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241-AW Double-Shell Tanks Integrity Assessment Report

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Abstract: This report presents the results of the integrity assessment of the 241-AW double-shell tank farm facility located in the 200 East Area of the Hanford Site. The assessment included the design evaluation and integrity examinations of the tanks and concluded that the facility is adequately designed, is compatible with the waste, and is fit for use. Recommendations including subsequent examinations, are made to ensure the continued safe operation of the tanks.

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**DELIVERABLE FOR CONTRACT
NUMBER 503, RELEASE NUMBER 57,
THE INTEGRITY ASSESSMENT REPORT
OF 241-AW DOUBLE-SHELL TANKS
(HNF-4529, Rev. 0)**

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Date Published:

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241-AW DOUBLE-SHELL TANKS
INTEGRITY ASSESSMENT REPORT

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**CERTIFICATION OF
241-AW DOUBLE-SHELL TANKS
INTEGRITY ASSESSMENT REPORT**

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based upon my assessment of the plans and procedures utilized for obtaining this information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

Tarlok S. Hundal, P.E.

9/1/99
Date

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241-AW DOUBLE-SHELL TANKS

INTEGRITY ASSESSMENT REPORT

1.0 INTRODUCTION

The 241-AW Tank Farm consists of six double-shell tanks located in the 200 East Area of the Hanford Site (Figure 1). These underground tanks were built under Project B-120 to provide long-term storage for the caustic high-level radioactive waste from various weapons processing facilities at Hanford. Waste is transferred to and from these tanks through a network of interconnecting underground piping and other ancillary facilities.

Lockheed Martin Hanford Corporation (LMHC) manages this facility for the U.S. Department of Energy, Richland Operations Office (DOE-RL). Chapter 173-303-640(2) of the Washington State Department of Ecology (WDOE) Dangerous Waste Regulations, Washington Administrative Code (WAC 1998) requires the performance of an integrity assessment for each existing tank system scheduled to store or treat dangerous waste. The *Double-Shell Tank System Integrity Program Plan* (DOE 1997) provides guidelines for the assessment activities.

The integrity assessment has two main parts: the design evaluation that addresses the adequacy of the design standards and corrosion protection measures, and the integrity assessment examination that shows the tank is not leaking and is in acceptable condition for further use.

2.0 PURPOSE

The purpose of this integrity assessment is to evaluate the condition and determine if the AW Tank Farm tanks were adequately designed with sufficient structural strength and compatibility with the waste so that they will not collapse, rupture, or fail during the facility's use.

The following shall be considered:

Design Standards- identify and evaluate the criteria to which the system was constructed and maintained.

Waste Characteristics- identify the waste (past and projected) and evaluate the adequacy of the design to handle the waste.

Corrosion Protection Measures- identify the material and evaluate the design and the operational practices for corrosion protection.

Age- document, estimate, or otherwise determine the age of the system.

Integrity Examinations- identify the existing condition of each component material based upon leak testing, visual examination, and/or ultrasonic (UT) inspection.

3.0 SCOPE

The scope of this integrity assessment includes all six AW double-shell tanks, the primary steel tank and the secondary concrete tank with steel liner plate. The integrity assessment of the transfer lines and pits associated with AW Tank Farm is not included in this report. The assessment of these lines and pits was reported in the *Double-Shell Tank Waste Transfer Piping/Pit System Integrity Assessment Report* (Hundal 1997).

4.0 DESCRIPTION

A typical AW double-shell tank consists of a 75-ft. diameter x 46.75-ft. high (between bottom of tank to high point of dome) primary steel tank made of ASTM A 537, Class 1 welded steel plates of varying thickness, 7/8 in. at bottom knuckle, 3/4 in. to 1/2 in. to 3/8 in. for the cylindrical shell, and 3/8 in. at the dome. The bottom of primary tank is built of 1/2-inch-thick plate. The primary tank is enclosed in an 80-ft. diameter secondary tank with a 2-ft. 6-in. annular space to monitor any leaks from the primary tank and for ventilation of the tank system. The entire secondary tank is made of 3/8-inch-thick ASTM A 537; Class 1 welded steel plates and is enclosed in a reinforced concrete shell (Drawing H-2-70394). The reinforced concrete shell tank has an 18-inch-thick wall, a 15-inch-thick dome and a varying foundation thickness of 2 ft. to 1 ft. The primary tank rests on an 8-inch-thick insulating concrete pad with air circulating vents radiating from the center out to the annulus area. The primary tank is capable of holding 1,000,000 gallons (specific gravity 2.0) or 1,140,000 gallons (specific gravity 1.7) of aqueous waste and solids. There is approximately 6.5 ft. of soil overburden over the top of the concrete tank dome (Figure 2).

4.1 DESIGN STANDARDS

The following paragraphs provide design requirements and other factors used in assessing the integrity of the AW double-shell tank system. The functional design criteria (ARH 1975) provided the design requirements for the AW Tanks Farm. Project B-120-C1 through C7,

and B-120-D1 specifications, provided the construction and design requirements for the AW Tank Farm, respectively. The AW tanks were designed, fabricated, and built during 1978-1980, per American Society of Mechanical Engineers Boiler and Pressure Vessel Code, ASME Section VIII, Division 2 (ASME 1974) and American Concrete Institute ACI 318 (ACI 1971) requirements. All welds were 100% visually inspected per Hanford Plant Standards (HPS) HPS-220-W and HPS-240-W. Nondestructive examination was performed on the primary and secondary tank welds. This included liquid penetrant examination of all welds on the interior surfaces of the primary and secondary tank bottoms to and including the top of bottom knuckles, and radiographic examination of all butt welds on the primary and secondary tanks except the welds of the cylindrical shell to the top dome knuckle and the welds located in the roof (knuckle and dome). The liquid penetrant examinations were performed before and after the bottoms were set in place, and furthermore, the welds on the interior surface of the bottom of the primary tank were examined after the tank was stress-relieved. Magnetic particle examinations were applied to weld repairs and to any surfaces where lugs, clips, etc. were removed and/or repaired. After the completion of the primary tank plates' welding and inspections/examinations, each tank was stress-relieved in accordance with ASME Section VIII, Div. 2 requirements. Stress relieving was conducted in order to mitigate nitrate-induced stress-corrosion cracking. After the primary tank was stress-relieved, it was successfully hydrostatic pressure tested by filling the tank with water up to a depth of 35 feet from the tank bottom for 24 hours.

The tank system was designed for a 50-year life expectancy with the primary tank plate total corrosion allowance of 0.050 in. (1 mil/year). The design cyclic loading consisted of 10 liquid level (full and empty) cycles and 10 thermal (from 70EF to 350EF and back to 70EF) cycles per year. The tanks were designed to withstand loads caused by Safe Shutdown Earthquake as defined in HPS SDC-4.1 (SDC 1974). This is equivalent to 0.25g horizontal and 0.17g vertical ground accelerations. Hydrodynamic effects were included in evaluating the structures considered with the primary tank full of waste. Wind loads were considered for the tank system during construction phase per HPS SDC-4.1 (SDC 1974) requirements.

4.2 WASTE CHARACTERISTICS AND COMPATIBILITY

The AW Tank Farm began to receive waste in July 1980 (Brevick 1995a, Brevick 1995b); each of the tanks has had a slightly different waste history. Waste descriptions, past and future are described below by tank in Table 1. Based on forecasts by Kirkbride et al (Kirkbride 1999), the AW tanks appear to be scheduled to be the source tanks for the vitrification process beginning around 2010-2020.

Table 1 Tank Composition History and Forecast

AW-101	
Past Waste Descriptions	<p>The initial waste into AW-101 in 1980 was non-complexed. That was followed by double-shell slurry, more non-complexed waste, and finally more double-shell slurry. In between the episodes of filling, the tank was emptied to various extents. The tank was filled with non-complexed waste in 1986. Since that time, no additional waste has been added. The current waste is designated double-shell slurry feed. In addition to a wide range of cations (ions of various metals), the waste contains the major anions shown in Table 2 plus approximately 3 wt. % residual complexants (Field 1998a).</p> <p>In 1993, it was designated a Hydrogen Watch List tank.</p>
Projected Future Waste	No waste additions are forecast at least through 2008 (Strode 1998).
Safety Considerations <ul style="list-style-type: none"> • Corrosion • Flammability • Waste Compatibility • Criticality 	<p>Although the tank is on the Hydrogen Watch List, hydrogen concentrations only amount to about 3% of the lower flammability level (LFL) (Field 1998a). Hu (Hu 1997) suggests it would take 54 days to reach 25% of the LFL if the only ventilation were barometric breathing. These numbers are based on undisturbed waste. If the waste were to turn over or be disturbed by the insertion of probes or other devices, there could be a sudden release of flammable gas. This is discussed and control methods (control of ignition sources and monitoring) are described by Noorani et al (Noorani 1998). Field further states that energetics, corrosion, and criticality are not a concern in AW-101. Nevertheless, as noted in the Part B Permit Application (DOE 1991), special procedures are in place for operational safety.</p>

AW-102	
Past Waste Descriptions	<p>The initial waste into AW-102 in 1980 was non-complexed. Since then, it has mostly received non-complexed and dilute non-complexed waste. It has also received Hanford Facilities waste. In addition to a wide range of cations (ions of various metals), the waste contains the major anions shown in Table 2 and less than about 1 wt. % of residual complexants (Brevick 1995a).</p> <p>The tank currently serves as a feed tank for the 242-A evaporator.</p>
Projected Future Waste	According to Strode (Strode 1998), beginning in 1999 this tank will be used as spare space. On an as-needed basis, dilute waste will be received from various holding tanks including AP-105. The dilute waste will then be fed to the 242-A evaporator.
Safety Considerations <ul style="list-style-type: none"> • Corrosion • Flammability • Waste Compatibility • Criticality 	<p>Hu (Hu 1997) suggests it would take 54 days to reach 25% of the LFL if the only ventilation were barometric breathing. These numbers are based on undisturbed waste. If the waste were to turn over or be disturbed by the insertion of probes or other devices, there could be a sudden release of flammable gas. This is discussed and control methods (control of ignition sources and monitoring) are described by Noorani et al (Noorani 1998). Blaak (Blaak 1999a) has noted that AW-102 is in compliance for flammability, energetics, criticality, and corrosivity.</p>

Table 1 Tank Composition History and Forecast (continued)

AW-103	
Past Waste Descriptions	The initial waste into AW-103 in 1980 was non-complexed. It has also received dilute PUREX waste, dilute double-shell slurry feed waste, additional non-complexed waste, and PUREX neutralized cladding removal waste. It has not received waste since 1992 and is considered an inactive dilute receiver tank. In addition to a wide range of cations (ions of various metals), the waste contains the major anions shown in Table 2 and only traces of residual complexants (Brevick 1995a).
Projected Future Waste	AW-103 is nearly full and has no near-term waste input projections except for possible topping with double-shell slurry feed (Strode 1998).
Safety Considerations <ul style="list-style-type: none"> • Corrosion • Flammability • Waste Compatibility • Criticality 	<p>According to Dodd (Dodd 1994) and Field (Field 1998b), Tank AW-103 is currently in compliance on all safety criteria.</p> <p>UT thickness measurements were made on both the primary and secondary steel shells. No measurements of thinning that exceeded 10% of the nominal wall thickness or pitting that exceeded 25% of the wall thickness were observed (Leshikar 1997). This is consistent with the comments of Dodd and Field above.</p>

AW-104	
Past Waste Descriptions	The initial waste into AW-104 in 1980 was non-complexed. Then it received complexed waste for about a year. Beginning in 1982, it contained non-complexed waste for about eight years. It has also contained PUREX waste. It currently contains dilute non-complexed waste. However, it has not received waste since 1992 and is considered an inactive dilute receiver tank. In addition to a wide range of cations (ions of various metals), the waste contains the major anions shown in Table 2 and trace amounts of organic compounds (Brevick 1995a).
Projected Future Waste	AW-104 is currently full and will remain so until late 1999 when the supernate will be transferred to the evaporator. Then it will begin to receive double-shell slurry from the evaporator and be filled by the end of 2000 (Strode 1998).
Safety Considerations <ul style="list-style-type: none"> • Corrosion • Flammability • Waste Compatibility • Criticality 	According to Dodd, Tank AW-104 is currently in compliance on all points (Dodd 1994). Waste sent to the tank in the future will be reviewed on a case-by-case basis and will have to meet the safety requirements.

AW-105	
Past Waste Descriptions	The initial waste into AW-105 in 1980 was non-complexed. It has received PUREX, non-complexed waste, and double-shell slurry feed. Since about 1990, it has contained dilute non-complexed waste and PUREX neutralized cladding removal waste. It is considered an active, dilute receiver tank for PUREX waste. In addition to a wide range of cations (ions of various metals), the waste contains the major anions shown in Table 2 and less than about 1 wt. % of residual organics and complexants (Brevick 1995a).
Projected Future Waste	Little activity is forecast by Strode (Strode 1998) through the end of 2000 except for receipt of 100 Area waste, which continues through 2005. At the end of 2000, it will begin to transfer waste to the evaporator though at least 2001.
Safety Considerations <ul style="list-style-type: none"> • Corrosion • Flammability • Waste Compatibility • Criticality 	Blaak (Blaak 1999b) has noted that AW-105 is in compliance for flammability, energetics, criticality, and corrosivity.

Table 1 Tank Composition History and Forecast (continued)

AW-106	
Past Waste Descriptions	The initial waste into AW-106 in 1980 was complexant concentrate. Since then, it has mostly received complexed, concentrated waste, double-shell slurry feed, and non-complexed wastes. Since 1990, it has contained dilute non-complexed waste. It is an active slurry receiver tank for the 242-A evaporator. In addition to a wide range of cations (ions of various metals), the waste contains the major anions shown in Table 2 and about 1 wt. % of residual organic materials and complexants (Brevick 1995a).
Projected Future Waste	According to Strode (Strode 1998), beginning in 1999, this tank will be used as spare space with occasional transfers from the evaporator.
Safety Considerations <ul style="list-style-type: none"> • Corrosion • Flammability • Waste Compatibility • Criticality 	Blaak (Blaak 1999c) notes that the waste in AW-106 is compliant with each of the safety considerations.

In addition to the observed compliance with the safety considerations, including corrosion, a more detailed corrosion evaluation follows. Average anion data (Table 2), the chemical species critical to compatibility of the waste with the tanks, have been taken from the Hanford files and abstracted from the noted documents. These data have been evaluated using the relationships developed by Divine (Divine 1985). The tanks have been found to be in compliance with the corrosivity requirements as has also been noted in Table 1.

Table 2 Tank Anion Content and Temperatures

	NO ₃ ⁻ mol/L	NO ₂ ⁻ mol/L	OH ⁻ mol/L	PO ₄ ⁻³ mol/L	SO ₄ ⁻² mol/L	AlO ₂ ^{-a} mol/L	T ^{b, #} °F
AW-101 ^{c, d}	2.6	2.4	5.58	0.01	0.04	0.47	98, 135
AW-102 ^e	0.56	0.51	0.43	0.01	0.01	0.03	79, 130
AW-103 ^{f, g}	0.07	0.03	0.19	0.01	0.01	0.00	76, 100
AW-104 ^h	2.6	2.2	0.2	0.01	0.01	0.00	90, 133
AW-105 ^{i, j}	0.5	0.08	0.5	0.0	0.01	0.00	77, 110
AW-106 ^{k, l}	1.9	1.9	0.8	0.02	0.05	0.31	89, 123

a - Hu 1997; b - Brevick 1995; c - Esch 1999; d - Benar 1998; e - Hardy 1998; f - Steen 1998a; g - Field 1998b; h - Steen 1997;

i - Esch 1997; j - Field 1998c; k - Tillman 1992; l - Steen 1998b

Temperatures are average and maximum.

Data from Hu (Hu 1997) for the nitrate, nitrite, and hydroxide concentrations vary slightly from the data shown in the table, but do not change the conclusions.

4.3 CORROSION PROTECTION

The corrosion protection is provided by design (selection of materials) (Vitro 1976a & b) and administrative controls (Kirch 1984). These protective features are discussed in the following paragraphs.

4.3.1 Corrosion Degradation Considerations

Several corrosion or degradation mechanisms were suggested by an expert panel (BNL 1997). These include:

- General (uniform) corrosion
- Pitting and crevice corrosion
- Stress-corrosion cracking
- Microbiologically-influenced corrosion
- Atmospheric corrosion
- Concentration cell or waterline corrosion
- Fatigue
- Wear
- Erosion and erosion corrosion
- Hydrogen embrittlement/Hydrogen-induced cracking
- Thermal embrittlement
- Radiation embrittlement
- Creep and stress relaxation
- Radiation-enhanced corrosion

Of these, only the first five are of concern. The remaining nine mechanisms would, if applicable, mainly affect the primary tank. They are briefly described and then readily eliminated.

- **Concentration cell or waterline corrosion has been** considered a possible problem. However, Zapp (Zapp 1992) has noted that unless the pH of the bulk waste is less than 9.5, there is no significant effect. Escalante (Escalante 1992) observed in his work that the waterline or meniscus region tends to be cathodically protected by the bulk waste.
- **Fatigue** is typically a concern only when the number of operating cycles exceeds about 1,000. According to the design document (Vitro 1976b), the expected number of operating cycles during the entire life is less than 1,000. Further, Schwenk and Scott (Schwenk 1996) have shown that the combination of system chemistry and the less severe operational cycling make corrosion fatigue insignificant.
- **Wear** is the degradation of the metal surface by motion against another surface. If the two surfaces are of the same composition, the wear is usually called fretting. There are two main locations where wear might occur: a) the lower surface of the bottom of the primary tank where it is in contact with the insulating concrete, and b) the region where the primary and secondary tanks meet at the top. The driving force for the motion is thermal expansion. As with fatigue, the number of temperature cycles is few so the amount of movement will be minimal. Though damage is visible after one cycle, it is not severe on iron even at 300,000 cycles (Davis 1987). Similar wear effects on the secondary tank are ignored because of the lower temperature differentials.
- **Erosion and erosion corrosion** were discussed by Smith and Elmore (Smith 1992). They observed little effect even when high velocity pumps were used to mix the waste. In normal operation, the flows are too slow to be of concern.

- **Hydrogen embrittlement and hydrogen-induced cracking** have not been observed in metals with strengths less than about 75 ksi (Davis 1987).
- **Thermal embrittlement** also does not occur at temperatures at or below the design temperature; there is essentially no diffusion of carbon in the metal (Bardes 1987).
- **Radiation embrittlement**, induced by high neutron fluxes, is not of concern in the tanks, because, unlike nuclear power plants, they generate essentially no neutrons and those produced are rapidly thermalized by the aqueous solutions.
- **Creep and stress relaxation** are high temperature (e.g., greater than about 500°F) phenomena. Again, according to the design documents (Vitro 1976a, Vitro 1976b), the design temperature is only 350°F. For A537 steel, there is little creep at temperatures up to the design value (Bardes 1987).
- **Radiation-enhanced corrosion** has been observed in neutral pH systems when the gamma dose rate exceeds 10^3 R/h (Davis 1987). Similar results were found by providing hydrogen peroxide. Because of the high alkalinity of the waste and the presence of the nitrite, no significant radiation effect is expected in the double-shell tanks.

The remaining five topics which are of potential concern, can affect either of the tanks or, in some cases, the concrete.

- **General (uniform) corrosion** in the liquid waste is a function of the waste composition. When the waste composition is maintained within the corrosion specifications (Kirch 1984), the corrosion rate is expected to be less than about 0.0005 in. per year (Divine 1985).

In general, the corrosion of the exterior of the annulus will be small because it is in contact with concrete. Local exceptions may occur if rainwater has penetrated between the concrete and the steel and reduced the pH. Corrosion of steel in Hanford soil tends to be approximately 0.006-0.008 in. per year (Jaske 1955) with some pitting. Tank characterization reports for AW-101 through AW-106 show that corrosion controls have been maintained (Field 1998a, b, c, d and Lambert 1998a, b).

- **Pitting and crevice corrosion** is not expected to occur in the tanks that are maintained within the corrosion specifications (Kirch 1984). However, in dilute simulated wastes, severe localized corrosion was observed (Divine 1985). These values are excluded by the corrosion specifications. No pitting is expected on the annulus.

It is uncertain the degree to which damage may have occurred during construction. At the Savannah River Site, pitting on the floor of the primary tank was observed during the wet lay-up as described below under microbiologically-influenced corrosion (Ondrejcin 1981).

- **Stress-corrosion cracking** of carbon steel waste tanks has been observed. Tank 16, a Savannah River Site Type II tank (the secondary tank is a 5-ft. high "pan"), went into service in May 1959. By November 15, 1959, crystallized waste was observed in an annulus inspection to be protruding from the exterior surface of the primary (Poe 1974). The cause was attributed to nitrate-induced cracking of the non-heat treated primary tank.

Since that time, all primary tanks, including Hanford tanks, have been heat-treated (Vitro 1976a). Schwenk (Schwenk 1996) has noted there is some concern that the in some cases the stresses in the knuckle are higher than predicted and could lead to stress-corrosion cracking. However, based on corrosion specifications (Kirch 1984), only tanks outside the specification should be liable for cracking.

No secondary tanks are heat-treated and are therefore only permitted to be in contact with the waste for one week (Vitro 1976a) to prevent stress-corrosion cracking failure.

The general corrosion literature notes that caustic cracking can occur if the steel is stressed and the temperature exceeds 140°F (Davis 1987). In their work, Divine et al. (Divine 1985) noted that caustic cracking of U-bends occurred at 140 °F in concentrated caustic solutions or in dilute environments. In both cases, the dangerous concentrations are outside the limits given by the corrosion specifications (Kirch 1984).

Because of its low operating temperature, the secondary tank should be immune to caustic cracking even in contact with the concrete.

- **Microbiologically-influenced corrosion** usually occurs in neutral pH water but can occur under extremes of pH and temperature. The most likely scenario is for microbiologically-influenced corrosion to initiate during the hydrotest period. It is estimated that about four days were required to fill the tank, a minimum of one day (Vitro 1976a & b) to do the test, and another four days to empty the tank. A small heel of water remained and plywood was put down to protect the tank during the final construction work. During the test period and the wet lay-up time, microbiologically-influenced corrosion could have begun. It is unknown whether the temperatures, radiation, or tank chemistry would sterilize the system once operation started.
- **Atmospheric corrosion** will be prevalent in all locations and is expected to be more severe inside the tanks. At the West Valley Nuclear site in New York, corrosion in the liquid, waste similar to that at Hanford, amounted to less than 0.001 in. per year, a value comparable to that at Hanford. In the vapor space above the waste, however, the corrosion rate was approximately 0.004 in. per year (Chang 1998).

The basic atmospheric corrosion rate in the annulus is expected to be low because the relative humidity is low at Hanford, typical corrosion rates are estimated at about 0.0003 in. per year. Due to the radiation field in the annulus, formation of nitric acid from humid air is feasible. However, based on an average humidity of about 55% over the year (Hoitink 1998) and the average radiation field in the annulus (Hu 1997), the estimated annular atmospheric corrosion rate is negligible

4.3.2 Corrective Measures

The only intentional corrective measure for corrosion control specified for out of specification tanks (Mulkey 1998) is to adjust the chemistry to be within specified values.

4.4 AGE OF THE SYSTEM

The farm went into operation in the middle of 1980 (Brevick 1995b). Therefore, it is now 19 years into its 50-year design life.

4.5 INTEGRITY EXAMINATIONS

This section presents the reviews of records and tank examinations that were done to assess the material soundness of the tanks, and to determine whether a tank is leaking or unfit for service. These examinations include the review of double-shell tank leak detection procedures and records, the results of visual examinations conducted on each double-shell tank, and the UT examinations of selected double-shell tanks.

4.5.1 Leak Test

The primary tanks were leak tested after the post-weld heat treatment. The leak test was performed by filling the tank with water to a height of 39 ft. and inspecting all accessible joints after 24 hours (Vitro 1976a). The joints were coated with chalk prior to filling the tank to make leaks easier to detect. No leaks were reported in the construction files.

Once the tanks were placed into service, the primary tank leak detection system, having liquid detection and airborne-radiation detection capability, was monitored; no leaks were detected.

The principal leak detection method is the daily monitoring of fixed height and variable height conductivity probes that detect the presence of liquid. The fixed height probes are adjusted to 1/4 in. above the floor of the secondary tank floor (see the Settlement Agreement and the Stipulated Order of Dismissal), which could detect a leak of less than 100 gallons from the primary tanks if none of the leakage were absorbed by the insulating concrete. The probes are function-tested at least every 182 days, adjusted if necessary, and the test results recorded using tank farms operation procedure (FDH 1999a) and saved in a permanent file. It should be noted that function testing involves pouring water down the conductivity probe, which can partly explain evidence of past liquid puddles on the tank floor under the probe.

Continuous Air Monitoring (CAM) is currently a supplementary leak detection system. Exhaust airflow is continuously sampled for radiation and an alarm condition occurs if the radioactivity level (counts per minute) rise to a predetermined setpoint. If an alarm occurs, the CAM's paper filter is read to determine the cause.

The leak detection systems are monitored daily and the results are reviewed and recorded per tank farms operations procedure (FDH 1999b). No leaks have been detected.

4.5.2 Visual Examination

Video tapes of the six AW tanks accessible from the annulus were examined for visible cracks, potential leak sites, and other physical impairments by trained engineers. The acceptability of the examination system was demonstrated by an acceptance test report (Sumsion 1992). The visual resolution met ASME standards for visual examinations (ASME 1989). Approximately 18% of the outer surface of the primary tanks and 30% of the inner surfaces of the secondary tanks were viewed using remotely-controlled video cameras lowered into the annulus (Walter 1992). Manned entry is not feasible due to the high radiation levels encountered (37 R/hr for AW-101). This visual examination found no indications of primary steel shell tank leakage. Some observations of degradation were noted, but the indications were judged to be not significant.

Rust was noted over many areas of both tanks, more heavily on the secondary tank shell than on the primary shell. This was similar to observations for other tanks. Two suspect indications were followed up by smear samples gathered by a remote mechanical arm. The analysis of the smears did not detect radioactivity greater than background levels, demonstrating that the indications were not due to leaks from the tanks. One puddle of water was observed under a leak detection system conductivity probe, and the report did not attribute this to a cause. Since water is poured down the conductivity probe during functional testing of the leak detection system, that is a probable cause.

Two tanks in the AP tank farm were internally examined using similar video equipment (Anantatmula 1997) and no significant indications were noted. The two tanks were chosen because they contained very low waste volumes, exposing large areas of the tank wall. The significance for the integrity assessment of the SY tanks is that conditions in the tanks that were examined favor atmospheric (or vapor phase) corrosion, and the only indications of this were minor.

4.5.3 Ultrasonic Examinations

In May 1996, the Tank Waste Remediation System Decision Board recommended and DOE-RL agreed that the condition of the double-shell tanks should be determined by UT examination of a limited area in six of the 28 double-shell tanks. The Washington State Department of Ecology (WDOE) has agreed that with the strategy of limited UT examination of six double-shell tanks (DOE 1997). Data collected during the UT examinations will be used to assess the condition of all 28 tanks.

The UT examinations of the six double-shell tanks were completed between November 1996 and June 1999 according to the following schedule:

Tank	Completion Date
AW-103	Nov. 24, 1996 (Leshikar 1997)
AN-107	April 9, 1998 (Jensen 1999a)
AZ-101	May 28, 1999 (Jensen 1999e)
AY-102	June 4, 1999 (Jensen 1999d)
AN-105	June 15, 1999 (Jensen 1999b)
AN-106	June 22, 1999 (Jensen 1999c)

The areas of each tank that were examined generally conform to the Engineering Task Plan (Pfluger 1999) and are shown schematically in Figures 3, 4 and 5. The examinations concentrated on the vertical wall region of the primary tank that is comprised of four or five courses (rings) of welded plates. The plate thickness is constant for each course, but is greater for the lower courses. The range of plate thickness is not the same for all double-shell tank farms. Generally, two vertical 15-inch-wide by full-height (35-ft.) strips were examined as well as 20-ft. lengths of both horizontal and vertical welds in the lower region of the tank. In addition, some primary tank lower knuckles and tank bottoms (above the ventilation slots) were examined. The secondary liner was examined in three tanks. The P-Scan UT inspection system that was used examined the full-thickness volume of the steel plate comprising the tank wall to detect and quantify wall thinning, pitting, and cracking. Reportable levels were 10% of thickness for thinning, 25% of thickness for pitting, and a crack with a size of 0.18 in.

The equipment, procedures, and personnel were qualified to the requirements of Sections V and XI of the ASME Code as described in the examination report for AW-103 (Leshikar 1997), and a demonstration was conducted on a full-size tank section mock-up. The mechanical UT scanner was housed in a remotely-controlled crawler to provide a 15-inch-wide scan path as the crawler advanced in a straight path along the primary tank wall. Water was used as the UT couplant. The electronic data was continuously transmitted via cables to a data acquisition trailer deployed at the site. The data report that was generated for each tank was reviewed independently by two experts and approved by a Level III UT Inspector. A formal report was then issued.

UT examinations were performed on secondary liners in three tanks: AW-103, AN-105, and AN-107. A vertical strip of wall was examined in Tank AW-103, the lower knuckle was examined in Tank AN-107, and the liner floor was examined in Tanks AN-105 and AN-107. See the individual UT reports listed above for the specific areas examined in each double-shell tank. No reportable levels for thinning, cracking, or pitting were found in any of the steel liners.

Six double-shell tanks were selected for UT examination of primary steel tanks based on several factors relating to their design and operating history. These factors included plate material, waste level and chemistry history, waste physical characteristics, waste temperature, and tank age (Schwenk and Scott 1996). Each known or suspected corrosion

mechanism for these steels when exposed to waste environments was considered and four observable conditions were defined that could be detected and measured by the UT equipment. Table 3 lists the main reasons each tank was selected for UT examination and the observable corrosion condition(s) considered most favored by that tank's design and operating history.

The results of the UT examinations of primary tanks are summarized in Table 4 along with the regions of each tank examined. The detailed descriptions of areas examined for each tank are contained in the individual reports listed above. There were no reportable cracks found in any of the six tanks. There was no reportable localized pitting or waterline attack found in any of the six tanks. There was reportable thinning only in two small areas of AN-105 located in the second ring down from the top knuckle. There was no reportable thinning for the other five tanks examined.

TABLE 3. Six Tanks Selected for UT Examination. (Pfluger, 1999)

Tank Number	Main Reason for Selection							Corrosion Condition Favored					
	Tank Age	Waste Temp	Low Inhibitor Levels	Abnormal Operation			Static Waste Height	Tank Steel	Other Chem. Species Cracking	General Corrosion (Thinning)	Pitting	Water-line Attack	Stress Corrosion Cracking
				Sludge Levels	H ₂	Changing Waste Height							
AW-103		X		X						X			
AN-107			X								X		X
AZ-101	X	X					X	X		X	X	X	X
AY-102	X	X				X		X		X			X
AN-105					X		X					X	
AN-106									X				X

TABLE 4. Summary of Primary Tank UT Examination Results.

Tank Number	Area Examined (see the referenced ultrasonic inspection reports for details)						Summary of Results			
	Plate Material						Welds and Heat Affected Zones			
	Vertical Wall	Lower Knuckle	Tank Bottom (slots)	Lower knuckle Weld	Lowest Vertical Weld	2 nd -lowest Vertical Weld	Reportable Thinning (>10% thickness)	Reportable Pitting (>25% thickness)	Reportable Waterline Attack ¹	Reportable Cracking (>0.18 in)
AW-103	X						no	no	no	no
AN-107	X	X	X	X	X	X	no	no	no	no
AZ-101	X			X	X	X	no	no	no	no
AY-102	X			(3)	X	X	no	no	no	no
AN-105	X	X		X	X	X	yes ²	no	no	no
AN-106 ⁴	X			X	X	X	no	no	no	no

1) Reportable level depends on geometry of observed attack.

2) Second ring from top showed general thinning <10% with two very small areas up to 20%. Top ring also showed general thinning <10% (Jensen 1999b).

3) An attempt was made to inspect the lower knuckle weld, but due to concrete spatter at this location it could not be inspected. However, in lieu of this lower knuckle weld, the horizontal weld between the next course of plates above the knuckle was inspected. See the UT report for 241-AY-102 (Jensen 1999d).

4) Tank AN-106 replaced AY-101 tank. Inspection of AY-101 failed because the crawler was unable to maintain contact with the primary tank wall. A build-up of unidentifiable scale, rust product, and apparent regions of concrete spatter caused poor contact between the crawler wheels and the tank wall.

5.0 CONCLUSIONS

This section presents the conclusions of the evaluation of the adequacy of the design standards used to construct the facility and the compatibility of the waste to the system and the corrosion control evaluation. It also includes a summary of the material conditions found during integrity examination assessment activities. Recommendations are provided in those areas where considered appropriate. The structural integrity evaluation of AW tanks was performed in 1992 (WHC 1992). The waste compatibility and corrosion protection evaluation was not included in the WHC 1992 report.

Based on the evaluations of the design standards, the waste characteristics and compatibility with the tank material, the corrosion protection, the age of the tanks, and the integrity examinations, the 241-AW tanks are not leaking and are fit for continuous use. Recommendations made in Section 6.0 will ensure the continued safe operation of the facility.

5.1 DESIGN STANDARDS

The structural integrity evaluation report (WHC 1992) found that the tank system was conservatively designed using applicable national codes, standards, and Hanford Site design criteria as the design basis. All design specifications, design criteria, construction records, and operating records underwent careful review and checking. The control and checking of design, procurement, and construction products ensured that the facilities complied with national codes, standards, and design specifications. It has been analytically demonstrated that the design of the double-shell tanks and transfer piping and drain systems provides conservative margins of safety against failures. These margins of safety are under continuing evaluation as new design and evaluation guidelines are formulated.

Control and monitoring of operating parameters ensure that design basis criteria are not exceeded. Corrective action is taken where needed as the site conducts ongoing tests, investigations, and reviews to ensure operations and maintenance of the facilities are conducted properly.

The AW tanks were designed for a maximum temperature of 350°F in contact with liquid waste, but as shown in Section 4.2 (Table 2), none of the tanks have exceeded 135°F and are therefore well within design limits. Estimated corrosion rates suggest that the design corrosion allowance of 0.050 in. for the 50-year life of the tank (Vitro 1976b) is adequate. The secondary tank is designed for a maximum of one week in contact with the waste to eliminate the chance for stress-corrosion cracking.

Review of the WHC 1992 report revealed that the current applicable codes and standards are essentially the same as the design basis in the key areas of design and construction. Based on current knowledge, it was concluded that the collapse, rupture, or failure from structural design, construction, or operational fault in the tank facilities is not imminent and is not reasonably probable for the remainder of the tank design life. However, numerous analyses were performed after the WHC 1992 report, which are listed in the recent documentation review of the tanks (HNF 1998) identifying various areas of concern noted in the following paragraphs.

Becker (Becker 1994) and Scott (Scott and Peterson 1995) identified that the load combinations were not completed to compare them with allowable limits. The safety margins built into the original design envelopes this concern as also shown in Julyk 1994 report, which addresses the stresses due to various load combinations. The WHC 1995 report identified the tank system may be vulnerable to unexpected corrosion mechanism under current corrosion control strategy. Section 5.3 concludes that there is no significant corrosion concern and no action is proposed at this time except for adjusting the waste chemistry (Mulkey 1998). Also recent UT testing of the AW-103 tank (Leshikar 1997) showed that the corrosion of the primary tank wall is insignificant as compared to the design allowable.

Degradation of tank concrete due to thermal cycles was identified in Han 1996 and WHC 1990, though the temperature in the tanks has not exceeded 135°F, which is well below the design limit of 350°F. Therefore, this concern is eliminated. The Julyk 1994 report determined that tanks can withstand loads due to revised loads of additional soil burden, soil density, and equipment loads. However, creep was not included in this analysis, but creep at the low waste temperature of 135°F does not initiate any concern for structural stability. The Julyk and Ralston 1995 report identified the concern about drop loads but the operational dome load controls mitigate any impact on the structural strength of the tank. The RLCA 1996 report identified some concerns due to sloshing-induced impact during a seismic event. It was noted that the effect was not quantified with the dome constrained at the top. However, considering the constrained dome effect, the impact due to sloshing (with high viscosity fluid of specific gravity of 1.7 or 2.0) should be of lesser magnitude as compared to the impact from a free standing tank without constraint at the top.

The concerns identified above by various analysts are acknowledged and are dispositioned with appropriate reasoning, primarily due to the fact that original built-in margins of safety envelope these concerns. Therefore, as reported in WHC 1992 findings, the tank system is determined to have adequate structural strength to withstand applicable loads for its continued operation.

5.2 WASTE CHARACTERISTICS AND COMPATIBILITY

Two topics are mandated for tank farm compatibility evaluations: waste characteristics and corrosion protection measures. Determining waste characteristics requires both a review of past practice and, where available, information on current analyses. Past practice provides a general picture of what is in the tanks but should be superseded by analysis of the tank contents. Because the tanks often were filled, partially drained, refilled, etc., the contents may be layered. Therefore, an analysis may provide details for the point at which the sample was taken, but be misleading for the rest of the tank. Thus, analyses must be smoothed with historical information.

All wastes contained within the tanks meet the Hanford corrosion specifications for corrosivity (Kirch 1984) and therefore are compatible with the steel tanks. Future wastes are also expected to meet these standards. Controls are in place to ensure tank intrusive and waste disturbing activities do not initiate a hydrogen deflagration.

From the information presented above on the wastes, none are considered energetic. Therefore, no reactions are expected that could pressurize the tanks above the design limit (Vitro 1976b) of 60 in. of water.

Only AW-101 is a Hydrogen Watch List tank. As noted in Section 4, the amount of hydrogen produced is low and the tank is unlikely to reach the 25% LFL.

5.3 CORROSION PROTECTION

As described in Section 4, several corrosion concerns were examined:

- General (uniform) corrosion
- Pitting and crevice corrosion
- Stress-corrosion cracking
- Microbiologically-influenced corrosion
- Atmospheric corrosion
- Concentration cell or waterline corrosion
- Fatigue
- Wear
- Erosion and erosion corrosion
- Hydrogen embrittlement /Hydrogen-induced cracking
- Thermal embrittlement
- Radiation embrittlement
- Creep and stress relaxation
- Radiation-enhanced corrosion

The last nine failure mechanisms in the list were readily eliminated in Section 4.3.1 as being insignificant or inapplicable to the tanks. The first five are of potential concern and evaluated in more detail. None were found to be of critical importance.

General (uniform) corrosion rates in the tank under the liquid are expected to be small, as are the rates in the annular space and on the exterior of the secondary tank. However, if rainwater has penetrated the concrete and reached the secondary tank, relatively high, but unknown, corrosion rates could be attained on the outside of the secondary tank. Nevertheless, these rates are not expected to impact the allowed one-week exposure time (Vitro 1976b) of the secondary containment to the waste, which is only applicable if the primary fails catastrophically by cracking. Catastrophic failure of the primary tank by corrosion is not probable.

Pitting and crevice corrosion during operation is not important when the waste is maintained within the corrosion specifications. There is a slight possibility of pitting on the exterior of the secondary tank, but even at the maximum forecast pitting rate, it will not impact the effectiveness of the secondary tank to contain leaks.

Stress-corrosion cracking has been shown to be of minor significance because of heat treatment of the primary and because of the waste chemistry. Schwenk and Scott (Schwenk 1996) notes that there is a possibility that the stresses in the knuckle may be higher than predicted, but this should not be a concern if the tank is within its corrosion specification defined waste composition range (Kirch 1984). Experience at Savannah River shows that if the tank cracks, the waste is likely to plug the crack. Therefore, catastrophic failure is not likely.

Microbiologically-influenced corrosion at this time is not a significant concern. Most effects of microbiologically-influenced corrosion occur within a few weeks or months and the most hazardous period was during the hydrotesting of the tanks nearly 20 years ago.

Atmospheric corrosion of the steel in the internal dome region is expected to be higher than that submerged in the liquid. The actual rate of corrosion is a function of the relative humidity and the ammonia concentration and cannot be calculated but must be evaluated by nondestructive techniques.

No action has been proposed for any potential corrosion problem except for adjusting the waste chemistry (Mulkey 1998).

5.4 FACILITY AGE

The tanks are approximately 19 years old out of the 50-year design life.

5.5 MATERIAL CONDITIONS

Review of visual examination records and UT examination record found no evidence of leaking, or degradation that would make a tank in the AW Tank Farm unfit for service.

5.5.1 Primary Tank

The visual examinations and leak detection system review showed that the primary tanks in the AW double-shell tanks are not leaking, and there was no evidence of any past leakage.

The six double-shell tanks that were examined by UT are tanks that are expected to corrode more than the general tank population. The preponderance of evidence from the UT examination of these six tanks suggests that the primary steel tanks in Hanford double-shell tanks are not degrading to any appreciable extent. The following conclusions are reached for corrosion of the primary tanks.

- **Stress-corrosion cracking was not found** in any of the six tanks examined, including four tanks that favored this corrosion mechanism. Tanks AZ-101 and AY-102 were fabricated from the least crack-resistant of the three steels used for double-shell tanks and had the longest exposure time and the highest waste temperatures. AY-102 also had the most fill/empty cycles that would result in more stress cycles for the lower knuckle. AN-106 had a high level of phosphate that could contribute to corrosion cracking and AN-107 had a low level of corrosion inhibitor.
- **Waterline attack was not found** in any of the six tanks examined, including two tanks that favored this corrosion mechanism. Tanks AZ-101 and AN-105 had remained at the same waste levels for extended periods (96 months for AZ-101 and 103 months for AN-105).
- **Pitting was not found** in the six tanks examined by UT, as defined by the inspection criteria (Pfluger 1999). However, localized pit-like indications were observed in tank AN-105 (Jensen 1999b). In addition, earlier visual examinations of two tanks that had previously held waste and a thermocouple tree that had been removed from a waste tank did show some moderate pitting. The interiors of the primary tanks for AP-104 and AP-107 were examined by visual means in 1997 when they were nearly empty (Anantatmula 1997). Both tanks had held waste for some period during their 10-year of operation. AP-104 had contained flush water and decontamination waste (from N Reactor) for several months and was then at the six-inch level for the following eight years. The thermocouple tree was examined by visual means just after removal from AZ-101 interior after 20 years of waste exposure (Schwenk and Scott 1997).
- **General corrosion (thinning) at reportable levels was found** in localized areas of one ring of AN-105 primary tank and was not found in any of the other five tanks

examined. For AN-105, there was general wall thinning at less than reportable levels for the ring nearest the top knuckle (referred to as Plate #1 in the UT report) and for the second ring down from the knuckle (Plate #2 in the UT report). The reportable corrosion thinning of this primary tank occurred only in two very small areas of the second ring down from the top knuckle. Reportable thinning for this ½-inch-thick plate is >0.050 in. The Inspection Review Panel (Anantatmula 1999) suspects the thinning in this tank is due to vapor-phase corrosion (general corrosion and pitting) during an earlier 16-month period when the tank contained double-shell slurry feed and the waste level was lower (Brevick 1995b). The panel also stated that the tank is currently full and contains waste that is considered to be benign from a corrosion standpoint. The structural analysis performed for the two small thinned areas showed the plate to be structurally acceptable. Importantly, the three tanks with the highest waste temperature showed no reportable thinning.

5.5.2 Secondary Tank Steel Liner

The visual examinations and leak detection system review showed that the secondary steel liners in the AW Tank Farm are not leaking and there was no evidence of any past leakage.

The UT examinations that were carried out on three secondary liners showed that the secondary liners in Hanford double-shell tanks remain structurally sound and are not corroding by thinning, cracking, or pitting to any appreciable extent.

6.0 RECOMMENDATIONS

The following recommendations are made to help ensure the continued safe operation of the AW double-shell tanks.

1. Consider the tanks in this farm for subsequent ultrasonic and visual examinations. Subsequent examinations should be performed on six tanks from the 28-tank population within the next ten years.
2. Within the next two years, ultrasonic inspections of the lower knuckle and bottom of the primary and secondary tanks should be performed on five of the 28 tanks.
3. The UT inspection of AW-103 (Leshikar 1997) showed no significant corrosion of the primary or the secondary tank walls. However, waste from AW-102 tank has been pumped into AN-105 tank and the UT inspection of AN-105 (Jensen 1999b) showed some thinning of its primary tank wall. It would be prudent to inspect the AW-102 tank also for corrosion of its primary tank wall.

7.0 FIGURES

CADFILE ZJJAS023E

Figure 2 Typical AW DST Configuration

ACAD FILE: 78AC0014G

Figure 3.

ACAD FILE: ZBAC00142

Figure 4.

ACAD FILE: ZBAC00143

Figure 5.

8.0 REFERENCES

- ACI 1971, *American Concrete Institute Building Code Requirements for Reinforced Concrete*, ACI-318, 1971 Edition, Detroit, Michigan.
- Anantatmula, R. P., 1997, *Visual Examination of 241-AP-104 and 241-AP-107*, HNF-SD-WM-RPT-307, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
- Anantatmula, R. P., 1999, *Possible Causes for Wall Thinning of Isolated Regions of Primary Wall of Tank 241-AN-105 as Revealed by the Recent Ultrasonic Examination*, Internal Memo 74700-99-RPA-008, Lockheed Martin Hanford Corporation, Richland, Washington.
- ARH 1975, *Functional Design Criteria-Additional High-Level Waste Storage Facilities*, ARH-CD-362, Rev. 2, Atlantic Richfield Hanford Company, Richland, Washington.
- ASME 1974, *American Society of Mechanical Engineers Boiler and Pressure Vessel Code*, ASME Section VIII, Division 2, 1974 Edition w/addenda through summer 1975. New York, New York.
- ASME 1989, *Rules for In-Service Inspection of Nuclear Power Plant Components, Section XI, Boiler and Pressure Vessel Code*, American Society of Mechanical Engineers, New York New York.
- Bardes, B. P., Ed., 1987, *Properties and Selection: Iron and Steels*, Vol. 1, Metals Handbook, 9th Edition, ASM International, Metals Park, Ohio.
- Becker 1994, *Accelerated Safety Analyses-Structural Analyses Phase I, Structural Sensitivity Evaluation of Single and Double-Shell Waste Storage Tanks*, WHC-SD-WM-SARR-012, Westinghouse Hanford Company, Richland, Washington.
- Benar, C. J., 1998, *Tank 241AW101 Cores 132 And 139 Analytical Results For The Final Report*, WHC-SD-WM-DP-192, Rev. 0B, Westinghouse Hanford Company, Richland, Washington.
- Blaak, T. M., 1999a, *Revised Waste Compatibility Assessment of Catch Tank 241-A-350 Contaminated Rainwater with Waste in Tank 241-AW-102*, Internal Memo 74100 99 015, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.
- Blaak, T. M., 1999b, *Waste Compatibility Assessment of Catch Tank 302-A Waste with Tank 241-AW-105 Waste*, Internal Memo 74100 99 020, Lockheed Martin Hanford Corporation, Richland, Washington.

- Blaak, T. M., 1999c, *Waste Compatibility Assessment of Tank 241-AW-106 Waste with Tank 241-AP-103 Waste*, Internal Memo 74100 99 019, Lockheed Martin Hanford Corporation, Richland, Washington.
- BNL 1997, K. Bandyopadhyay, et al, *Guidelines for Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks*, BNL 52527, January, 1997, Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York.
- Brevick, C. H., L. A. Gaddis, and W. W. Picket, 1995a, *Historical Tank Content Estimates for the Southeast Quadrant of the Hanford 200 Areas*, WHC-SD-WM-ER-350, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Brevick, C. H., L. A. Gaddis, and W. W. Picket, 1995b, *Supporting Document for the Southeast Quadrant Historical Tank Content Estimate Report for the AW-Tank Farm*, WHC-SD-WM-ER-316, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Chang, J. Y., 1998, *Corrosion Monitoring and Control for Tanks 8D-1 & 8D-2*, Report of the Fourth Annual Corrosion Meeting, West Valley, New York.
- Davis, J. R., Ed., 1987 *Corrosion*, Vol. 13, Metals Handbook, 9th Edition, ASM International, Metals Park, Ohio.
- Divine, J. R., W. M. Bowen, D. B. Mackey, D. J. Bates, and K. W. Pool, 1985, *Prediction Equations for Corrosion Rates of A-537 and A-516 Steels in Double-Shell Slurry, Future PUREX, and Hanford Facilities Wastes*, PNL-5488, Pacific Northwest Laboratory, Richland, Washington.
- DOE 1991, *Double-Shell Tank System Dangerous Waste Permit Application*, DOE/RL-90-39, U. S. Department of Energy, Richland, Washington.
- DOE 1997, Letter from J. K. McClusky (DOE-RL) To H. J. Hatch (FDH), (Letter No. 97-WSD-258, Dated Dec. 23, 1997), Contract Number DE-AC06-96RL13200 - U. S. Department of Energy, Richland Operations Office (RL), *Double-Shell Tank (DST) System Integrity Program Plan*. Richland, Washington.
- Dodd, R. A., 1994, *242-A Evaporator Campaign 95-1 Waste Compatibility Assessment of Tank 241-AW-103 and 241-AW-104 Waste with Tank 241-AP-107 Waste*, Internal Memo 7CF10 042 094, Westinghouse Hanford Company, Richland, Washington.
- Escalante, E., 1992, NIST, Personal Communication to Dr. J. R. Divine, PE.
- Esch, R. A., 1997, *Tank 241AW105 Grab Samples Analytical Results For The Final Report*, HNF-SD-WM-DP-214, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
- Esch, R. A., 1999, *Tank 241AW101 Low Activity Waste Envelope A Analytical Results For The Final Report*, HNF-1652 Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
- FDH 1999a, *Perform AW DST 101 Through 106 Annulus Conductivity Probe Leak Detection Functional Test*, Tank Farm Plant Operations Procedure TF-FT-239-008, Rev. C-10, July 29, 1999. Fluor Daniel Hanford, Inc., Richland, Washington.

- FDH 1999b, *AP, AW Tank Farms Daily Rounds*, Tank Farm Plant Operations Procedure TF-OR-A-03, Rev. E-52, July 3, 1999. Fluor Daniel Hanford, Inc., Richland, Washington.
- Field, J. G., 1998a, *Tank Characterization Report For Double-Shell Tank 241-AW-101*, HNF-SD-WM-ER-470, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.
- Field, J. G., 1998b, *Tank Characterization Report For DST 241AW-103*, WHC-SD-WM-ER-455, Rev. 1A, Westinghouse Hanford Company, Richland, Washington.
- Field, J. G., 1998c, *Tank Characterization Report For DST 241AW-105*, WHC-SD-WM-ER-364, REV. 2, Westinghouse Hanford Company, Richland, Washington.
- Field, J. G., 1998d, *Tank Characterization Report for DST-241-AW-104*, HNF-SD-WM-ER-453, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.
- Han, F. C., 1996, *Structural Integrity and Potential Failure Modes of the Hanford High-Level Waste Tanks*, WHC-SD-TWR-RPT-002, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.
- Hardy, D. B., 1998, *60 Day Waste Compatibility Safety Issue And Final Results For Tank 241AW-102 And Grab Samples 2AW-95-1, 2AW95-2 and 2AW95-3*, WHC-SD-WM-DP-149, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.
- HNF 1998, *241-AN/AW Analysis Documentation Review*, HNF-3138, Rev. 0, COGEMA Engineering Corporation, Richland, Washington.
- Hoitink, D. J. and K. W. Burk, 1998, *Hanford Site Climatological Data Summary 1997, with Historical Data*, PNNL-11794, Richland, Washington.
- Hu, T. A., 1997, *Calculations of Hydrogen Release Rate at Steady State for Double-Shell Tanks*, HNF-SD-WM-CN-117, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
- Hundal, T. S., 1997, *Double-Shell Tank Waste Transfer Piping/Pit System Integrity Assessment Report*, HNF-SD-WM-ER-623, Rev. 0, SGN Eurisys Services Corporation, Richland, Washington.
- Jaske, R. T., 1955, *Evaluation of Soil Corrosion at Hanford Atomic Products Operation*, HW-33911 General Electric, Richland, Washington.
- Jensen, C. E., 1999a, *Final Results of Tank 241-AN-107 Ultrasonic Inspection*, HNF-3353 Revision 1, Lockheed Martin Hanford Corporation, Richland, Washington.
- Jensen, C. E., 1999b, *Final Results of Double-Shell Tank 241-AN-105 Ultrasonic Inspection*, HNF-4816, Lockheed Martin Hanford Corporation, Richland, Washington.

- Jensen, C. E., 1999c, *Final Results of Double-Shell Tank 241-AN-106 Ultrasonic Inspection*, HNF-4817, Lockheed Martin Hanford Corporation, Richland, Washington.
- Jensen, C. E., 1999d, *Final Results of Double-Shell Tank 241-AY-102 Ultrasonic Inspection*, HNF-4818, Lockheed Martin Hanford Corporation, Richland, Washington.
- Jensen, C. E., 1999e, *Final Results of Double-Shell Tank 241-AZ-101 Ultrasonic Inspection*, HNF-4819, Lockheed Martin Hanford Corporation, Richland, Washington.
- Julyk, L. J. and G. H. Ralston, 1996, *Drop Load Evaluation for TWRS FSAR*, WHC-SD-WM-TI-782, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Julyk, L. J., et al., 1994, *241-AW/AN Waste Storage Tanks – Supplemental Gravity Load Analysis*, WHC-SD-WM-ANAL-035, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Kirch, N. W., 1984, *Technical Basis for Waste Tank Corrosion Specifications*, SD-WM-TI-150, Rockwell Hanford Operations, Richland, Washington.
- Kirkbride, R. A., G. K. Allen, R. M. Orme, R. S. Wittman, J. H. Baldwin, T. W. Crawford, J. Jo, L. J. Fergestrom, T. M. Hohl, and D. L. Penwell, 1999, *Tank Waste Remediation System Operation and Utilization Plan to Support Waste Feed Delivery*, HNF-SD-WM-SP-012, Rev. 1, U. S. Department of Energy, Richland, Washington.
- Lambert, S. L., 1998a, *Tank Characterization Report for DST 241-AW-103*, HNF-SD-WM-ER-363, Rev. 1-B, COGEMA Engineering Corporation, Richland, Washington.
- Lambert, S. L., 1998b, *Tank Characterization Report for Double-Shell Tank 241-AW-106*, HNF-SD-WM-ER-365, Rev. 1B, COGEMA Engineering Corporation, Richland, Washington.
- Leshikar, G. A., 1997, *Final Report: Ultrasonic Examination of Tank 241-AW-103 Walls*, HNF-SD-WM-TRP-282, Rev. 0, SGN Eurisys Services Corporation, Richland, Washington.
- Mulkey, C. H., 1998, *Double-Shell Tank Waste Analysis Plan*, HNF-SD-WM-EV-053, Rev. 5, Lockheed Martin Hanford Corporation, Richland, Washington.
- Noorani, Y. G. and G. W. Ryan, 1998, *Tank Waste Remediation System Basis for Interim Operation: Appendix E - Flammable Gas/Slurry Growth Unreviewed Safety Question: Justification for Continued Operation for the Tank Farms at the Hanford Site*, HNF-SD-WM-BIO-001, Rev. 1, Fluor Daniel Hanford, Inc., Richland, Washington.

- Ondrejcin, R. S. and D. A. Mezzanotte, 1981, *Mechanism of Waste Tank Pitting*, DPST-81-591 (Draft), E. I. duPont de Nemours & Company, Aiken, South Carolina.
- Pfluger, D. C., 1999, *Engineering Task Plan for the Ultrasonic Inspection of Hanford Double-Shell Tanks*, HBNF-2820, Rev. 2, Lockheed Martin Hanford Corporation, Richland, Washington.
- Poe, W. L., 1974, *Leakage from Waste Tank 16: Amount, Fate, and Impact*, E. I. duPont de Nemours & Company, Aiken, South Carolina.
- RLCA, 1996, *Evaluation of Hanford High Level Waste Tank Failure Modes for Seismic Loading*, prepared for the U. S. Department of Energy – Richland Operations, by Robert L. Cloud & Associates, Inc. Berkeley, California.
- Scott, M.A. and W. S. Peterson, 1995, *ASA Structural Analyses Phase II, ACI Code Evaluation of the Maximum Loads in the Concrete Dome, Haunch, and Upper Wall of Double-Shell Waste Storage Tanks*, WHC-SD-WM-SARR-032, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Schwenk, E. B. and K. V. Scott, 1996, *Description of Double-Shell Tank Selection Criteria for Inspection*, WHC-SD-WM-ER-529, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Schwenk E. B. and K.V. Scott, 1997, *Visual Examination of Thermocouple Trees Removed from Double-Shell Tank 241-AZ-101*, HNF-SD-WM-ER-688, Rev. 0, SGN Eurisys Services Corporation, Richland, Washington.
- SDC 1974, *Architectural Civil Design Criteria, Design Loads for Structures*, SDC-4.1, Rev. 7, Hanford Plant Standards, U. S. Department of Energy, Richland, Washington.
- Smith, H. D. and M. R. Elmore, 1992, *Corrosion Studies of Carbon Steel under Impinging Jets of Simulated Slurries of Neutralized Current Acid Waste (NCAW) and Neutralized Cladding Removal Waste (NCRW)*, PNL-7816, Pacific Northwest Laboratory, Richland, Washington.
- Steen, F. H., 1997, *Tank 241AW104 Cores 204 and 206 Analytical Results For The Final Report*, HNF-SD-WM-DP-264, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
- Steen, F. H., 1998a, *Tank 241AW103 Cores 193 and 194 Analytical Results For The Final Report*, HNF-SD-WM-DP-249, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

- Steen, F. H., 1998b, *Tank 241AW106 Grab Samples 6AW97-4, 6AW97-5 and 6AW97-6 Analytical Results For The Final Report*, HNF-SD-WM-DP-303, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
- Strode, J. N. and V. C. Boyles, 1998, *Operation Waste Volume Projection*, HNF-SD-WM-ER-O29, Rev. 24, Lockheed Martin Hanford Corporation, Richland, Washington.
- Sumsion, M. L., 1992, *The Acceptance Test Report for Double-Shell Tank Inspections*, WHC-SD-WM-ATR-018, Westinghouse Hanford Company, Richland, Washington.
- Tillman, J. H., 1992, *222s Analytical Lab Sample For 242 Evaporator Feed Characterization Project Tank 106AW*, WHC-SD-WM-DP-025 Addendum 16, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- Vitro 1976a, *Construction Specification for Primary and Secondary Steel Tanks, 1976, Project B-120, 241-AW Tank Farm*, B-120-C4, Vitro Engineering Corporation, Richland, Washington.
- Vitro 1976b, *Design Specification for Primary and Secondary Steel Tanks, 1976, Project B-120, 241-AW Tank Farm*, B-120-D1, Vitro Engineering Corporation, Richland, Washington.
- WAC 1998, *Dangerous Waste Regulations*, Washington Administrative Code, Chapter 173-303, Washington State Department of Ecology, Olympia, Washington.
- Walter, E. J., 1992, *Visual Examination Report for Tank Annuli at the 241-AW Tank Farm*, WHC-SD-WM-RPT-034, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- WHC 1990, *Summary Status on the Seismic Evaluation of Hanford Site Radioactive Waste Storage Tanks*, WHC-EP-0373, Westinghouse Hanford Company, Richland, Washington.
- WHC 1992, *Structural Integrity Evaluation of 241-AW-Tank Farm Dangerous Waste Storage Tank Facilities*, WHC-SD-WM-ER-126, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC 1995, *Hanford Waste Tank System Degradation Mechanism*, WHC-SD-WM-ER-414, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Zapp, P. E. and D. T. Hobbs, 1992 *Inhibiting Pitting Corrosion in Carbon Steel Exposed to Dilute Radioactive Waste Slurries*, paper no. 98, CORROSION/92, NACE International, Houston, Texas.

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