Remote Visual Inspection of Hanford Site Single-Shell Tanks
Hanford Site, Washington, USA - 11335

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ABSTRACT

The waste contained in the 149 single-shell tanks is actively being retrieved and stored in 28 double-shell tanks which provide improved leak integrity and better accessibility for inspection. The waste being staged in the double-shell tanks will be removed and sent to the Waste Treatment and Immobilization Plant, for treatment and vitrification.

Waste retrieval from the single-shell tanks will continue for several decades requiring single-shell tanks to remain in service long past the initial design life. Due to the extended use of single-shell tanks, a panel of subject matter experts was commissioned to aid the Tank Operating Contractor in better understanding the current structural integrity of the single-shell tanks. One of the recommendations made by the panel was to perform visual inspections of the single-shell tanks to identify signs of degradation in the concrete dome.

Remote visual inspection is the currently utilized method of performing qualitative in-service inspections. These inspections supply an overview of the condition of the tank providing valuable information related to concrete degradation (i.e. cracks, spalling, rust stains). Remote inspection equipment is utilized in the nuclear industry for its ability to allow workers to maintain safe distances from radioactive and chemical exposure while still obtaining high quality imagery.

INTRODUCTION

The River Protection Project (RPP) is a key element of the U.S. Department of Energy (DOE) environmental clean-up of the stored byproducts of World War II and cold-war era nuclear weapons production at the Hanford Site in southeastern Washington State. The RPP mission is to store, retrieve, treat, and dispose of the highly radioactive waste in tanks in an environmentally sound, safe, and cost-effective manner [1]. These activities require the storage, treatment, and disposal of mixed waste, which requires compliance with radioactive and dangerous waste regulations.

Accomplishing the RPP mission requires providing and maintaining adequate tank capacity for waste storage and waste feed delivery to the Waste Treatment and Immobilization Plant (WTP). The waste contained in the 149 single-shell tanks (SSTs) is actively being retrieved and stored in 28 double-shell tanks (DSTs), which provide improved leak integrity and better accessibility for inspection. The integrity of the SSTs [2] and DSTs [3] have been addressed per the requirements found in the State Washington Administrative Code [4].

The Tank Operating Contractor (TOC) initiated an enhanced Single-Shell Tank Integrity Project (SSTIP) in 2008. This project improves the understanding of the SST integrity to support the continued use of the SSTs to hold waste. The use of the SSTs would allow the safe and effective management of the waste, as well as assuring that once retrieved the tanks will remain structurally sound through the life of the mission. An SSTIP expert panel was assembled to identify and recommend ways to enhance ongoing tank integrity activities. The panel made 10 primary and 23 secondary recommendations to enhance the SSTIP [5]. As part of the structural integrity enhancements, the panel recommended a one-time visual inspection as a nondestructive evaluation (NDE) technique to gain insight to the current condition of the tanks' concrete.

The TOC adopted this recommendation as a baseline activity for the SSTIP [6]. The use of visual inspections of waste storage tank interiors provides a qualitative indication of the aging mechanisms present in SSTs. In conjunction with other recommendations these inspection will give a robust understanding to the structural integrity of the SSTs.

DESCRIPTION OF SINGLE-SHELL TANK SYSTEM

The SSTs were constructed over a period of roughly 22 years (from 1943 to 1965), with a presumed design life of 20 years. Table I covers the construction dates, number and type of tanks, design capacity, and current age. The SSTs were constructed to store the radioactive waste produced by the irradiated reactor fuel reprocessing facilities located in 200 East and 200 West Areas.

The SSTs consist of a single steel liner which is surrounded by a reinforced concrete structure. The steel liner rests atop a layer of grout and waterproofing asphalt membrane that separates it from the concrete structure. 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 (See Fig 1). None of these designs has a secondary containment or utilized post-weld heat treatment to reduce welding stresses and minimize the possibility of stress corrosion cracking failure.

There are two SST diameters 6.1-m (20-ft) and 22.9-m (75-ft). The tanks range from 7.6-m (25-ft) to 14.9-m (49-ft) in height depending on storage capacity. The concrete structures vary in thickness based on the type of SST as well as the location on the tank structure. The SST headspaces are enclosed by reinforced concrete with access penetration risers located in various regions of the tank dome. 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.

Table I. Single-Shell Tank Construction and Age as of 2010.

Tank Farm	Number of Tanks	Tank Type	Capacity (Liters)	Construction Period	Initial Operation	Current Age (Years)
241-A	6	Type IVB	3,785,412	1953-1956	1956-1957	56
241-AX	4	Type IVC	3,785,412	1963-1965	1965	45
241-B	4 - 200 Series	Type I	208,198	1943-1944	1952	58
	12 - 100 Series	Type II	2,006,268	1943-1944	1945-1947	65
241-BX	12	Type II	2,006,268	1946-1947	1948-1951	62
241-BY	12	Type III	2,869,342	1948-1949	1950-1951	60
241-C	4 - 200 Series	Type I	208,198	1944-1945	1947-1948	63
	12 - 100 Series	Type II	2,006,268	1943-1944	1946-1948	64
241-S	12	Type III	2,869,342	1950-1951	1952-1953	60
241-SX	15	Type IVA	3,785,412	1953-1955	1954-1959	57
241-T	4 - 200 Series	Type I	208,198	1943-1944	1952	58
	12 - 100 Series	Type II	2,006,268	1943-1944	1945-1947	67
241-TX	18	Type III	2,869,342	1947-1948	1950-1952	62
241-TY	6	Type III	2,869,342	1951-1952	1953	59
241-U	4 - 200 Series	Type I	208,198	1943-1944	1954-1956	54
	12 - 100 Series	Type II	2,006,268	1943-1944	1946-1949	64
Total	149					

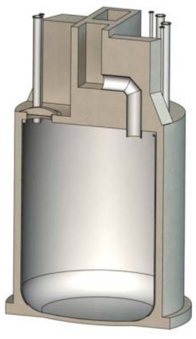
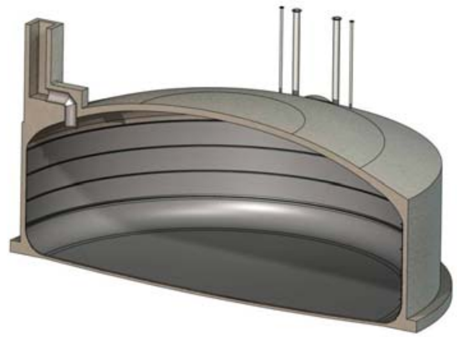
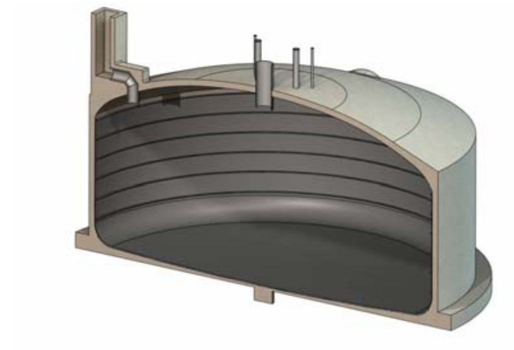
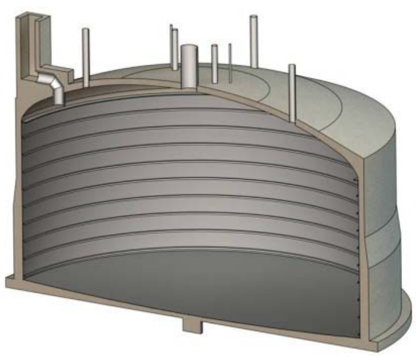
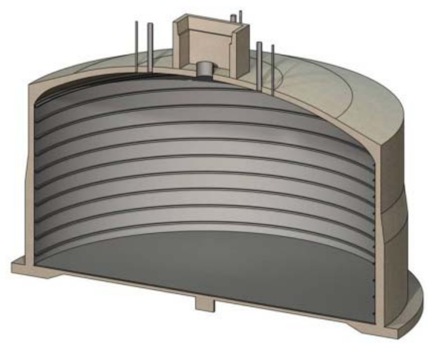
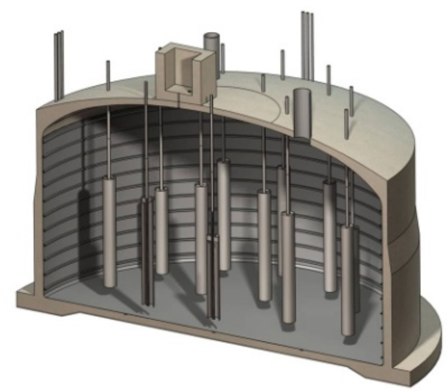
SST Type I **208,198 L** 	**SST Type II** **2,006,268 L** 	**SST Type III** **2,869,342 L** 
SST Type IVA **3,785,412 L** 	**SST Type IVB** **3,785,412 L** 	**SST Type IVC** **3,785,412 L** 

Fig. 1. Single-Shell Tank Types

SINGLE-SHELL TANK VISUAL INSPECTION EQUIPMENT

Camera systems used in Hanford SSTs for remote visual inspections are compact radiation resistant units. The small diameter of most tank access risers, and their limited number typically limit the use of some of the more powerful camera and lighting systems available. The camera provides a real-time image to a viewing system which is monitored and recorded by tank farm personnel. The lighting intensity can be adjusted based on the application to ensure the luminance requirement of the camera is met. The camera zoom, pan, and tilt functions can also be adjusted by tank farm camera operators to highlight and closely view areas of interest in the tank. All equipment used for monitoring or inspection is qualified for use by performance demonstration. See Table II for features of the camera used for SST waste storage tank inspections.

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 (i.e. spot lighting or full headspace illumination).

Table II. Remote Camera Inspection System Features.

Equipment	Zoom	Pan	Tilt	Resolution	Light Output	Minimum Access Diameter
GE System - PTZ140	36x Optical 12x Digital	360 Degrees	129 Degrees	470 HTV Lines	Two 35 watt lamps	15.2-cm (6-in) Riser

SINGLE-SHELL TANK INSPECTION SEQUENCE

As a part of the selection process for the first year of SST inspections, the TOC determined that the initial twelve tanks to be inspected during FY 2010 be a representative sample of the 149 SSTs located on the Hanford site [6]. The tanks would represent structures with different configurations and subjected to various conditions. Such conditions/configurations include:

- Suspected Tank Integrity – Confirmed leaking SSTs typically were subjected to harsh conditions such as temperature spikes during waste additions. The effects of these conditions could also have potential effects to the concrete dome condition.

- Tank Type – The geometry of the tank's concrete shell varies by tank type. Differences in concrete reinforcement, wall thickness, and riser penetrations could lead to a correlation between in-tank inspection findings and the structure.

- Waste Types – SSTs received various types of waste during their service. The visual inspection of the interior structure may provide insight on the condition of the steel in terms of corrosion and the concrete if gas release events were a factor.

- Exposed Sidewall – Tanks with large amounts of exposed steel liner present a greater opportunity to inspection a larger percentage of the steel, thus increasing the ability to determine their current condition.

- Accessibility – Available risers for the use of remote visual inspection dictates the selection of equipment (riser penetration sizes) and location in the tank. Tanks with current riser availability allow inspections to occur quickly.

- Dome Loading – There are areas of relatively higher dome loads based on historic in-tank inspections. This includes large masses of saltcake crystals adhered to equipment suspended from the tank dome.

- Concrete Dome and Waste Temperatures – Large fluctuations in tank waste and concrete temperatures in excess of 121°C (250°F) can contribute to degradation in the mechanical properties of the concrete.

- Other Physical Anomalies – These would include the additions of various chemicals (resin, Portland Cement, acids), bulged liners, etc.

By using the selected criteria, SSTs were chosen to cover as many combinations of conditions. By inspecting these tanks future inspections can be further prioritized to focus first on tanks which have similar characteristics of tanks which show signs of degradation.

SINGLE-SHELL TANK INSPECTION CRITERIA

The criteria provided to tank farm inspectors for the examination of the reinforced concrete dome include the identification of concrete spalling, rust stains, cracks ≥ 0.159-cm (1/16-in) wide, and visible reinforcing steel patterns. All of these indications would suggest a certain level of degradation of the concrete dome.

SINGLE-SHELL TANK INSPECTION RESULTS

Tanks inspected in Fiscal Year (FY) 2010 include SSTs 241-A-105, 241-A-106, 241-AX-102, 241-B-102, 241-BY-110, 241-C-110, 241-S-101, 241-S-103, 241-S-104, 241-S-108, 241-SX-101, and 241-U-104. Results of the inspections showed no detectable change in the concrete dome condition from previous inspections [7]. A primary focus of the inspections was the tank haunch section of the concrete dome where extensive cracking would suggest too high of a demand on the reinforced dome in its current condition. No areas of concern were noted in any of the FY 2010 inspected SST reinforced concrete domes. The appearance of the SST steel liner surface is highly variable compared to the concrete surfaces, for example Figure 2 highlights the interface point of the concrete haunch, lead flashing, and the steel liner in tank 241-U-104 during the FY 2010 visual inspection.

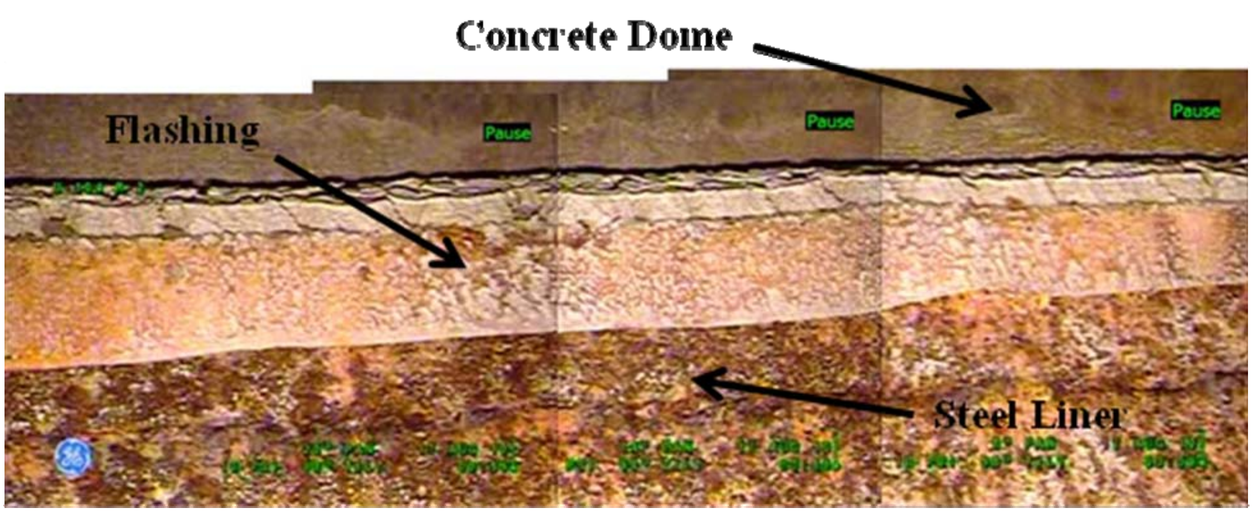


Fig. 2. FY 2010 Inspection of Tank 241-U-104 Steel Liner and Reinforced Concrete Haunch

Qualitative comparisons are performed whenever possible to attempt to identify any changes in the tank's condition since the last in-tank inspection. Photographs of each SST have been periodically taken throughout their service life up until 1993. These photos provide a baseline for comparative changes in the tank condition. Figure 3 and Figure 4 provide examples of the tank haunch regions in tanks 241-B-102 and 241-C-110 compared to the condition in the 1985 and 1986 inspections.

Fig. 3. Comparative Photographs of Tank 241-B-102 Haunch Region

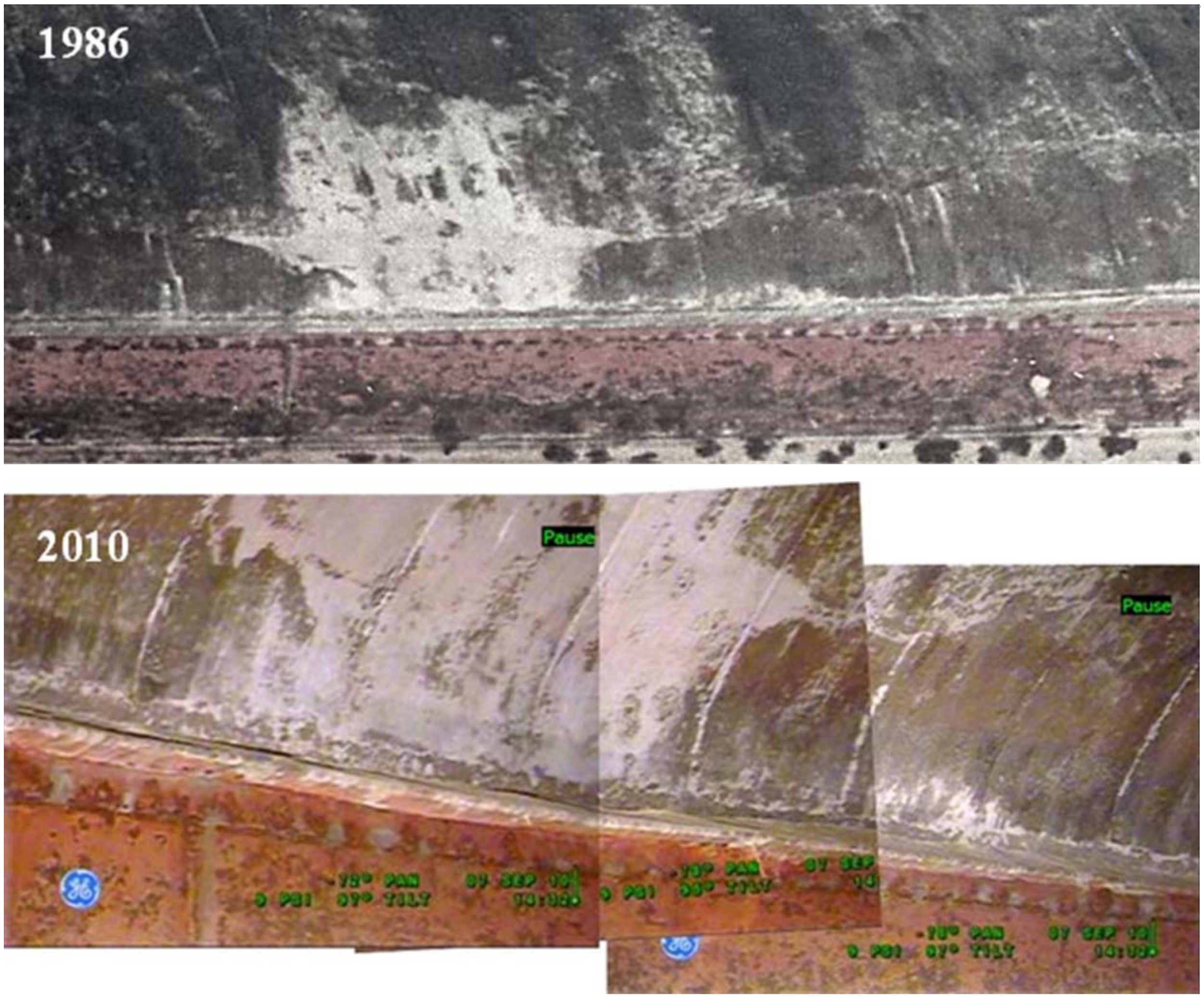


Fig. 4. Comparative Photographs of Tank 241-C-110 Haunch Region

SUMMARY

The concrete domes of twelve Hanford SSTs were inspected during FY2010 using a remotely-operated video camera inserted into the dome space through an access riser. The objective of the inspections was to determine the condition of the concrete dome based on its surface appearance, and from the appearance make conclusions about the structural integrity. Indications of concrete spalling, rust, cracks wider than 0.159-cm (1/16-in), and reinforcement steel patterns were used to identify suspect integrity.

Selection of the FY2010 SSTs was based on process and thermal histories, as well as tank design, to ensure a broad cross-section of Hanford's 149 SSTs were evaluated. None of the twelve inspections detected meaningful changes in the appearance of the concrete since the last inspection entries two to three decades ago. During FY2011 the interior concrete in an additional twelve SSTs will be inspected. In addition, the tank's liner condition will be examined to look for areas of interest.

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