inspection is conducted. To-date, six of the integrity inspection reports have been prepared:

- RPP-RPT-31599, Double-Shell Tank Integrity Inspection Report for 241-AN Tank Farm
- RPP-RPT-34310, Double-Shell Tank Integrity Inspection Report for 241-AZ Tank Farm
- RPP-RPT-34311, Double-Shell Tank Integrity Inspection Report for 241-AY Tank Farm
- RPP-RPT-38738, Double-Shell Tank Integrity Inspection Report for 241-AP Tank Farm
- RPP-RPT-39149, Double-Shell Tank Integrity Inspection Report for 241-SY Tank Farm
- RPP-RPT-42147, Double-Shell Tank Integrity Inspection Report for 241-AW Tank Farm.

The following documents are planned updates to the annulus inspections using ≥95 percent coverage. This information will be added to the integrity inspection reports.

- RPP-ASMT-53793, Tank-AY-102 leak Assessment Report
- RPP-RPT-54814, Tank AY-101 Annulus Extent of Condition Baseline Inspection
- RPP-RPT-54815, 241-AZ Farm Annulus Extent of Condition Baseline Inspection
- RPP-RPT-54816, 241-SY Farm Annulus Extent of Condition Baseline Inspection.
This label annotates which tank and containment wall is being displayed.

The legend explains the color code for ultrasonic testing scan paths, and which colors represent an image from the interior side of the primary tank wall or the exterior side of the primary wall, as seen in the annulus.

Each of these numbers directly correlates to an image in the Tank Inspection Integrity Guide. For instance, number 03 shows the relative location of Photo ID# AN-107-03.
The **Photo ID** is the number used to identify the picture and relevant data. The first five characters (e.g., AN-107) identify which tank the photo is from, while the last two digits of this number (e.g., 03) are used to correlate this entry with the Tank Integrity Inspection Map.

**Date of Inspection** lists the date the visual inspection was performed.

**Date of Review** lists the fiscal year an inspection report commented on this region.

**Location**
- Extensor of primary tank shell, along Courses 3 and 2, joining bottom edge of primary shell plate
- F7301M2 number 5A and primary shell plate
- F7301M2 number 5B, Riser 46.
- DVID#10258

Corrosion along circumferential weld joining Course 2 and 3. Noticeable corrosion product directly above weld continues up to Course 1. Possible surface condensation on the outside of primary shell has accelerated corrosion along this area.

**Description** and **Location** fields give a verbal description of the area of interest and how to locate it, respectively. The DVID# is the reference number used to identify the DVD from which the photo was taken. The number represents the number of the DVD stored in the Visual Inspection Archive.

**Shipping Mark**
- F7301M2 3G5922 0400C
- F7301M2 3G5922 0600C

**Nominal Thickness** 0.500

**Nominal Length** 471.25

**Nominal Width** 92.75

Details indicate wall plate data taken from the Certified Material Test Reports.

---

**Figure 3-5.** AN Tank Integrity Inspection Guide Example
DST annulus and primary in-tank inspections are performed to identify possible tank leaks, provide early warnings of aging mechanisms, and support volumetric inspection of the primary steel tank. Table 3-1 and Table 3-2 provide the evaluation factors that make up the inspection criteria for primary in-tank and annulus inspections, respectively. These criteria primarily focus on different forms of corrosion that relate to tank leak integrity (e.g., pitting, cracking, etc.) versus the inspection of the concrete dome of the SSTs, which pertains to the tank’s structural integrity.

**Table 3-1. Criteria for Double-Shell Tank Primary In-Tank Inspections**

<table>
<thead>
<tr>
<th>Tank feature</th>
<th>Evaluation factors</th>
<th>Probable locations</th>
<th>Reason to identify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary tank</td>
<td>Increased general corrosion in comparison to previous inspection</td>
<td>Any visible region on the primary steel tank</td>
<td>A substantial change in corrosion product between inspections indicates a corrosion mechanism that was not present or was recently introduced into the tank environment.</td>
</tr>
<tr>
<td>Primary tank</td>
<td>Pitting along the historical liquid-air interfaces</td>
<td>Beachline marks typically along the primary tank wall indicate the interface between the headspace environment and the liquid waste</td>
<td>These interfaces could be a region where pitting occurs under certain conditions. Over time and under the right conditions, these pits could penetrate through the primary tank, compromising the tank’s integrity.</td>
</tr>
<tr>
<td>Primary tank</td>
<td>Cracks</td>
<td>Along the visible surface of the vertical section of the primary tank</td>
<td>Cracking suggests the primary tank integrity has been compromised.</td>
</tr>
<tr>
<td>Access risers</td>
<td>Corrosion of steel access riser penetrations</td>
<td>Along the bottom edge of the riser penetrations</td>
<td>For steel risers, increased corrosion, including metal loss, suggests an environment that is conducive to vapor space corrosion.</td>
</tr>
<tr>
<td>In-tank equipment</td>
<td>Corrosion</td>
<td>Along the visible surfaces of the tank equipment</td>
<td>Corrosion of the equipment may provide evidence as to the aggressive/passive nature of the waste and the environment the equipment is used in.</td>
</tr>
</tbody>
</table>
### Table 3-2. Criteria for Double-Shell Tank Annulus Inspections

<table>
<thead>
<tr>
<th>Tank feature</th>
<th>Evaluation factors</th>
<th>Probable locations</th>
<th>Reason to identify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior of primary tank</td>
<td>Increased general corrosion in comparison to previous inspection</td>
<td>Any visible region on the exterior of the primary steel tank</td>
<td>A substantial change in corrosion product between inspections indicates a corrosion mechanism that was not present or was recently introduced into the annulus environment.</td>
</tr>
<tr>
<td>Interior of secondary liner</td>
<td>Increased general corrosion in comparison to previous inspection</td>
<td>Any visible region on the interior of the secondary liner</td>
<td>A substantial change in corrosion product between inspections indicates a corrosion mechanism that was not present or was recently introduced into the annulus environment.</td>
</tr>
<tr>
<td>Exterior of primary tank</td>
<td>Pitting along the historical liquid-air interfaces</td>
<td>These regions coincide with the historical interface between the headspace environment and the liquid waste</td>
<td>These interfaces could be a region where pitting occurs under certain conditions. Over time and under the right conditions, these pits could penetrate through the primary tank, compromising the tank’s integrity.</td>
</tr>
<tr>
<td>Exterior of primary tank</td>
<td>Cracks</td>
<td>Along the visible exterior surface of the vertical section of the primary tank</td>
<td>Cracking suggests the primary tank integrity has been compromised.</td>
</tr>
<tr>
<td>Exterior of primary tank</td>
<td>Annulus intrusion</td>
<td>The converging section of the primary tank and secondary liner near the top of the tank</td>
<td>Annulus intrusion introduces liquid into the tank, increasing the chance for localized corrosion especially if the annulus ventilation system is not active.</td>
</tr>
<tr>
<td>Exterior of primary tank</td>
<td>Waste leakage from slots in refractory</td>
<td>Annulus floor and refractory slots</td>
<td>The presence of chemicals on the annulus floor or in the vicinity of the slots can indicate a past waste leak. Changes to the puddle configuration can give an indication of the continued leakage.</td>
</tr>
<tr>
<td>Concrete refractory</td>
<td>Refractory concrete cracking</td>
<td>At the bottom of the annulus located under the primary tank</td>
<td>Cracking of the refractory concrete provides insight as to the loads it is being subjected to.</td>
</tr>
</tbody>
</table>
3.3 DOUBLE-SHELL TANK EVALUATION FACTORS

Historical visual inspections of the DST interiors and annuli provide evidence of anomalies that should be used during future inspections to help identify areas of interest in other DSTs. In addition to anomalies from previous inspections, there are also evaluation factors that must be identified to ensure the tank’s leak integrity. These evaluation factors include cracks in the steel tank, visible rust stains, signs of liquid intrusion in the annulus, pitting along the liquid-air interface (LAI), corrosion of access risers, and other indicators. All of these evaluation factors are indicators of various aging mechanisms during the ongoing service of the specific DST. Sections 3.3.1 and 3.3.2 describe and provide visual examples of some of the key evaluation factors.

3.3.1 Primary Tank Inspection Evaluation Factors

Increased General Corrosion in Comparison to Previous Inspection

There is currently no evidence of any substantial increase in corrosion visible from the in-tank inspections that would provide a clear representation of increased general corrosion. Changes in the appearance are typically due to an increase in lighting, camera resolution, or a different viewing angle than the previous inspection. Section 3.3.2 provides an example of increased general corrosion in the DST annuli. A noticeable change in the steel tank’s condition might suggest an aggressive change in the waste chemical components or a change in the tank’s headspace conditions.

Pitting Along Historical Liquid-Air Interfaces

Under specific conditions, there is a known potential for pitting to occur along the LAI in the DSTs (Figure 3-6 and Figure 3-7). For this reason, the inspection of the DST interior is to include the current LAI and any other visible signs of previous LAIs. Historical LAIs are typically visible due to the presence of salt buildup known as beachlines.

Figure 3-6. Potential Pitting in Liquid-Air Interface Region in Tank SY-102

Figure 3-7. Close-Up of Potential Pitting in Liquid-Air Interface Region in Tank SY-102
Primary Tank Cracks

Confirmation of steel liner cracks as seen from the tank interior is very difficult using standard visual inspection methods in DSTs and SSTs. To increase the ability to identify cracks in the steel tank, multiple riser penetrations are used to allow indirect illumination of the surface at an angle different than the camera is using. Even with ideal illumination, physical size and depth of the crack would require a volumetric form of NDE, such as an ultrasonic inspection. While there are no known cracks in any DSTs at the Hanford Site, there are available examples of cracks in Savannah River Site (SRS) waste storage tanks. As with the SSTs, the SRS tanks did not receive post-weld heat treatment, thus making them more susceptible to cracking near the connecting welds. Section 3.3.2 includes examples of primary tank cracks, as seen from the annulus.

Corrosion of Steel Access Riser Penetrations

Corrosion of the steel access riser penetrations indicates that the moisture level in the headspace of the tank is high. The moisture condenses up inside the riser, depending on the time of year and in-tank temperature, and travels back down, concentrating on the lower edges of the penetration. The inspection should concentrate on the end of the penetration to identify increased corrosion. Typical signs of corrosion anywhere else on the riser would be around the heat-affected zone where the steel pipe connects to the primary tank dome. Figure 3-8 shows light corrosion on the Tank AP-102 access riser penetration.

3.3.2 Annulus Inspection Evaluation Factors

Increased General Corrosion In Comparison to Previous Inspection:

In certain DSTs, primarily AY Farm, there has been a noticeable increase in general corrosion (Figure 3-9). This increased level of corrosion was caused by the combination of two items: (1) the shutdown of the annulus ventilation system for several years, and (2) the presence of water intrusion into the annulus during the same period of time. While both of these items have been corrected, annulus inspections should still attempt to identify any dramatic changes in the annulus that indicate either an equipment issue or the presence of increased moisture in the annulus.
Figure 3-9. Increased General Corrosion in the Tank AY-101 Annulus

Primary Tank Cracks

Confirmation of steel liner cracks, as seen from the tank annulus, is significantly easier than the tank interior. An inspection in the tank interior only provides a line of sight to the steel surface above the liquid level, while an annulus inspection provides a line of sight along the entire exterior of the primary tank. Cracks visible in the annulus will potentially appear similar to that seen in the non-heat-treated SRS tanks, as shown in Figure 3-10 and Figure 3-11.

Figure 3-10. Savannah River Site Tank 16 Crack on Vertical Weld (1972)
Figure 3-11. Savannah River Site Tank 15 Vapor Space Crack

Annulus Intrusion

Water intrusion into the annulus increases the amount of moisture in contact with the primary tank and secondary liner. As seen in AY Farm, water intrusion caused rust stains, which originated from the converging section of the primary tank and secondary liner and traveled down the primary tank terminating at the primary bottom knuckle. Water intrusion increases the rate of corrosion. The primary inspection region for this evaluation factor is at the converging section of the primary tank and section liner, as seen in Figure 3-12.
Figure 3-12. Evidence of Water Intrusion in AY Farm Tank Annuli
Waste leakage from slots in Refractory

Inspection of the annulus floor and the slots in the refractory provide the initial indication of leakage from the primary tank. Photos taken in Tank AY-102 provide an example of the refractory slots and the annulus floor.

Figure 3-13. Tank AY-102 Annulus View

3.4 SINGLE-SHELL TANK VISUAL INSPECTIONS

Using remote video equipment during planned visual assessments, the SSTs are visually examined for conditions inside the tank (above the waste level) on the surface of the steel liner, concrete dome, risers, in-tank equipment, and waste surface. The present approach for conducting visual examinations of SSTs is to perform a video examination of each tank’s interior once, to identify any areas of concern and estimate the need to reexamine the tank more frequently.

The SSTs are visually inspected using work instructions documented in a work package.

The tank interior visual examination will be performed through one or more of the tank’s risers. The risers selected should allow the inspection of the haunch and center dome region for each SST to be observed to the extent practical. Figure 3-14 shows the generic concrete inspection regions. The primary focus of the SST inspection is based on the evaluation factors listed in Table 3-3. These criteria can typically be evaluated using qualitative measures.

The SST visual examinations can be compared against previous in-tank photographs and videos to aid in determining changes in specific areas of interest. The results of each fiscal year’s inspections will be combined into a report to document the findings for each of the SSTs.
Descriptions of anomalies identified on the concrete dome will use the terminology in American Concrete Institute (ACI) 201.1 R-08, *Guide for Conducting a Visual Inspection of Concrete in Service*, when possible. This approach should provide a consistent definition of terminology throughout the course of the SST inspections.
### Figure 3-14. Single-Shell Tank Concrete Dome General Inspection Regions

#### Table 3-3. Criteria for Single Shell Tank Inspections

<table>
<thead>
<tr>
<th>Tank feature</th>
<th>Evaluation factors</th>
<th>Probable locations</th>
<th>Reason to identify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete dome</td>
<td>Cracking in excess of 1/16-in., rust stains, and spalling</td>
<td>The curved haunch (above the top section of the steel liner) and the center of the tank dome</td>
<td>Cracking, rust stains, and spalling would result from degradation mechanisms such as rebar corrosion.</td>
</tr>
<tr>
<td>Access risers, concrete dome or waste surface</td>
<td>Signs of liquid intrusion</td>
<td>Dripping from inside or outside risers, moisture stains along the tank dome, dripping from structural rings on the wall, or pooling on the waste surface</td>
<td>Water intrusion into SSTs should be minimized to prevent liquid levels in the tanks from increasing.</td>
</tr>
<tr>
<td>Access risers</td>
<td>Corrosion of steel access riser penetrations</td>
<td>Along the bottom edge of the riser penetrations</td>
<td>For steel risers, increased corrosion, including metal loss, suggests an environment that is conducive to vapor space corrosion.</td>
</tr>
<tr>
<td>Steel liner</td>
<td>Pitting along the historical liquid-air interfaces</td>
<td>Beachline marks typically along the steel liner wall indicate the interface between the headspace environment and the liquid waste</td>
<td>These interfaces could be a region where pitting occurs under certain conditions. Over time and under the right conditions, these pits could penetrate through the steel liner, compromising the liner’s integrity.</td>
</tr>
<tr>
<td>Steel liner</td>
<td>Tar deposits</td>
<td>Anywhere along the steel liner</td>
<td>Several mastic layers were installed between the steel liner and the concrete wall. Evidence of tar on the steel liner may suggest a through-wall penetration.</td>
</tr>
<tr>
<td>Steel liner</td>
<td>Cracks</td>
<td>Along the visible surface of the steel liner</td>
<td>Cracking suggests the liner integrity has been compromised.</td>
</tr>
<tr>
<td>In-tank equipment</td>
<td>Corrosion</td>
<td>Along the visible surfaces of the tank equipment</td>
<td>Corrosion of the equipment may provide evidence as to the aggressive/passive nature of the waste and the environment the equipment was used in.</td>
</tr>
<tr>
<td>Enraf gauge plummet</td>
<td>Sensing liquid or solid, and surface conditions</td>
<td>Area under plummet</td>
<td>To determine possible adequacy of reading and possible reasons for anomalous data.</td>
</tr>
<tr>
<td>LOW</td>
<td>Waste conditions around LOW</td>
<td>Waste around LOW</td>
<td>To help interpret neutron scan data.</td>
</tr>
<tr>
<td>Inlet and outlet wall nozzles</td>
<td>Evidence of liquid submersion (spares) and line pluggage</td>
<td>See tank drawings for locations</td>
<td>To see if liquid could have gone to soil through spares, and see which overflow lines may be plugged.</td>
</tr>
</tbody>
</table>

LOW = liquid observation well. SST = single-shell tank.
The following have been included in non-waste retrieval-related SST inspections since November 2012:

- Expansion of observations to detect water intrusion – Intrusions are determined by observing drips from risers/pit drains into pools on the waste surface and by interpretation of stains on the tank dome.
- Observation of tank Enraf gauge plummet and surface it rests on – Knowledge of the resting surface for the plummet is necessary to adequately interpret Enraf data values and changes in the data.
- Observation of the waste surface around the tank liquid observation well (LOW), if present – Knowledge of the waste surface around the LOW is helpful for interpreting the LOW neutron scan data.
- Observation of the waste surface for the presence of liquid and general waste surface conditions – Knowledge of the waste surface and fraction of liquid is necessary for more accurate estimation of waste supernatant liquid volumes and total waste volumes.
- Observation of the tank inlet and outlet nozzles for evidence of plugging and the spare inlet nozzles for evidence of waste having risen to that level:
  - Evaluation of assumed leaking tanks has indicated that for a number of tanks assumed to be leaking based on an increase in the drywell logging radiation level, the radiation level increase was due to filling the tank above the spare inlet nozzle opening, not from a breach in the liner. Filling the tank above the nozzle opening resulted in liquid entering the soil when the liquid worked its way around the seal at the end of the nozzle outside the tank. Observing the nozzles and evidence on the tank wall around the nozzles enables better estimation of whether an overflow through the spare inlets may have occurred.
  - Knowledge of the inlet and outlet nozzles connected to other tanks that are plugged indicates which tank headspaces may be “breathing” with adjacent tanks.

### 3.4.1 Tank Dome Conditions

Historical visual inspection records of the SST interiors provide evidence of anomalies that should be used during future inspections to help identify areas of interest in other SSTs. Areas of concern include reinforced concrete cracking, spalling, or visible rust stains on the dome, signs of liquid intrusion, and other indicators. All these evaluation factors are indicators of various aging mechanisms during the service of the specific SST.

The regions of the tank dome under the largest amounts of stress due to dome loading are the haunch and the peak of the tank dome. The inspection of these two regions provides qualitative evidence as to the current structural integrity of the dome and information that can be compared against previous inspections to help identify changes since the last inspection.

In some tanks, minor surface cracking is noted in the haunch region with minor localized spalling. Figure 3-15 provides an example of this evaluation factor in SST S-112.
Figure 3-15. Possible Concrete Cracking and Spalling (Tank S-112)

The nomenclature used to describe conditions of distress (real or potential) on the concrete dome uses the terminology, to the extent practical, in ACI 201.1 R-08 (July 2008 version). ACI 201.1 R-08 segregates problems noted during concrete inspection into categories of cracking, distress, and textural features and phenomena. Each of these is subdivided into numerous subcategories with a definition and description of each subcategory. Because of the inability to physically inspect the concrete dome of an SST, and the limitations of the video cameras used, it is not practical to attain the degree of specificity called for in ACI 201.1 R-08 for a concrete inspection, nor is it practical to accurately describe all the distress patterns observed to the degree expected for a formal concrete physical inspection. The concerns noted in the concrete dome (or top for 200-series tanks) inspections when described in the inspection report are limited to the following descriptions.

- **Cracking** – ACI 201.1 R-08 calls for reporting crack width and segregates cracks into one of 13 patterns. Table 3-3 requires the ability to discern cracks greater than 1/16 in. There is no ability to measure a crack width in an SST dome except by comparison if there is an item of known dimension nearby. No crack widths are stated in the inspection reports nor are cracks segregated into any patterns. Where a crack is observed on the concrete, an image is usually included in the summary report. Where more than one is observed in a tank, at least one image is included that typifies the cracks in that tank.
• **Distress** – ACI 201.1 R-08 segregates distress into 21 subcategories, with some of those further subdivided. Potential concrete distress descriptions in the annual reports are limited to dusting and chalking, efflorescence, joint spalls, joint leakage, scaling, and spalls.

• **Textural Features and Phenomena** – ACI 201.1 R-08 segregates textural features and phenomena into 16 subcategories. Potential concrete textural features and phenomena descriptions in the summary reports are limited to air voids, discoloration, staining, and stalactites.

Because of the limitations in SST inspections, qualifying words such as “apparent” are used to describe many observations that may or may not be an actual occurrence of concrete cracking, distress, or other concern.

Several subjects specific to SST dome or ceiling inspection include the presence of white material on the concrete, circumferential lines that look like cracks in the concrete, and the presence of small stalactites on the edge of the lead flashing in the tanks.

**White Material on Tank Dome**

An example of the limited ability to conclusively describe a condition in a tank is the presence of white salts on the underside of the concrete on the tank dome (or top in 200-series tanks) in many tanks. ACI 201.1 R-08 describes several examples of distress that could result in these white salts as:

• 2.2.1 *Chalking* – “Formation of a loose powder resulting from the disintegration of the surface of concrete or an applied coating, such as cementitious coating.”

• 2.2.9 *Dusting* – “The development of a powdered material at the surface of hardened concrete.”

• 2.2.10 *Efflorescence* – “A deposit of salts, usually white, formed on a surface, the substance having emerged in solution from within either concrete or masonry and subsequently been precipitated by a reaction, such as carbonation or evaporation.”

• 2.2.13.3 *Joint leakage* – “Liquid migrating through the joint” (such as a construction form joint).

In addition to these possible sources of material on the concrete surface, salt on the tank dome could also be present due to:

• Waste salts from operation of an airlift circulator
• Salts from chemical decontamination performed in a riser or pit
• Salts from waste solution mists depositing and drying on the dome
• Salts from in-tank activities splashing up on the dome
• Deposition of ammonium nitrate formed from ammonia in the tank headspace, similar to what is thought to be occurring in the Tank A-105 headspace (WRPS-1100725, “Ammonium Nitrate in Tank 241-A-105” [Reeploeg 2011]).
Most of the time, it cannot be determined from the video image whether the material is waste salt, decontamination chemicals, a constituent of the concrete, or deposition salts left from evaporation of intrusion water. In most cases, the presence of the material is noted and a suggestion made as to what the image may be.

The subjective terms mild, moderate, and significant are used to describe the level of white material observed on a tank dome. Figure 3-16 gives an example of each.

Figure 3-16. Examples of White Material on Tank Domes or Tops

Circumferential Lines on Tank Dome

Many SSTs have circumferential lines on the dome that can appear from a distance to be cracks. Examples can be seen in the “moderate” and “significant” images in Figure 3-17. These lines are likely due to construction finishing activities. Figure 3-17 is a construction photo from 1947 showing part of the haunch area chiseled out for repair in a BX Farm tank. Figure 3-18 shows a repaired section (not the same location). The lines shown in Figure 3-18 look very similar to the circumferential lines seen in Figure 3-16 about 66 years later.
Figure 3-17. Section of a BX Farm Tank Dome Under Repair in 1947

Figure 3-18. Section of a BX Farm Tank Dome Following Repair
Stalactites

ACI 201.1 R-08 defines stalactites as:

- 2.3.14 Stalactite – “A downward pointing deposit formed as an accretion of mineral matter produced by evaporation of dripping liquid from the surface of concrete, commonly shaped like an icicle.”

Several of the SSTs have numerous thin, approximately 3- to 5-in. long stalactites hanging from the edge of the lead flashing on the top stiffener ring. Whether these stalactites are salts remaining from evaporation of intrusion water, material remaining after evaporation of the zinc fluosilicate wash put on the underside of the dome during construction in some tanks, material drawn from the coating or concrete by intrusion water, or due to some other factor is unknown. The presence or absence of these stalactites is observed for each tank. Figure 3-19 shows examples of several stalactites.

Figure 3-19. Stalactites on Lead Flashing
3.4.2 Tank Steel Liners, Risers, and In-Tank Equipment

The level of corrosion present on the tank liner, in-tank equipment, and the tank risers is a qualitative judgment. The limitations of the video inspection process do not permit a quantitative estimate of the corrosion levels. The observed level of corrosion on the tank liner is subjectively categorized as mild, moderate, severe, or very severe. Figure 3-20 provides examples of how the tank liner corrosion is judged.

In addition to corrosion on tank liners, several tanks show what appear to be material growths on the liner. Whether this is liner corrosion, an unusual waste formation, or due to some other cause is unknown. Figure 3-20, photographs I, K, O, and P, provides several examples of these apparent material growths.

Examples of Mild Liner Corrosion (A) through (D)

Figure 3-20. Examples of Tank Liner Corrosion and Material Growth Accumulation (page 1 of 4)
Examples of Moderate Liner Corrosion (E) through (H)

(E)  
(F)  
(G)  
(H)  

Figure 3-20. Examples of Tank Liner Corrosion and Material Growth Accumulation (page 2 of 4)
Examples of Severe Liner Corrosion (I) through (L)

(I) (some material growths also)

(J)

(K) (some material growths also)

(L)

Figure 3-20. Examples of Tank Liner Corrosion and Material Growth Accumulation
(page 3 of 4)
Examples of Very Severe Liner Corrosion (M and N)

Examples of Material Growth Accumulation on Liner (O) and (P)

Figure 3-20. Examples of Tank Liner Corrosion and Material Growth Accumulation (page 4 of 4)
Confirmation of steel liner cracks is very difficult using standard visual inspection methods in DSTs and SSTs. To increase the ability to identify cracks in the steel liner, multiple risers may be used to allow indirect illumination of the surface at an angle different than that of the camera. Even with ideal illumination, physical size and depth of the crack would require a form of NDE such as an ultrasonic inspection. Figure 3-21 provides an example of a possible crack in the Tank SX-112 steel liner.

![Possible Steel Liner Crack](Tank SX-112)

Figure 3-21. Possible Steel Liner Crack (Tank SX-112)

The observed level of corrosion on in-tank equipment and tank risers is subjectively categorized as mild, moderate, or severe (no very severe corrosion has been noted on in-tank equipment and risers) to provide a level of consistency to these judgments. Figure 3-22 provides examples of how corrosion on risers and in-tank equipment is judged.
Examples of Mild Equipment and Riser Corrosion (A) through (D)

Figure 3-22. Examples of Tank Equipment and Riser Corrosion Levels (page 1 of 3)
Examples of Moderate Equipment and Riser Corrosion (E) through (H)

(E)  (F)

(G)  (H)

Figure 3-22. Examples of Tank Equipment and Riser Corrosion Levels (page 2 of 3)
Examples of Severe Equipment and Riser Corrosion (I) through (L)

Figure 3-22. Examples of Tank Equipment and Riser Corrosion Levels (page 3 of 3)
**Tar Deposits**

Tar deposits have been found in multiple SSTs suggesting either the potential for through-wall perforations or leaks past the flashing at the top of the tanks. During tank construction, a three-ply asphaltic membrane was applied between the steel liner and the concrete wall. In some cases, it appears that the tar-like substance flowed over the edge of the tank flashing. In the examples shown for Tanks BY-107, BY-110, and TX-114, the tar origin appears to be through holes in the steel liner itself (Figure 3-23, Figure 3-24, and Figure 3-25). These examples suggest the tar flowed down the wall while the liquid level was below the intrusion point.

Inverse tar rings shown in Figure 3-26 suggest that the tar intrusion into the tank occurred when liquid level was above the tar causing it to float up the wall of the tank. It should be noted if the inverse tar ring originates from the stiffener ring attachment as shown in BX-108.

![Image of Tar Ring](image_url)
Figure 3-24. Tar Deposits (Tank BY-110)

Figure 3-25. Tar Deposits (Tank TX-114)
When the discovery of the tar deposits in Tank BY-110 was first identified, ARH-1496, *Review of Storage Tank Integrity*, was issued to document the finding and potential causes. In this review, it was noted that the liner perforations occurred horizontally at elevations corresponding to levels at which the tank liquid had been held for long periods. The LAI regions are known to be susceptible to pitting if waste chemistry and tank headspace conditions are not controlled. The LAI region is an evaluation factor and should be included in the SST inspections.
3.4.3 Signs of Liquid Intrusion

An intrusion is the undesirable and unplanned entry of water to an SST. With the elimination of a pressurized water supply to the SST farms, excluding the farms with waste retrieval operations, intrusion water consists of rain, snow melt, or condensation seeping into a tank from pits, risers, or other openings to the tank. The following terms should be used in the inspection reports.

- **Intrusion visually confirmed** – An intrusion that is visually confirmed is one where drips onto the waste surface from the tank dome have been observed.

- **Intrusion confirmed** – An intrusion that is confirmed, but not visually confirmed, is one where no drips were observed but tank level change data, and usually a liquid pool size increase, indicate that an intrusion has occurred and is still occurring.

- **Possible intrusion** – A possible intrusion is one that is not confirmed but where either level change data, pool size change, or other visual evidence indicates an intrusion likely occurred in the recent past but the evidence is not sufficient to confirm an intrusion is occurring.

Intrusion into SSTs is cause for concern, especially in SSTs that are known or assumed leakers. Liquid provides the medium and driving force to carry contaminated materials through the breached liner into the surrounding soil, depending on the location of the flaw in the liner. Figure 3-27 provides an example of water intrusion into Tank T-102.

The photograph in Figure 3-27 was taken April 30, 1980. During the period from about 1978 to 1984, Line 6175 in T Farm was suspected to be actively draining rainwater and snowmelt from the Tank TR-153 booster pump pit into Tank T-102 via one of the tank’s sidewall nozzles. The estimated drainage during the period was reported as 2,600 gal.

Figure 3-28 provides an example of visually confirmed liquid intrusion into a pool in Tank BY-103 in February 2014.
Figure 3-27. Signs of Liquid Intrusion (Tank T-102)

Figure 3-28. Signs of Liquid Intrusion (Tank BY-103)
4.0 EQUIPMENT DESCRIPTION

Camera systems used in Hanford DSTs and SSTs for remote visual inspections are all compact radiation-resistant units. Tank access riser diameters typically limit the use of some of the more powerful camera and lighting systems available. Each camera used provides a real-time image to a viewing system, which is monitored and recorded by tank farms personnel. The lighting intensity can be adjusted based on the application to ensure the minimum luminance requirement of the camera is met. The camera zoom, pan, and tilt functions can also be adjusted by tank farms camera operators to highlight and closely view areas of interest in the tank. Table 4-1 summarizes the features of cameras used for waste storage tank inspections. All equipment used for monitoring or inspection is qualified for use by performance demonstration.

Table 4-1. Remote Camera Inspection System Features

<table>
<thead>
<tr>
<th>Camera System</th>
<th>Zoom</th>
<th>Pan</th>
<th>Tilt</th>
<th>Resolution</th>
<th>Light output</th>
<th>Minimum access diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE System - PTZ140</td>
<td>36x optical</td>
<td>360 degrees</td>
<td>129 degrees</td>
<td>470 HTV lines</td>
<td>Two 35 W lamps</td>
<td>6-in. riser</td>
</tr>
<tr>
<td></td>
<td>12x digital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GE System - PTZ70</td>
<td>10x optical</td>
<td>360 degrees</td>
<td>135 degrees</td>
<td>470 HTV lines</td>
<td>Eight 4 W lamps</td>
<td>3-in. riser</td>
</tr>
<tr>
<td></td>
<td>4x digital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RJ Electronics RCS-2010-B</td>
<td>10x optical</td>
<td>360 degrees</td>
<td>150 degrees</td>
<td>470 HTV lines</td>
<td>One 71 W lamp</td>
<td>3-in. riser</td>
</tr>
<tr>
<td></td>
<td>4x digital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Supplemental lighting is also used in combination with the inspection camera lights to aid in viewing areas at farther distances. These lighting systems vary in size and intensity based on the desired result (e.g., spot lighting or full headspace illumination). The use of supplemental lighting may be required during specific SST inspections due to the proximity of the riser to the regions of interest.
5.0 RECORDS

All photograph and video records will be stored for a minimum of 20 years by records management per TO-020-142 and TFC-BSM-IRM_AD-C-05, *Photographic and Video Production*.

All reports detailing the results of inspections performed in DSTs and SSTs will be submitted and stored by records management per TFC-BSM-IRM_DC-C-02, *Records Management*. 
6.0 REFERENCES

ACI 201.1, 2008, Guide for Conducting a Visual Inspection of Concrete in Service, R-08, American Concrete Institute, Farmington Hills, Michigan.


RPP-RPT-31599, 2013, Double-Shell Tank Integrity Inspection Report for 241-AN Tank Farm, Rev. 5, Washington River Protection Solutions, LLC, Richland, Washington.


