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241-AZ Double-Shell Tanks Integrity Assessment Report

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Abstract: This report presents the results of the integrity assessment of the 241-AZ 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-AZ DOUBLE-SHELL TANKS
(HNF-4957, Rev. 0)**

Prepared by:

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Date Published:

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INTEGRITY ASSESSMENT REPORT

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

1.0 INTRODUCTION

The 241-AZ Tank Farm consists of two double-shell tanks and is located in the 200 East Area of the Hanford Site (See Figure 1). These underground tanks were built to store aging waste under Project HAP-647 and were completed in 1974-1976. These two tanks have received various wastes beginning in 1976 and aging waste during 1984 through 1990. They now receive only condensate from other aging waste tanks.

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 part 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 determine if the AZ tanks were adequately designed with sufficient structural strength and compatibility with the stored waste and have been adequately maintained such that they will not collapse, rupture, or fail during the facility's use.

The following shall be considered:

Design Standards- identify and evaluate the standards and requirements to which the tank system was designed, constructed, and maintained.

Waste Characteristics- identify the waste (past and projected) and evaluate the compatibility of the tank components with the waste.

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

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

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

3.0 SCOPE

The scope of this integrity assessment includes the primary steel tank and the secondary steel-lined concrete tank for both tanks AZ-101 and AZ-102. The integrity assessment of the transfer lines and pits associated with AZ 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

Schematics of the double-shell tank are shown in Figures 2 and 3. The primary inner tank that contains the waste is 75 ft. in diameter and 46 ft. 9 in. tall. The primary tank is a fully-enclosed tank, fabricated from carbon steel plates, and was stress-relieved following welding. The secondary concrete tank is five feet larger in diameter than the primary tank, thus creating a 2.5-ft. annulus between the two tanks. The foundation and vertical walls of the concrete tank are lined with carbon steel (also welded plate), which becomes the containment barrier if the primary tank should leak. The concrete tank has an elliptical dome, which is lined by the top portion of the primary steel tank. The total concrete enclosure provides the structural support to resist the soil loading and the annulus, which is fully lined with steel, is a leak detection chamber. Specific design details will be discussed later in this report. The two double-shell tanks were designed and constructed to be identical in every respect.

4.1 DESIGN STANDARDS

The following paragraphs present the design requirements and other factors used in assessing the integrity of the 241-AZ double-shell tank facility. The standard requirements for the 241-AZ double-shell tanks are contained in two specifications and nine drawings issued to Project HAP-647 (Project HAP-647 1970) and in the Design Criteria document (Hatch 1970). The following conditions were required to be addressed in the design.

- Primary vapor space pressure - 6 and + 60 in. H₂O

- Annulus vapor space pressure..... + 12 in. H₂O
- Liquid waste specific gravity..... 1.8 average (liquid + sludge)
- Maximum liquid waste depth 30 ft.
- Earth cover..... 7 ft.
- Soil unit weight.....110 lb./ft³
- Tank dome live load..... 40 lb./ft² + 50 ton concentrated
- Temperature (average cross-section)

Vapor (above 30 ft.)	220 °F
Liquid (4 to 30 ft.)	260 °F
Sludge (0 to 4 ft.)	350 °F
- Ground accelerations- seismic design

	<u>Horizontal</u>	<u>Vertical</u>
Operating Basis Earthquake	0.12 g	0.08 g
Design Basis Earthquake	0.25 g	0.17 g

Horizontal and vertical accelerations were assumed to act simultaneously.

The 241-AZ storage tanks were designed, fabricated, and inspected in accordance with the two national codes listed below.

- American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, Subsection B, 1968 Edition. (Referred to as the ASME Code) (ASME 1968).

The 1963 Building Code Requirements for Reinforced Concrete (ACI 1963).

The design documentation does not specify an expected service life for the 241-AZ tank system or a design criteria for the secondary steel liner. The secondary steel liner functions as a leakage barrier.

After the reinforced concrete foundation slab was completed, base portions of the secondary liner, insulating concrete pad, and primary tank bottom were fabricated and inspected in that order. The primary tank was then fabricated complete, stress-relieved and hydrotested. The secondary steel liner was then fabricated as a tank ending where it meets the top of the primary tank. The reinforcing steel for the concrete tank was welded in place and the steel tanks braced to support the poured concrete. The concrete tank walls and dome were sequentially poured, using the exposed portions of the steel tanks as a form. Special precautions were taken to avoid any reintroduction of high stresses in the primary tank during fabrication steps subsequent to the stress relief. Both 241 AZ-101 and 241-AZ-102 primary steel tanks were successfully hydrotested by filling to a depth of 39 ft. and holding for 24 hours. The nominal operating level

is 30 ft. Portions of the tanks were completed as subassemblies at the fabricator's shop and then transported to the site.

4.1.1 Primary Tank and Secondary Steel Liner

Both the primary tank and the secondary steel liner were fabricated from welded ASTM A515, Grade 60 carbon steel plates (ASTM 1969). The plate thickness for the primary tank vertical wall ranges from 7/8 in. for the lower knuckle to 3/8 in. at the tangent line to the dome. The plate thickness for the dome is 3/8 in. (except for a 1/2-inch-thick center portion) and for the tank floor 1/2 in. (except for a 1-inch-thick center portion). The plate thickness for the entire secondary steel liner is 3/8 in. except for the bottom knuckle which is 1/2 in. These values represent the minimum plate thickness. The actual thickness of each plate was measured and reported by the supplier(s). Every weld is full penetration. Extensive examinations were required on the welds, including radiography, magnetic particle, dye penetrant, visual, and leak testing. The materials, welding processes, and specific examination requirements that were specified for these tanks are listed in Appendix A.

The design analysis for the primary tank and secondary steel liner was completed by the contractor, Pittsburgh Des Moines Steel Company, which accounted for all applicable design conditions from the design documents (PDM 1970). The analysis for design basis earthquake used the methodology specified in TID-7024 (USAEC 1963) and a seismic response spectrum essentially the same as that used for design of the Fast Flux Test Facility located at the Hanford Site. All stresses for the individual loads and load combinations, including the design basis earthquake, were within those allowed by the ASME Code. The seismic analysis checked for sliding of the unanchored primary tank bottom on the insulating concrete and determined that there was adequate margin against slip.

4.1.2 Reinforced Concrete Tank Structure

The concrete tank has an 18-inch-thick vertical wall, a 15-inch-thick elliptical dome, and a foundation thickness varying from 1 ft. to 2 ft. The haunch region, however, ranges up to about 47 in. in thickness. There are approximately 140 dome penetrations (carbon steel pipe) ranging in diameter from 2 in. to 42 in. The foundation extends outward 33 inches beyond the concrete tank wall and has an array of drain slots to prevent water (or waste) entrapment beneath the bottom of the steel liner. These drain slots connect to the leak detection system. The foundation was protected from high temperatures during the stress relief of the primary steel tank by an 8-inch-thick pad of insulating concrete that has ventilation channels for air circulation.

The concrete strength for the 241-AZ concrete tank structures was specified as 3,000 psi at 28 days and ASTM A615, Grade 60 was required for the reinforcing steel. The design of the concrete tank was based on analyses by K. P. Milbradt at the Illinois Institute of Technology (Milbradt 1973) and John Blume and Associates (Blume 1971). In each case the stresses compared favorably to those published by the American Concrete Institute: Milbradt used the 1963 concrete code (ACI 1963), and Blume referred to the 1965 ACI design handbook (ACI

1965), which is based on the 1963 code. Milbradt also confirmed that the soil stresses below the foundations were within those allowed for the site soils. The AZ concrete tank design was analyzed for seismic loads from a 0.25g design basis earthquake for the Hanford Site (USAEC 1963) by John A. Blume and Associates using the AXIDYN computer model (Blume 1971). The combined soil-tank model was applied down to the basalt. "No critical overstressing was found on any part of the soil-tank structure."

4.1.3 Construction

Pittsburgh Des Moines Steel Company was the fabricator for the steel tanks. Their drawings, specifications, procedures, qualifications, etc. satisfactorily implemented the design standards in place. The "deviations from drawing requirements" during fabrication were resolved to the satisfaction of the Title III Inspector representing the DOE and the cognizant Hanford Site design representative(s).

During fit-up of the uppermost shell ring, during the erection of primary tank AZ-102, inspection of the ring (presumably, the weld-prep at the edge of the plate) showed indications of plate laminations. Subsequent examinations using the straight-beam UT technique (per Section V of the ASME Code) revealed two areas of suspected plate lamination. One of these areas slightly exceeded that allowed by code. (Section III of the ASME Code allows lamellar-type indications if contained within a 3-in. diameter circle.) The condition was accepted based on its size, its position away from any weld seam, and because it was an isolated incident. No other incidents important to the tank integrity were found in the fabrication records.

4.2 WASTE CHARACTERISTICS AND COMPATIBILITY

The AZ Tank Farm contains two tanks. The primary tanks and secondary liner tanks were fabricated from A-515, Grade 60 carbon steel (Hatch 1970). The construction operating specifications (Vitro 1970) include:

- Temperature

Vapor, above 30 ft	220 °F
Liquid, 4 to 30 ft	260 °F
Sludge, 0 to 4 ft	350 °F
- Specific Gravity

Liquid + Sludge	1.8 (average)
-----------------	---------------

The tanks first received waste in 1976 (Brevick 1995a) though according to Templeton (Templeton 1995), construction on AZ-101 continued through 1977. Ryan (Ryan 1995) states AZ-102 was completed in 1975. Waste descriptions, past and future, are described below by tank in Table 1. Based on forecasts by Kirkbride et al (Kirkbride 1999), the AZ tanks are proposed to be source tanks for the vitrification process.

Table 1 Tank Composition History and Forecast

AZ-101	
Past Waste Descriptions	<p>The initial waste into AZ-101 in 1976 was evaporator waste, which continued to be added through 1977. Then in 1978 through 1980, it received complexed waste, double-shell slurry feed waste, non-complexed waste, water, evaporator waste, residual liquor, and complexant concentrate waste. It then received non-complexed waste until January 1984. Then until 1986 it received PUREX waste. It has held aging waste from 1984 to the present. It is an inactive, concentrated waste holding tank that receives only condensate from other aging waste tanks. (Brevick 1995a)</p> <p>It contains less than 0.1 wt. % organics and complexants.</p> <p>The maximum temperature in 1994 ranged from 166 to 184 °F. (Templeton 1999)</p>
Projected Future Waste	<p>According to Strobe and Boyles (Strobe 1998) and Kirkbride et al (Kirkbride 1999), the waste in AZ-101 is to be transferred to vitrification in approximately 2001/2004. It will then receive waste from other tanks, for example SY-102 or AY-102. Beginning in about 2004 and running to about 2007, those wastes will be transferred to vitrification. New waste, possibly from SY-102 or AW-103, is expected to be put in the tank beginning in about 2008/2011 where it will remain until at least 2015.</p>
Safety Considerations <ul style="list-style-type: none"> • Corrosion • Flammability • Waste Compatibility • Criticality 	<p>Based on the work of Hu (Hu 1997) and Divine et al (Divine 1985), corrosion is not a significant consideration. Hu calculates that sufficient hydrogen is generated to be of concern if ventilation ceases; 25% of the lower flammability limit (LFL) could be reached in about three weeks without ventilation. Nevertheless, no field measurements were located to suggest hydrogen generation presents a problem. The current waste is compatible with the tank material and, based on Strobe (Strobe 1998) new wastes will be similar to what have been in the tank. Hodgson (Hodgson 1995) and Templeton (Templeton 1999) state that the tank is in compliance as regards criticality, corrosion, and energetics. Compatibility with other waste is not yet a concern at this time because it does not receive any; reviews will be performed when source tanks are firmly defined.</p>

Table 1 Tank Composition History and Forecast (continued)

AZ-102	
Past Waste Descriptions	AZ-102 began service in 1976 with the receipt of water and was labeled as a spare tank. In 1976 and 1977, it received evaporator waste and then residual liquor waste. From 1978 through 1983, it received complexant concentrate waste. For two months, December 1983 through January 1984, it received complexed waste. For the next two years, it received non-complexed waste. Then from 1986 to 1990, it received PUREX waste. It currently contains aging waste and receives only condensate from other aging tanks (Brevick 1995a). It contains less than 0.1 wt. % organic material.
Projected Future Waste	According to Strode and Boyles (Strode 1998) and Kirkbride et al (Kirkbride 1999), AZ-102 will be decanted of its supernate in about 2001/2003. Then in about 2009/2013, waste from C-104 or AW-105 will be moved to AZ-102. The liquid waste will in turn be sent to vitrification with the solids remaining until at least 2015.
Safety Considerations <ul style="list-style-type: none"> • Corrosion • Flammability • Waste Compatibility • Criticality 	Based on the work of Hu (Hu 1997) and Divine et al (Divine 1985), corrosion is not a significant consideration. Hu calculates that sufficient hydrogen is generated to be of concern if ventilation ceases; 25% of the lower flammability limit (LFL) could be reached in about three weeks without ventilation. Nevertheless, no field measurements were located suggest hydrogen generation presents a problem. The current waste is compatible with the tank material, and based on Strode (Strode 1998) new wastes will be similar to what have been in the tank. Ryan (Ryan 1995) and Schreiber (Schreiber 1995) state that the tank is in compliance as regards criticality, corrosion, and energetics. Compatibility with other waste is not a concern at this time because it does not receive any; reviews will be performed when source tanks are firmly defined.

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 et al (Divine 1985) and corrosion is not considered to be a concern. Both tanks are in compliance with flammability, waste compatibility, and criticality requirements.

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 ⁻ mol/L	AlO ₂ ⁻ mol/L	T ^{a, #} °F
AZ-101 ^{b, c}	1.07	1.24	0.67	0.01	0.16	0.35	148, 263
AZ-102 ^{d, e}	0.38	0.6	0.11	0.00	0.18	0.06	116, 249

a - Brevick 1995a; b - Rollison 1995a; c - Rollison 1995b; d - Rollison 1995c; e - Rollison 1995d

Temperatures are average and maximum respectively.

Data from Hu (Hu 1997) for the nitrate and nitrite 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 1970) 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 and waterline corrosion
- Fatigue
- Erosion and erosion corrosion
- Wear
- 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 corrosion mechanisms would, if applicable, mainly affect the primary tank. They are briefly described and then readily eliminated.

- **Concentration cell and 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 documents (Vitro 1970), the expected number of operating cycles, during the entire life, is less than 1,000. Further, Schwenk and Scott (Schwenk 1996) have shown the combination of system chemistry and the less severe operational cycling make fatigue corrosion insignificant.
- **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.
- **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 small 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.

- **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 (i.e., greater than about 500°F) phenomena. Again, according to the design document (Vitro 1970), the design temperature is only 350°F. For A515 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 that are of potential concern can affect either of the tanks and, in some cases, the concrete.

- **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 (Chang 1998). In the vapor space above the waste, however, the corrosion rate was approximately 0.004 in. per year.

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.

- **General (uniform) corrosion** in the liquid waste is a function of the waste composition. When the waste composition is maintained within the technical 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.

- **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.

The general corrosion literature notes that caustic cracking can occur if the steel is stressed and the temperature exceeds 140°F (Davis 1987). In his work, Divine (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 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 test period and the wet lay-up time, microbiologically-influenced corrosion could have started. It is unknown whether the temperatures, radiation, or tank chemistry would sterilize the system.

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 within specified values.

4.4 AGE OF THE TANK SYSTEM

Construction began in late 1971 or early 1972 and started and stopped for several years. Although site construction apparently continued until 1977, the two tanks were completed sometime earlier. Both tanks began operation in late 1976 (Brevick 1995b). The operational age of the tanks is approximately 23 years (as of 1999). The design requirements document for the AZ Tank Farm (Hatch 1970) does not specify the service life or corrosion allowance for the design.

4.5 INTEGRITY EXAMINATIONS

This section presents records reviews and tank examinations that were carried out in order to assess the material soundness and to determine if each tank is not leaking. These 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 examination program for the double-shell tanks and the results from the tanks examined.

4.5.1 Leak Test

The primary tanks were leak tested after being stress-relieved. The leak test, or hydrostatic test, was done by filling the tank with water to a height of 39 ft. and inspecting all accessible joints after 24 hours. The joints were coated with chalk prior to filling the tank to make leaks easier to detect. No leaks were noted in the construction files.

Detection systems for liquid leaks and airborne radiation level have been in place since the first double-shell tanks began operation.

The principal leak detection method is the daily monitoring of fixed-height and variable-height conductivity probes that detect the presence of liquid. The probes are at a fixed height of 1/8 in. for the AZ double-shell tanks, which would detect a leak of less than 100 gallons from a primary tank assuming none of the leakage was absorbed by the insulating concrete. The probes are function-tested at least every six months and the test results recorded per tank farms operations procedure (FDH 1999).

The probes are monitored continuously via alarms per tank farm operations procedure (FDH 1998). No leaks have been detected.

Continuous Air Monitoring is a supplementary leak detection system. Outlet filters in the annulus air handling system are monitored for radioactive contamination. A potential leak condition is reported when the detection equipment reports twice the background level.

4.5.2 Visual Examinations

The visual examinations of 241-AZ-101 and 241-AZ-102 were completed on July 26 and July 28, 1993, respectively. These were closed circuit television (CCTV) examinations of two selected areas of the annuli of the tanks and were designed to detect visible cracks, potential leak sites, and other physical impairments. The objectives, procedures, observations, and conclusions are described in the visual examination report (Harris 1993). Permanent records include videotapes and color photographs in addition to the written assessments. The acceptance testing and detailed description of the equipment and activities are contained in the acceptance test report (Sumsion 1992).

Approximately 18% of the primary shell surface and 30% of the secondary liner surface were examined in each tank. The two viewed areas of the annulus are on opposite sides of the tank and are about equal.

“This visual examination found no indications of primary shell leakage. Further, this examination did not detect evidence of visible cracks, potential leak sites, or other physical impairments to the tank shells.” (Harris 1993)

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 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. These are listed below.

• 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). Schematics are as included as 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 depths for these three conditions were 10%(t), 25%(t), and 0.18 in., respectively, where t is the nominal wall thickness.

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). A demonstration that was conducted on a full-size tank section mock-up was also described in that report. The mechanical UT scanner was housed in a remotely-controlled crawler that provided the 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 steel 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 was 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 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 UT 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)
				Sludge Levels	H ₂	Changing Waste Height				
AW-103		X		X						X
AN-107			X							
AZ-101	X	X					X	X		X
AY-102	X	X				X		X		X
AN-105					X		X			
AN-106									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						Reportable Thinning (>10% thickness)	Reportable Pitting (>25% thickness)	Reportable Waterline Attack ¹	Reportable Cracking (>0.18 in)
	Vertical Wall	Lower Knuckle	Tank Bottom (slots)	Lower knuckle Weld	Lowest Vertical Weld	2 nd -lowest Vertical Weld				
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 for the design evaluations, corrosion and compatibility reviews, and integrity examinations that were completed for the 241-AZ double-shell tanks. The reviews of design, fabrication, and design analyses documentation against the requirements of the applicable codes and standards showed that these steel and concrete tanks were conservatively designed, constructed to the design requirements, and correctly analyzed for combined normal and seismic conditions. The systematic corrosion and compatibility reviews did not anticipate any structurally significant corrosion.

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-AZ 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 1968 Edition of the ASME Code used the design-by-rule approach. Design-by-analysis, prevalent in the code today, was first adopted for Sections III and VIII, Div. 1 in the 1969 Edition. Therefore, documentation of later analyses germane to the AZ tanks will also be cited for this design evaluation. Since the design of the AY and AZ tanks are nearly identical (Fisher 1994), some later analyses were for AY/AZ tanks. [The only differences noted were a slightly larger outside radius of curvature for the concrete dome for AY tanks (1,260 in. versus 1,198 in.) and slight differences in plate thickness for the steel tanks.]

The 1968 Edition of the ASME Code did not require thermal analysis of the primary steel tank. However, an analysis that included thermal gradient loading was performed in 1982 per Section III, Div. 1 requirements (ASME 1982), and concluded that the maximum stress intensity and principal stress for the primary steel tank are within allowable limits, including a 0.050-in. reduction in wall thickness for corrosion. Buckling of the primary tank dome was also analyzed and found not to be a problem (Vollert 1982).

The design included a positive vapor pressure in the tank of 60 in. of water. Operating experience has shown this to be conservative. The physical limitations of the existing primary tank vent systems will not permit a positive vapor-space pressure (Becker 1994a).

The maximum design temperature was 350°F for the waste. Operating experience has shown this to be conservative, because the maximum reported temperature in AZ-101 and AZ-102 was 263°F and 249°F respectively (Brevick 1995a). Huisingh (Huisingh 1994) reported 215°F and 240°F, respectively, for the two tanks. Although these temperatures are the highest reported for double-shell tank waste, they are still considerably below the design temperature. The current

operational limit on waste temperature is 215°F as will be discussed in a later paragraph in this section.

The design of the secondary steel liner is considered adequate. The liner is anchored to the concrete structure and, therefore, simply follows the movements of the concrete tank (i.e., it is displacement-controlled). The design of the double-shell tank did not rely on any structural contribution by the steel liner. The wall thickness is adequate for losses due to corrosion and oxidation.

The 1963 Edition of the ACI Building Code did not require ultimate load analysis of the secondary concrete tank or the consideration of thermal creep of concrete. However, an analysis that included both of these was performed in 1982 and predicted sufficient structural capacity for safe long-term operation (Vollert 1982). The axisymmetric analysis using the SAFECRACK computer program included plasticity, creep, and concrete cracking and the effects of elevated temperature exposure on concrete properties (PCA 1981). The analysis assumed a different density for the soil (115 lbf/ft³ instead of the 110 lbf/ft³ specified by the design), but the design value for soil density is conservative since Pianka (Pianka 1994) lists the same value as that used by Vollert (Vollert 1982). The specified design temperature for the concrete tank (350°F) is the same as that specified for the maximum waste temperature. This is conservative because of the insulating effect of the annulus. Also, should waste leak into the annulus, it will be pumped out within one week. The tank temperature is also conservative because of the low waste temperatures cited above. The Vollert (Vollert 1982) analysis is conservative because of the reasons just cited and because both creep and property degradation of concrete are less for lower temperatures (Kassir 1996).

The design used a 28-day strength for concrete. This is conservative since concrete continues to harden appreciably with time (for example, winter 1958).

The seismic acceleration used in the analyses for the AZ tanks (Blume 1971) was 0.25g, which is essentially the same as the 0.26g in the current site criteria (HNF-PRO-97). This slight difference in seismic loading is insignificant compared with safety margins built into the design. The site criteria require two orthogonal horizontal directions, but for the radially symmetric double-shell tank, an axisymmetric model as used by Blume is appropriate. The fact that the increase in wall pressure due to a seismic-induced impact against the dome was not included in the Blume (Blume 1971) analysis is not considered consequential due to the high viscosity of the waste and the constraint of the dome. The omission of the tank wall/footing discontinuity from the model is unlikely to affect the conclusions. The records search did not find an analysis of the combined effect of normal and seismic loading. However, a later analysis combined vertical seismic loads with normal loads to conclude that the dome loading on Tank AZ-101 was acceptable (Ryan 1989). Importantly, the results of the DELPHI Study (Han 1996) show the seismic loading to be a minor player in the tank failure scenarios.

The Hanford waste tank facilities are currently operating safely under the umbrella of the Basis of Interim Operation (BIO) (Duke 1998a) and the associated technical safety requirements released in 1998. Importantly, the BIO contains no reservations particular to the continued safe operation of the 241-AZ facility. A two-phase structural analysis sensitivity study for the upper

portions of the concrete enclosure tank was completed in 1995 (Becker 1994b and Scott 1995) to provide information for the BIO and, in particular, the technical safety requirement-governing operation of the double-shell tank facilities (Duke 1998b). During these studies, state-of-the-art analyses were completed for the 241-AZ concrete tanks with the resulting stresses meeting those allowed in more recent editions of the ACI 349 Code (ACI 1992) and ASME Code (ASME 1994). Currently, the technical safety requirement authorizes 8.3 feet of soil at a soil unit weight of 125 lbf/ft³ and a 100-ton concentrated load for AY and AZ double-shell tanks, compared to 7.5 ft. of soil and 100 tons for the other double-shell tanks. This attests to the adequacy of the AY/AZ concrete tank design. These authorized loads are both higher than the original design values. The current technical safety requirement limit for waste temperature (sludge) is 215°F.

A document review of AY/AZ analyses (Abatt 1998) has noted some concerns regarding certain variables pertaining to the tanks. Those not yet addressed in this report include pressure loads due to wind, abnormal pump loads, riser impact loads, and thermal cyclic history missing from the Vollert (Vollert 1982) thermal analysis. Any pressure loads from wind would simply add or subtract slightly from the hydrostatic loads. Since these are small when compared to the thermally-induced loads, the slight changes due to the wind are considered very minor and, therefore insignificant. Abnormal pump loads are associated with pump plugging or failure. Given the current status of these tanks as condensate receivers, these incidents are too improbable to be considered. Riser impact loads are considered not to be relevant to this assessment since they are not unique to the AZ tank farm and are addressed by site dome-load control procedures.

The single remaining (Abatt 1998) concern is the possible effect of thermal cycling history on the Vollert (Vollert 1982) and Scott (Scott 1995) thermal analyses of the AZ tanks. The somewhat elevated maximum temperatures of 263°F and 249°F for the two tanks were noted above. Brevick also reports temperature swings (ΔT) of 226 and 196° F, respectively, for the two tanks (Brevick 1995b). This magnitude of thermal cycling may be significant. These data represent only the period from 1983 to 1990. See the recommendation in Section 6.0.

The successful leak-free operation of the 241-AZ tank system for 23 years suggests that the design is adequate for continued service. A visual examination conducted in 1993 showed no evidence of leakage or any physical impairment to the tank shells that would impact the design (Harris 1993). Additional confirmation of an adequate 241-AZ double-shell tank design is provided by the leak-free performance of the 26 additional double-shell tanks of a very similar design that are operating at Hanford.

The 241-AZ double-shell tanks were conservatively designed to the requirements of existing codes and standards. The design requirements, including all of the extensive tests and examinations, were satisfactorily translated to the fabricator's specifications and drawings and an excellent quality control program assured that these requirements were met during fabrication. One instance of localized plate laminations was found but this was appropriately analyzed and determined to be an acceptable condition.

Analyses using methods suitable to today's practices, as noted above, have been applied to the AZ tank design and concluded that these tanks have adequate strength to provide many more

years of safe storage of Hanford waste, assuming a total corrosion allowance of 0.050 in. (0.001 in./year for 50 years). Analyses included the effects of long-term exposure at elevated temperatures on the behavior of the tank concrete. Seismic analyses showed that a 0.26g safe shutdown earthquake would put minimal demands on the concrete tank structure and, therefore, the seismic resistance of the tank would remain intact.

5.2 WASTE CHARACTERISTICS AND COMPATIBILITY

All wastes contained within the tanks meet the Hanford Technical Specifications for corrosivity (Kirch 1984) and are therefore compatible with the steel tanks. Future wastes are also expected meet these standards.

The secondary tank is limited for a maximum of one week in contact with the waste to eliminate the chance for stress-corrosion cracking.

From the information presented above on the wastes, none are considered energetic; none of the tanks are on the Hydrogen Watch List and no special controls are required. No reactions are expected that could pressurize the tanks above the design limit (Vitro 1970) of 60 in. of water.

5.3 CORROSION PROTECTION

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

- Atmospheric corrosion
- General (uniform) corrosion
- *Pitting and crevice corrosion*
- Stress-corrosion cracking
- Microbiologically-influenced corrosion
- Concentration cell and waterline corrosion
- Fatigue
- Erosion and erosion corrosion
- Wear
- 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 as being insignificant or inapplicable to the tanks. The first five are of potential concern and were evaluated in Section 4.3.1 in some detail. None were found to be of critical importance.

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.

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. Nevertheless, these rates are not expected to impact the allowed one-week exposure time (Vitro 1970) 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 technical specifications (Kirch 1984). 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 to contain leaks.

Stress-corrosion cracking has been shown to be of minor significance because of heat treatment of the primary tank shell and because of the waste chemistry. Further, experience at Savannah River shows that if the tank cracks, the waste is likely to plug the crack. Therefore, catastrophic failure is not likely (Poe 1974).

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 30 years ago.

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

5.4 FACILITY AGE

The operational age of the 241-AZ double-shell tank farm facility is approximately 23 years (as of 1999). The latter half of service life has been as "inactive dilute receiver tanks." A service life was not addressed in the design documents, but Vollert (Vollert 1982) has qualified the design of the primary tank for 50 years with a corrosion allowance of 0.050 in.

5.5 MATERIAL CONDITION

5.5.1 Primary Tank

The visual examinations and leak detection system review showed that the primary tanks in AZ-101 and AZ-102 are not leaking and there was no evidence of any past leakage.

The six tanks that were UT-examined 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.

Unfortunately, the surface condition of the lower knuckle of AY-102¹ did not allow UT examination. However, due to the age of the tank, any stress corrosion cracking occurring would likely have propagated through the wall. Also, corrosion-fatigue cracking typically requires 1,000 cycles before it is a problem. None of the tanks are expected to experience 1,000 stress cycles.

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 (Anantamula 1997). Both tanks had held waste for some period during their 10 years of operation. AP-104 had contained flush water and decontamination waste (from N Reactor) for several months and then was 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).

Since penetration by pitting is rapid (Davis 1987), active pitting is not occurring in the Hanford double-shell tanks. Otherwise, pitting would have been found at reportable levels during UT examinations. Also, if pitting had occurred in tanks that contained untreated water prior to waste addition, progression would likely be arrested by the addition of waste containing OH^- or NO_3^- (Davis 1987).

General corrosion (Thinning) at reportable levels was found in localized areas of one ring of the 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 (Anantamula, 1999) suspects

¹ Poured concrete used for the repair of the adjacent Kaolite pad left concrete adhering to the surface of the lower knuckle. Kaolite is a registered trade name of Babcock & Wilcox Co.

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.

Wall thinning by corrosion is not prevalent for Hanford double-shell tanks because five tanks that collectively represent the highest waste temperatures, two plate materials, longest exposure times, many waste types, and four tank farms, showed no reportable wall thinning for exposures to all three waste phases (liquid, vapor, and sludge).

Waste temperature is not a significant contributor to wall thinning in Hanford double-shell tanks.

There is nothing apparently unique about the design, material, or fabrication of the primary tank in AN-105 that could explain the observed wall thinning. It is not known what operational parameters caused the wall thinning to occur only in AN-105. For example, the similar waste level histories for AN-106 and AN-107 did not precipitate corrosion thinning in those tanks. Also, Tank AY-102 contained only water for the first five years and it did not show thinning in the vapor space. See the recommendations in Section 6.0.

5.5.2 Steel Liner

The visual examinations and leak detection system review showed that the secondary steel liners in AZ-101 and AZ-102 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 AZ DSTs.

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. Perform more complete research into the thermal cycle history of both 241-AZ-101 and -102 and determine any effects on thermal model analyses already completed (Vollert 1982 and Scott 1995). This could affect the remaining service life.

7.0 FIGURES

ZBAC0122

Figure 1.

Figure 2.

ACAD FILE: ZBAG00140

Figure 3.

ACAD FILE: ZBAC00142

Figure 4.

ACAD FILE: ZBAC00143

Figure 5.

8.0 REFERENCES

- Abatt, G. and M. A. Scott, 1998, *241-AY/AZ Analysis Documentation Review*, HNF-3139, Revision 0, COGEMA Engineering Corporation, Richland, Washington.
- ACI 1963, *Building Code Requirements for Reinforced Concrete (ACI 318-63)*, American Concrete Institute, Detroit, Michigan.
- ACI 1992, *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-92)*, American Concrete Institute, Detroit, Michigan.
- ACI 1965, *Reinforced Concrete Design Handbook: Working Stress Method*, Third Edition, Publication SP-3, American Concrete Institute, Detroit, Michigan.
- Anantatmula, R. P., 1997, *Visual Examination of 241-AP-104 and 241-AP-107*, HNF-SD-WM-RPT-307, Revision 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.
- ASME 1968, *ASME Boiler and Pressure Vessel Code*, American Society of Mechanical Engineers, New York, New York.
- ASME 1982, *ASME Boiler and Pressure Vessel Code*, Section III, Div. 1, American Society of Mechanical Engineers, New York, New York.
- ASME 1994, *ASME Boiler and Pressure Vessel Code*, Section III, Div. 2, American Society of Mechanical Engineers, New York, New York.
- ASTM 1969, Annual Book of ASTM Standards, *American Society for Testing and Materials*, 1969 Edition, Philadelphia, Pennsylvania.
- Bardes, B. P., Ed., 1987, *Properties and Selection: Iron and Steels*, Vol. 1, Metals Handbook, 9th Edition, ASM International, Metals Park, Ohio.
- Becker, D.L., 1994a, *Single- and Double-Shell Tanks Load Report for Accelerated Safety Analysis*, WHC-SD-ES-286, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Becker, D.L., 1994b, *Accelerated Safety Analysis – Structural Analyses Phase I – Sensitivity Evaluation of Single- and Double-Shell Waste Storage Tanks*, WHC-SD-WM-SARR-012, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Blume, 1971, *Seismic Analysis of Underground Waste Storage Tanks 241-AZ-101 and -102 at Hanford, Washington*, ARH-R-85, Rev. 0, prepared by John A. Blume & Associates, Engineers, San Francisco for Atlantic Richfield Hanford Company, 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. Pickett, 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, W. W. Pickett, 1995b, *Supporting Document for the Southeast Quadrant Historical Tank Content Estimate Report for AZ-Tank Farm*, WHC-SD-WM-ER-318, Rev. 0, ICF Kaiser 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 1997, Letter No. 97-WSD-258, J. K. McClusky (DOE-RL) to J. Hatch (FDH), December 23, 1997, *Double-Shell Tank System Integrity Program Plan*, Contract Number DE-AC06-96RL13200, U. S. Department of Energy, Richland Operations Office (RL), Richland Washington.
- Duke, 1998a, *Tank Waste Remediation System Basis for Interim Operation*, HNF-SD-WM-BIO-001, Rev. 0, Duke Engineering & Services of Hanford, Inc., Richland, Washington.
- Duke, 1998b, *Tank Waste Remediation System Technical Safety Requirements*, HNF-SD-WM-TSR-006, Rev. 0, Duke Engineering & Services of Hanford, Inc., Richland, Washington.
- Escalante, E., 1992, NIST, Personal Communication to Dr. J. R. Divine, P.E.
- FDH 1998, *AY And AZ Tank Farms Monthly Rounds*, Tank Farm Plant Operation Procedure TF-OR-EF-AYAZ-M, Rev. B-2, February 10, 1998, Fluor Daniel Hanford Corporation, Richland, Washington.

- FDH 1999, *Perform Functional Test For AY/AZ Aging Waste Facility Annulus Leak Detectors*, , Tank Farm Plant Operations Procedure TF-FT-259-008, Rev. B-3, February 25, 1999, Fluor Daniel Hanford Corporation, Richland, Washington.
- Fisher, T. W. and D. J. Shank, 1994, *Single- and Double-Shell Waste Tank Design Comparisons at Hanford, Washington*, WHC-SD-WM-TI-598, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Han, F. C., 1996, *DELPHI Expert Panel Evaluation of Hanford High Level Waste Tank Failure Modes and Release Quantities*, (compiled and edited by L. Leach) WHC-SD-TWR-RPT-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Harris, J., 1993, *Visual Examination Report for Tank Annuli at the 241-AY and AZ Tank Farm*, WHC-SD-WM-RPT-078, Rev. 0, Westinghouse Hanford Company for the U. S. Department of Energy, Richland Field Office, Richland, Washington.
- Hatch, J. C., 1970, *Design Criteria PUREX AZ Tank Farm*, ARH-1437, Atlantic Richfield Hanford Company, Richland, Washington.
- HNF-PRO-97, *Project Hanford Policy and Procedure System, Engineering and Evaluation*, Fluor Daniel Hanford Corporation, Richland, Washington.
- Hodgson, K. M., 1995, *Tank Characterization Report of Double-Shell Tank 241-AZ-101*, WHC-SD-WM-ER-410, Rev. 0, Westinghouse Hanford Company, 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.
- Huisingh, J. S., N. D. Ha, and B. D. Flanagan, 1994, *Maximum Surface-Level and Temperature Histories for Hanford Waste Tanks*, WHC-SD-WM-TI-591, Rev. 0, Westinghouse Hanford Company, 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 Rev. 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., 1995, *Development of In-Structure Design Spectra for Dome Mounted Equipment on Underground Waste Storage Tanks at the Hanford Site*, WHC-SD-WM-TI-713, Rev. 0, prepared by ICF Kaiser Hanford Company for Westinghouse Hanford Company, Richland, Washington.
- Kassir, M. K., K. K. Bandyopadhyay and M. Reich, October, 1996, *Thermal Degradation of Concrete in the Temperature Range from Ambient to 315 °C (600 °F)*, BNL 52384 (Rev. 10/96), Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York.
- 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.
- Leshikar, G. A., 1997, *Final Report: Ultrasonic Examination of Tank 241-AW-103 Walls*, HNF-SD-WM-TRP-282, Rev. 0, SGN Eurisys Service Corporation, Richland, Washington.
- Milbradt, K.P., 1973, *Final Report Strength and Stress Analysis for AZ Waste Tanks at Hanford Washington*, WHC-MR-0198, Westinghouse Hanford Company, 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.
- Ondrejcin, R. S. and D. A. Mezzanotte, 1981, *Mechanism of Waste Tank Pitting*, DPST-81-591, E. I. duPont de Nemours & Co, Aiken, South Carolina. Not approved for public release and not sent to the NTIS.

PCA 1981, *Effects of Long-Term Exposure to Elevated Temperature on the Mechanical Properties of Hanford Concrete*, RHO-C-54, October 1981, Portland Cement Association, Detroit, Michigan.

PDM, 1970, *ASME Stress Analysis Report for the 241-AZ Tanks*, Pittsburgh-Des Moines Steel Company, Pittsburgh, Pennsylvania (Hanford Record Box 074081).

Pfluger, D. C., 1999, *Engineering Task Plan for the Ultrasonic Inspection of Hanford Double-Shell Tanks*, HNF-2820, Rev. 2, Lockheed Martin Hanford Corporation, Richland, Washington.

Pianka, E. W., 1994, *Soil Load Above Hanford Waste Storage Tanks*, WHC-SD-WM-TI-665, Revision 0B, Westinghouse Hanford Company, Richland, Washington.

Poe, W. L., 1974, *Leakage from Waste Tank 16: Amount, Fate, and Impact*, E. I. duPont de Nemours & Co, Aiken, South Carolina.

Project HAP-647, 1970,

Specifications

HWS-8981	Excavation and Tank Foundation
HWS-8982	Primary and Secondary Steel Tanks

Engineering Drawings

H-2-67243	Structural Concrete Tank Foundation Plan and Detail
H-2-67244	Structural insulating Concrete Plan and Details
H-2-67245	Concrete Tank Section and Haunch Reinforcement
H-2-67246	Concrete Dome Reinforcement Plan and Details
H-2-67247	Concrete Haunch Reinforcement at Annulus Access
H-2-67314	Plan Tank 101 Penetrations and Schedule
H-2-67315	Plan Tank 102 Penetrations and Schedule
H-2-67316	Penetration Details Tank 101 and 102
H-2-67317	Tanks 101 and 102 Sections and Details

Rollison, M. D., 1995a, *Results for 241-AZ-101 Grab Samples*, Internal Memo 8E480-95-023, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Rollison, M. D., 1995b, *Results for 241-AZ-101 Grab Samples*, Internal Memo 75970-95-037, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

Rollison, M. D., 1995c, *Results for 241-AZ-102 Grab Samples*, Internal Memo 8E480-95-024, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Rollison, M. D., 1995d, *Results for 241-AZ-102 Grab Samples*, Internal Memo 75970-95-039, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Ryan, G. W., 1995, *Tank Characterization Report for the Double-Shell Tank 241-AZ-102*, WHC-SD-WM-ER-411, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Ryan, J. A., 1989, *Analysis of Underground Double-Shell Tank 241-AZ-101*, WHC-SD-WM-DA-050, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Schreiber, R. D., 1995, *Tank Characterization Report for the Double-Shell Tank 241-AZ-102*, WHC-SD-WM-ER-411, Rev. 0-A, 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.
- Scott, M.A. and W.S. Peterson, 1995, *Accelerated Safety Analyses Structural Analyses Phase II ACI Code Evaluations 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.
- 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.
- Strode, J. N. and V. C. Boyles, 1998, *Operation Waste Volume Projection*, HNF-SD-WM-ER-029, 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.
- Templeton, A. M., 1999, *Tank Characterization Report for Double-shell Tank 241-AZ-101*, WHC-SD-WM-ER-410, Rev. 0-C, Lockheed Martin Hanford Corporation, Richland, Washington.
- USAEC, 1963, *Nuclear Reactors and Earthquakes*, TID-7024, U.S. Atomic Energy Commission, Washington, D.C.
- Vitro 1970, *Specifications for Primary and Secondary Steel Tanks Project HAP-647 Tank Farm Expansion, 241-AZ Tank Farm*, HWS-8982, Rev. 2, Vitro Engineering Corporation, Richland, Washington.

Vollert, F. R., 1982, *Thermal Creep and Ultimate Load Analysis of the 241-AY/AZ Reinforced Concrete Underground Waste Storage Tank*, SD-RE-TI-041, Rockwell Hanford Operations, Richland, Washington.

WAC 1998, *Dangerous Waste Regulations*, Washington Administrative Code, Chapter 173-303-640(2), Washington State Department of Ecology, Olympia, Washington.

Winter, George, L. C. Urquhart, C. E. O'Rourke, Arthur H. Nilson, all of Cornell University, 1958, *Design of Concrete Structures*, p. 15, McGraw Hill Publishing Company, New York, New York.

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.

APPENDIX A – CONSTRUCTION RECORDS

A-1 Materials and Welding Processes Specified for 241-AZ-Double-Shell Tanks

A-2 Construction Records for Plate Lamination Incident for AZ-101 Primary Tank

**A-1 MATERIALS AND WELDING PROCESSES
SPECIFIED FOR 241-AZ DOUBLE-SHELL TANKS**

A. Materials specified for 241-AZ double-shell tanks*

Primary and Secondary Tanks	Welded ASTM A515, GR 60 Carbon Steel Plates
Temporary Attachments Clips, etc. and Structural Steel Shapes	ASTM A36
Carbon Steel Pipe	ASTM A53, GR B (Type E or S) ASTM A106, GR A or B (Type E or S) ASTM A134/283 Welded (Sizes > 24")
Carbon Steel Welding Fittings	ASTM A234, GR WPB
Flanges	ASTM A181 GR I
Stainless Steel Pipe 12 inches and smaller	ASTM A312, Type 304L
20-inch Vapor Vent Pipe	ASTM A409, Type 304L
Flexible Annulus Penetration Sleeves (Double convoluted, Plain end, $\pm 1"$ of axial and lateral movement)	Bellows- 304, 316, or 321 SS Pipe Ends- Sch 40 A106

B. The following welding methods were allowed.

The contractor was required to use automatic welding processes wherever possible. A removable copper backup was required for all automatic welding except above upper knuckles where permanent backing strips were allowed. All welders, welding operators, and welding procedures were to be qualified to Section IX of the ASME Code. Welding materials were to comply with ASTM A233, ASTM A559, or ASTM A558. All butt welds were to be full penetration.

C. The following examinations during welding and fabrication were required.

Radiographic examination (100%) was required for:

- 1) all butt welds on the primary tank except those above the dome knuckle-to-side plate tangent,
- 2) all butt welds on the secondary tank joining floor plates, knuckles, and first course of side plates,
- 3) all weld extensions on plate surfaces at intersections of welds requiring radiographic examination.

* This information is taken from drawings and specifications issued to Project HAP-647. The reader should review Specification HWS-8982 and drawings listed in Drawing Index No. H-2-67240 for accurate referencing.

Magnetic particle examination was required for:

- 1) all areas on either surfaces of primary tank where clips, lugs, etc., have been removed and all areas of plate repair except for surfaces of primary tank dome plates,

Vacuum leak testing was required (before and after stress relief) for:

- 1) full length of all welds in bottom of primary and secondary tanks.

Visual inspection was required for:

- 1) all welds and weld preps (after cleaning),
- 2) each pass on multi-pass welds.

A-2 CONSTRUCTION RECORDS FOR PLATE LAMINATION INCIDENT FOR AZ-101 PRIMARY TANK

NL-124 (REV. 9-68) RICHMOND, VIRGINIA		U. S. NUCLEAR ENERGY COMMISSION RICHMOND OPERATIONS OFFICE CONTRACTORS CONSTRUCTION REPORT FOR WEEK ENDING <u>March 18, 1972</u>		☐ AEC AREA ENGINEER ☐ OTHER: <u>Bex</u> <u>033369</u>	
PART I					
CONTRACT NO. <u>AT (45-1)-2176</u>			CONTRACT TITLE <u>Tank Farm Expansion For Purex Waste Storage Facility No. 241-AZ</u>		
CONTRACTOR <u>Pittsburgh-Des Moines Steel Co.</u>					
SUBMITTED BY <u>Brent B. Hacking</u>					
TITLE <u>Project Manager</u>			PROJECT NO. <u>HAP-647</u>		
PART II MANPOWER			PART-III PROGRESS STATUS		
	MANUAL	NON - MANUAL	DATE	SCHEDULED	ACTUAL
FORCE ON PAYROLL (THURSDAY)	17.0	7.0	STARTING	11-13-70	11-23-70
AVE. DAILY FORCE PRESENT	17.0	7.0	READY-FOR-USE		
TOTAL MAN - DAYS <u>4390</u>	<u>THIS WEEK</u> 120	<u>TO DATE</u> 3838	<u>TO COMPLETE</u> 552	COMPLETION 8-17-72	
				% COMPLETE 61	63
PART IV PERTINENT BRIEF COMMENTS ON PROGRESS, DELAY, IMPORTANT EVENTS					
PROGRESS THIS WEEK: Finished welding in penetration in Tank 101 Dome. Welded in Dome Saucer plates in Tank 101. Welding Horizontal PR-4 Shell Ring in Tank 102. Hung Primary upper Knuckles on Friday on Tank 102. Finished Magnetic Particle Examination of Primary bottom and knuckle plates in Tank 101. Hired an additional Laborer to do the cleaning for MT.					
DELAYS:					
IMPORTANT EVENTS: E.J. Bartell's brought a load of insulation blankets on to the jobsite.					
PROBLEMS: Found Laminations in PR-4 Shell plates in Tank 102 on Thursday. Vitro checked plates with ultra-sonic testing on Friday.					
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> RECEIVED <i>Vitro</i> / HES MAR 24 1972 AM 7,8,9,10,11,12,1,2,3,4,5,6 PM </div>					

Sheet

U.S. NUCLEAR ENERGY COMMISSION
RICHLAND OPERATIONS OFFICE

CONTRACTORS CONSTRUCTION REPORT

FOR WEEK ENDING March 25, 1972

TO:
☐ AEC AREA ENGINEER
☐ OTHER:

PART I CONTRACT NO. <u>AT (45-1)-2176</u> CONTRACTOR <u>Pittsburgh-Des Moines Steel Co.</u> SUBMITTED BY <u>Brent B. Hacking</u> TITLE <u>Project Manager</u>				CONTRACT TITLE <u>Tank Farm Expansion</u> <u>For Purex Waste Storage</u> <u>Facility No. 241-AZ</u>			
PROJECT NO. <u>HAP-647</u>							
PART II MANPOWER							
	MANUAL	NON - MANUAL					
FORCE ON PAYROLL (THURSDAY)	16.0	7.0					
AVE. DAILY FORCE PRESENT	17.0	7.0					
TOTAL	THIS WEEK	TO DATE	TO COMPLETE				
MAN - DAYS	119	3957	433				
PART III PROGRESS STATUS							
	DATE	SCHEDULED	ACTUAL				
STARTING		11-13-70	11-23-70				
READY-FOR-USE							
COMPLETION		8-17-72					
% COMPLETE		63	69				
PART IV PERTINENT BRIEF COMMENTS ON PROGRESS, DELAY, IMPORTANT EVENTS							
<p><u>PROGRESS THIS WEEK:</u> All X-raying on Tank 101 was completed and accepted and the okay was given to go ahead with Stress Relieving preparation on Wednesday. E.J. Bartell began hanging Stress Relieving Insulation on Tank 101 on Thursday. Welding on upper Primary Knuckles vertical and horizontal seams in Tank 102. Welding dome sub-assemblies for Tank 102. Material for Stress Relieving equipment support system arrived on jobsite Friday.</p> <p><u>DELAYS:</u></p> <p><u>IMPORTANT EVENTS:</u> Tank 101 X-raying was completed and approval was given to begin making preparation for Stress Relieving.</p> <p><u>PROBLEMS:</u> Still waiting word on Laminated shell plates. Our schedule indicates that we should be welding the laminated plates in to place.</p>

NONDESTRUCTIVE TEST REPORT NONDESTRUCTIVE TEST APPLICATIONS 306 BLDG., 300 AREA - TEL. 3682		REPORT NO. 72-41-1	
				DATE 3/27/72	
CLIENT VITRO			CURT. P.O. NO.		WORK ORDER NO. B 51458
ATTENTION: D. Mager			☐ PENETRANT ☒ ULTRASONIC		☐ MAGNETIC PARTICLE ☐ EDDY CURRENT
ADDRESS 2101 M Bldg. 200 East Area			ACCEPT. STD. None Specified		
MATERIAL/PART/DWG. NO. Carbon Steel 3/8" Plate (A 515)					
Tank 102 Radio Waste Storage					
SPEC. None			TECH. DATA ASTM A578 and B&PV SEC.V SA435 Modified		
TEST EQUIPMENT Branson Sonoray, 5 MHz 3/4" diameter transducer and glycerin. No calibration					
sample was available.					
SET UP DATA Adjusted equipment to produce 4 back reflections, from the 3/8" material, displayed approximately 3/4" apart on the CRT.					
TEST RESULTS <p>The following is the second of two reports regarding the inspection of the subject plate material.</p> <p>During the first inspection, the inspector was given no specific test parameters, but was requested by the customer (VITRO) to ultrasonically examine the plate for laminations and to determine the "general condition" of the plate.</p> <p>Using this generality as a guideline, the inspector scanned the random areas chosen by the customer. This inspection did disclose areas throughout the plate that could be termed laminar (by definition), but in this instance to avoid misinterpretation, a more suitable description may be as follows: "closely spaced intermittent reflections in a plane near midthickness of the plate". This condition could be caused by many small inclusions or actual micro laminations.</p> <p>Subsequent to the first inspection, it was realized that a more specific type of information was required, so VITRO Engineering requested that the inspection be repeated using guidelines based on the ASME Boiler & Pressure Vessel Code, Section V, SA435 (Modified for 3/8" plate).</p> <p>With definitive criteria now available to the inspectors, the plate was reinspected with the following results:</p> <p>TEST DATA:</p> <ol style="list-style-type: none"> 1. No laminar indications were noted during the UT spot examination on a 3 foot by 6 foot section between RT 23 thru RT 29 using a 2 inch step over pattern. 2. The area between RT9-10 was evaluated. An area approximately 2 inches square was marked below RT10 six inches from the bottom of the plate as being a laminar discontinuity. <p style="text-align: right;"> <u>RL George/WC Milliron-UT Level II</u> <u>NDT Technicians</u> SIGNATURE TITLE </p>

WADCO CORPORATION	NONDESTRUCTIVE TEST REPORT NONDESTRUCTIVE TEST APPLICATIONS 306 BLDG., 300 AREA - TEL. 3682	REPORT NO. 72-41-1 DATE 3/27/72
<p>3. A strip 2 inches wide by 3 feet long between RT 16-17 revealed no lamination.</p> <p>4. In a 1 inch strip immediately below the longitudinal weld at top of the plate between RT 175 to 179, 187-188, 205-208, 213-214, 225-226, 234-235 no laminar type indications were noted.</p> <p>5. A 1 inch area below longitudinal weld at top of plate RT 89-92 revealed sporadic or intermittent reflectors parallel to the weld. However, there was no loss of back reflectors.</p> <p>6. Clockwise to the weld, bottom of the plate at RT 88 - a 4 inch long by 3 inch wide area was revealed to be laminated.</p> <p>All measurements are larger than actual discontinuity as areas were marked at extreme edge of 3/4 inch diameter transducers.</p>

HANFORD ENGINEERING SERVICES
A DIVISION OF VITRO CORPORATION OF AMERICA
DESIGN ANALYSIS

FOR AZ TANK FARM-TX 102
LOCATION 200 EAST
SUBJECT ULTRASONIC TESTING

PAGE
JOB NO. HAP-647
DATE 3-27-72
BY D.S. MAGER

VER.ICAL WELD IDENTIFICATION

SLAB
No. 5-1 5-1 5-1 5-1 1-2 1-2 9-2 9-2

HEAT
No. 92B163 92B163 92B163 92B163 92B208 92B208 92B449 92B449

AREAS TESTED:

9-10 - 12" x 37"
16 - 2" x 37"
17 - 2" x 37"
23-29 - 3" x 6"
88 - 3" x 4"
89-92 - 1" x 36"
175-179 - 1" x 48"
187-188 - 1" x 12"
205-208 - 1" x 36"
213-214 - 1" x 12"
225-226 - 1" x 12"
234-235 - 1" x 12"

DEFINITIONS
FROM METALS HANDBOOK

DISCONTINUITY -	Any interruption in the normal physical structure or configuration of a part, such as cracks, laps, seams, inclusions or porosity. A discontinuity may or may not affect the usefulness of a part.
CRACK -	A break without parting A break so that fissures appear A narrow opening or fissure
LAP -	Surface defect appearing as a seam, caused by folding over hot metal, fins or sharp corners and then rolling or forging them into the surface but not welding them.
LAMINATION -	Metal defects with separation or weakness generally aligned parallel to the work surface of the metal. May be the result of pipe, blisters, seams, inclusions or segregation elongated and made directional by working.
SEAM -	(1) On the surface of metal, an unwelded fold or lap which appears as a crack, usually resulting from a defect obtained in casting or working. (2) Mechanical or welded joints.
STRINGER -	In wrought materials, an elongated configuration of microconstituents or foreign material aligned in the direction of working. Commonly, the term is associated with elongated oxide or sulfide inclusions in steel.
INCLUSIONS -	Non-metallic materials in a solid metallic matrix.
POROSITY -	Fine holes or pores within a metal.
FISSURE -	A split or crack in a cellular material. (ASTM Glossary and Index)

DISTRIBUTION SHEET

To Distribution	From Tank Systems Integrity Engr'g	Page 1 of 1
Project Title/Work Order 241-AZ Double-Shell Tanks Integrity Assessment Report		Date 9/8/99
		EDT No. 628080
		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./Appendix Only	EDT/ECN Only
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D. B. Smet	R1-56	x			
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T. B. Veneziano	S7-40	x			
M. L. Ramsay	S7-54	x			