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241-AY Double-Shell Tanks Integrity Assessment Report

C. E. Jensen
Prepared by Lockheed Martin Hanford Corporation, Richland, WA 99352
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Abstract: This report presents the results of the integrity assessment of the 241-AY 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-AY DOUBLE-SHELL TANKS (HNF-4959, Rev. 0)

Prepared by:

D. G. Harman and J. R. Divine
COGEMA Engineering Corporation
Post Office Box 840
Richland, Washington 99352

Date Published:

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241-AY DOUBLE-SHELL TANKS

INTEGRITY ASSESSMENT REPORT

Prepared by: K Vscott / for Date 9/1/99
D. G. Harman, ADVENT Engineering Services, Inc.

Date 8 Sept 99
J. R. Divine, ChemMet Ltd., PC

Reviewed by: W. W. Smyth Date 8/31/99
W. W. Smyth, COGEMA Engineering Corporation

Date 9/1/99
T. S. Hundal, COGEMA Engineering Corporation

Approved by: K V Scott Date 9/1/99
K. V. Scott, Manager, Cogema Engineering Corporation

INDEPENDENT, QUALIFIED,
REGISTERED PROFESSIONAL ENGINEER
(IQRPE)

CERTIFICATION OF

241-AY 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."

TSHundal 9/1/99

Tarlok S. Hundal, PE — Date

TARLOK SINGH HUNDAL
STATE OF WASHINGTON
20213
REGISTERED
PROFESSIONAL ENGINEER

9/1/99

EXPIRES 2/15/2000

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241-AY DOUBLE-SHELL TANKS

INTEGRITY ASSESSMENT REPORT

1.0 INTRODUCTION

The 241-AY Tank Farm consists of two double-shell tanks (DSTs) and is located in the 200 East Area of the Hanford Site (see Figure 1). These underground tanks were built under Project IAP-614 in 1968 to 1970 as storage for aging waste and were the first DSTs at Hanford. These two tanks have received various wastes beginning in 1971 and aging waste during 1976 through 1978. They now receive condensate from other aging waste tanks and AY-102 is receiving high heat waste from Tank C-106.

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 AY tanks were adequately designed with sufficient structural strength and compatibility with the stored waste and have been adequately maintained 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 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 Examination- identify the existing condition of each component material based on leak testing, visual, and/or ultrasonic examinations.

3.0 SCOPE

The scope of this assessment includes the primary steel tank and the secondary steel-lined concrete enclosure tank for both AY-101 and AY-102 DSTs. The integrity assessment of the piping system, encasement, and pits was reported in *Double-Shell Tank Waste Transfer Piping/Pit System Integrity Assessment Report* (Hundal 1997).

4.0 DESCRIPTION

The AY Tank Farm was to have been an extension of the existing AX Tank Farm utilizing the same single-shell design (Hatch 1967a). The AX tank design, however, was not used for the AY tanks, and instead a "tank-in-tank" (double-shell) concept was adopted (Hatch 1967a). A description of the studies leading to the double-shell design is included in Hatch (Hatch 1967b).

A schematic of the DST is shown in Figure 2. The primary inner tank that contains the waste is 75 ft. in diameter and 46 ft. 9 in. tall. It is a fully-enclosed tank, fabricated from carbon steel plates, and is 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 necessary to resist the soil loading and the annulus that is fully lined with steel is a leak detection chamber. Specific design details will be discussed later in this report. The two AY DSTs were designed and constructed to be essentially identical in every respect.

4.1 DESIGN STANDARDS

The following paragraphs provide the design requirements and other factors used in assessing the integrity of the AY DST system. The design standards requirements for the 241-AY DSTs are contained in three specifications and nine drawings issued to Project IAP-614 (Project-614 1968) and in the design criteria document (Hatch 1967a).

The 241-AY 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 VIII, Division 2. [Referred to as the ASME Code] (ASME 1965).

- Building Code Requirements for Reinforced Concrete, ACI 318-63. [Referred to as the ACI Building Code] (ACI 1963).

The primary steel tank was designed for an internal vapor pressure of 60 in. of water and a vacuum pressure of 6 in. of water. The maximum design temperature for the tank contents was 350°F (for the solids). The design basis specific gravity of the waste contents was 1.8, the viscosity of the liquid was 0.5-1.0 cP, and the pH was 8-10.

The concrete enclosure tank was designed for live loads consisting of a uniformly distributed surface load of 40 lbf/ft^2 and a 100,000-lbf (50-ton) concentrated surface load. Dead loads included 8 ft. of earth cover (120 lbf/ft^3) and the concrete tank components (150 lbf/ft^3). The design of the concrete tank structure for the AY tanks was based on that for the AX single-shell tanks, but with important design improvements suggested by studies conducted at the Illinois Institute of Technology (IIT) (Hatch 1967a). The IIT work incorporated onsite measurements and sampling in order to model thermal and soil loading of the concrete shell. The analysis method used separate non-linear axisymmetric loading (Milbradt 1972, 1973).

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

The AY design was analyzed for loading from the 0.12g Operating Basis Earthquake for Hanford (TID 7024 1963) by K. P. Milbradt of IIT using the dynamic-elastic method (Shaw 1970). An independent analysis of the same type was conducted during a third-party review of the AY design and concluded that the primary steel tank was adequate to resist the 0.25g horizontal ground motion Design Basis Earthquake for Hanford (Holmes & Narver 1968).

4.1.1 Primary Tank and Secondary Steel Liner

Both the primary tank and secondary liner were fabricated from welded ASTM A515, Grade 60 carbon steel plates (ASTM 1965). The plate thickness for the primary tank vertical wall ranges from 7/8 –in. for the lower knuckle to 3/8 –in. at the upper tangent line. The plate thickness for the dome is 3/8 –in. (except for a 1/2-in. thick center portion) and for the tank floor ¼ in. (except for a 1-in. thick center portion). The plate thickness for the entire secondary steel liner is ¼ in. except for the haunch, which is 3/8 in. These values represent the minimum plate thickness.

Every weld is full penetration. When plates of different thickness were welded together, the inside surface of the tank remained flush except for the base where the outside surface remained flush and the thicker plate had a 4-to-1 taper at fit-up. This occurred at four elevations and two base locations for the primary tank and at a single elevation for the secondary liner. Extensive examinations were required for 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.

4.1.2 Reinforced Concrete Tank Structure

The concrete tank has an 18-in. thick vertical wall, a 15-in. thick elliptical dome, and a foundation thickness varying from 10.5 to 23.5 in.. The haunch region, however, ranges up to about 47 in. in thickness. The size and placement of the additional steel reinforcement in the haunch region was part of the IIT program (Milbradt 1967, 1968). There are approximately 140 dome penetrations (carbon steel pipe) ranging in diameter from 2 in. to 42 in. The foundation extends outward 33 in. beyond the concrete tank wall. The foundation has an array of drain slots to prevent water (or, waste) entrapment beneath the bottom of the secondary steel tank. 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-in. thick pad of insulating concrete.

4.1.3 Construction

Pittsburgh Des Moines Steel Company was the fabricator for the steel tanks and liners. Their drawings, specifications, procedures, qualifications, etc. satisfactorily implemented the design standards in place. The "deviations from drawing requirements" were resolved to the satisfaction of the Title III Inspector who represented the U. S. Department of Energy and the cognizant design representative(s) at Hanford. Copies of the Title III Inspector's verification check sheets for the fabrication of both primary tanks are included in Appendix A.

A single excavation was prepared for both AY DST facilities with an access road left for the contractors. After the reinforced concrete foundation slab was completed, the 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 dome 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 wall 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 AY-101 and AY-102 primary steel tanks were successfully hydrotested by filling them to a depth of 39 feet and holding for 24 hours. The nominal operating level is 30 ft. A more detailed fabrication sequence is included in Appendix A. Portions of the tanks were completed as subassemblies at the fabricator's shop and then transported to the site.

The insulating concrete pad (Kaolite 2200-LI* castable refractory) for both AY tanks deteriorated at the outer perimeter during the stress relief heat treatment (Lien 1969). Following extensive

* Registered trade name of Babcock & Wilcox Co.

testing and analysis (Caudill 1970), an outer ring of Kaolite was removed and replaced with reinforced concrete (Drawing H-2-35299). The newly placed concrete extends inward a minimum of 9 in. beyond the tangent point of the primary tank knuckle and provides full support of the knuckle. During its removal, the portion of the refractory located inward from the knuckle tangent point was found to be sound. This modification was reviewed by a "hazard review task force," which concluded the modified slab to be "adequate and necessary for the safe operation of the 241-AY Tank Farm Facility" (Matheison 1970).

The specified stress-relief annealing treatment required holding the entire primary tank at a soaking temperature of 1150°F ±50°F for one hour. The actual stress relief cycles were 1,080°F for 3.3 hours (AY-101) and 1,020°F for 4.2 hours (AY-102). The applicable part of the ASME Code states that the following combinations of temperature and holding time provide acceptable stress relieving.

Minimum Temperature	Time Per Inch Thickness
1,100°F	One hour
1,050°F	Two hours
1,000°F	Three hours

Earlier nitrate-cracking testing had qualified the minimum specified stress relief treatment (1 hour/1,100°F). Additional tests were then run to demonstrate the adequacy of the lower-temperature cycles. All of these tests are summarized in Moore (Moore 1970). A copy of this letter is included in Appendix A.

4.2 WASTE CHARACTERISTICS AND COMPATIBILITY

The design operating specifications for the AY tanks (Project-614 1968) include:

- Temperature
  - Vapor, above 30 ft — 200-220 °F
  - Liquid, 4 to 30 ft — 210-260 °F
  - Sludge, 0 to 4 ft — 280-350 °F
- Specific Gravity
  - Liquid — 1.0-1.6
  - Sludge — 1.6-2.5
- pH — 8-10

Based on Kirch's work, the operations have to meet the corrosion specifications (Kirch 1984), which restrict the pH to approximately 12 or higher (pH 12 is about 0.01 M NaOH). The corrosion specifications are based on testing at temperatures up to 356°F (180°C). Though higher than originally stated in the design, it is safer considering the presence of nitrate in the waste.

Though both the tanks first received aging waste in 1976 (Brevick 1995), 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 AY tanks are proposed to be source tanks for the vitrification process beginning around 2007 to 2020.

Table 1 Tank Composition History and Forecast

AY-101	
Past Waste Descriptions	The initial waste into AY-101 in 1971 was B-Plant high-level waste. This continued until 1976 when aging waste was introduced. Active B-Plant cesium feed waste was introduced in 1978. Beginning in 1980, it received complexant concentrate waste and then complexed waste from 1981 to 1990. Since 1990, the tank has contained dilute complexed waste. It is currently considered an inactive aging waste tank, a dilute receiver tank receiving condensate from other aging waste tanks. It contains less than 3 wt. % organics and complexants. The temperatures over the last four years, through May 1999, from Personal Computer Surveillance Analysis Computer System (PCSACS), have averaged about 90 °F with a maximum of about 125 °F.
Projected Future Waste	According to Strode and Boyles (Strode 1998), AY-101 is to be emptied of everything but some solids and then serve as a receiver for neutralized current acid waste (NCAW) and then, later, single-shell tank wastes.
Safety Considerations • 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 although the hydroxide concentration is presently low. Hu also notes that insufficient hydrogen is generated to be of concern even if ventilation ceases. 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. Blaak (Blaak 1997) states that, except for corrosion, the tank is in compliance on all counts.

AY-102	
Past Waste Descriptions	AY-102 began service in 1971 with the receipt of water and was considered a spare tank. It then received evaporator waste from 1976 to 1977. Not until 1977 did it receive aging waste. From 1978 to 1980, it received double-shell slurry feed waste and B-Plant waste from 1980 to 1992. It is an inactive aging waste tank that receives condensate from other aging waste tanks. It contains less than 0.5-wt. % organic material. The temperatures over the last four years, through May 1999, from PCSACS, have averaged about 75 °F with a maximum of about 95 °F.
Projected Future Waste	According to Strode and Boyles (Strode 1998), AY-102 serves as a receiver for C-106 and later, C-104 waste.
Safety Considerations • Corrosion • Flammability • Waste Compatibility • Criticality	Based on the work of Hu (Hu 1997), Anantutmula et al., (Anuntutmula et al., 1994), and Divine et al (Divine 1985), corrosion is not a significant consideration unless additional nitrate is added without a compensating amount of hydroxide and nitrite. Hu also notes that sufficient hydrogen is generated from radiolysis to be of concern if ventilation ceases for about six months. 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. Blaak (Blaak 1997) states that the tank is in compliance on all counts.

In addition to the observed compliance with the safety considerations, including corrosion, a more detailed corrosion evaluation follows. The average anion data shown in Table 2, the chemical species critical to compatibility of the waste with the tanks, has been taken from the Hanford files and abstracted from the noted documents. Tank AY-101 is not in compliance with the corrosion specifications (Kirch 1984) based on hydroxide requirements as can be seen in Table 1; Tank AY-102 is in compliance. These data have been evaluated using the relationships developed by Divine et al (Divine 1985) and corrosion is not considered to be a concern in AY-101 because of the high nitrite concentration (Anantutmula et al., 1994). 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
AY-101 [b, c]	0.41	0.78	0.003	0.01	0.06	0	94, 247
AY-102 [d, f, g]	0.008	0.028	0.055	0.005	0.003	0	77, 123

a - Brevick 1995; b - Esch 1996; c - Miller 1997; d - Ryan 1995; e - Steen 1998; f - Esch 1995; g - Nuzum 1997
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) (Project-614 1968) 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 to be considered are listed below:

- 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 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. Anantutmula and Danielson (Anantutmula and Danielson 1996), also observed that the waste below protected the waterline region in the majority of their laboratory experiments. Anodic behavior of the meniscus region was only observed when there was no nitrite in the solution, which will be an unlikely condition to be found in a Hanford waste tank.
- **Fatigue** is typically a concern only when the number of operating cycles exceeds about 1,000. According to the design documents (Project-614 1968), 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 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 tank and secondary liner 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 liner 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, the waste generates essentially no neutrons.
- **Creep and stress relaxation** are high temperature (e.g., greater than about 500°F) phenomena. Again, according to the design document (Project-614 1968), 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 DSTs.

The remaining five topics, which are of potential concern, can affect the primary tank, liner, and 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, Anantutmula and Divine 1995) with some pitting.

- **Pitting and crevice corrosion** are 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.

  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 liner should be immune to caustic cracking even in contact with the concrete. If the primary tank fails, the secondary liner will be susceptible to nitrate cracking.

- **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 would be 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. However, after 28 years of service, it is unlikely that serious pitting occurred or has continued.

- **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 (< 0.025 mm/y), 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 based on engineering experience 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

Only one intentional corrective measure for corrosion control is specified for out-of-specification tanks (Mulkey 1998) - to adjust the chemistry to within specified values.

4.4 TANK AGE

The 241-AY Tank Farm began operation in mid-1971 (Brevick 1995). The tanks are approximately 28 years old (as of 1999).

4.5 INTEGRITY EXAMINATIONS

This section presents reviews and tank examinations that were carried out in order to assess the material soundness and to determine if either tank was leaking or unfit for use. These reviews and examinations include the review of DST leak detection procedures and records, the results of visual examinations conducted on each DST, and the ultrasonic (UT) examination program for the DSTs and the results from the tanks examined.

4.5.1 Leak Test

The primary tanks were leak tested after the post-weld heat treatment. The leak test, and/or hydrostatic test, was performed 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 DSTs 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 inch for the AY DSTs, 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 alarm tank farms operation 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 Examination

The visual examinations of 241-AY-101 and 241-AY-102 were completed on June 1 and May 28, 1992, 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 percent of the primary shell surface and 30 percent 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 Examination of Six Representative Tanks

In May 1996, the Tank Waste Remediation System (TWRS) Decision Board recommended and DOE-RL agreed that the condition of the DSTs should be determined by UT examination of a limited area in six of the 28 DSTs. The Washington State Department of Ecology (WDOE) has agreed with the strategy of limited UT examination of six DSTs (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 DSTs 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). The schematics are shown in Figures 3 through 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 DST farms. Generally, two vertical 15-in. 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 percent (t), 25 percent (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-in. 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 were 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 AW-103, the lower knuckle was examined in AN-107, and the liner floor was examined in AN-105 and AN-107. See the individual UT reports listed above for the specific areas examined in each DST. No reportable levels for thinning, cracking, or pitting was found in any of the steel liners.

Six DSTs 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 environment, 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			
				Abnormal Operation									
	Tank Age	Waste Temp	Low Inhibitor Levels	Sludge Levels	H_2	Changing Waste Height	Static Waste Height	Tank Steel	Other Chem. Species Cracking	General Corrosion (Thinning)	Pitting	Water-line Attack	Stress Corrosion Cracking
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 UT 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	Second 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 for the design evaluations, corrosion and compatibility reviews, and integrity examinations that were completed for the 241-AY DSTs. 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.

The visual examinations and leak test reviews showed the AY tanks are not leaking and have not leaked in the past. The UT examinations of six DSTs representing the design and operating conditions most favorable to corrosion damage showed no reportable levels of any pits or cracks and reportable (and acceptable) levels of general corrosion (thinning) were found only in local regions of one tank.

The design evaluation and evidence from the integrity examinations suggest that the 241-AY tanks are structurally sound and are fit for use. Recommendations are made in Section 6.0 to ensure continuous safe operation of the facility.

5.1 DESIGN STANDARDS

The 1965 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 AY 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, as identified by Scott (Scott 1998) 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. vs. 1,198 in.) and slight differences in plate thickness for the steel tanks].

The 1965 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 to Section III, Div. 1 (ASME 1982) requirements, 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 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. The maximum reported temperature for either AY-101 or AY-102 is less than 160°F (Huisingh 1994 and Brevick 1995a). There were references to earlier higher temperatures for sludge in the AY tanks (Lawler 1983 and Bendixsen 1990), but these may not be valid since Brevick (Brevick 1995a) did not include them. See a recommendation in Section 6 of this report. The current operational limit on waste temperature is 215°F for all DSTs (Duke 1998a).

The design of the secondary steel liner is considered adequate. It 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 DSTs did not rely on any structural contribution by the 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 soil density than that specified (115 lbf/ft^3 instead of 120 lbf/ft^3), but the design values are conservative since Pianka (Pianka 1994) lists the same value 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, the concrete tank temperature is conservative because the maximum measured waste temperatures (cited previously, above) were much less than the design temperature. 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 (Winter 1958).

The seismic analyses completed during the design of the AY tanks did not use finite element techniques that allow adequate load combinations and the now outdated technology did not incorporate the current understanding of soil-structure interaction. Later analyses by J. L. Blume of the nearly identical 241-AZ tanks using the axisymmetric AXIDYN computer model (Blume 1971) effectively qualified the AY tanks for 0.25g seismic behavior (Vollert 1982). The combined soil-tank model was applied down to the basalt. "No critical overstressing was found on any part of the soil-tank structure for the load conditions assumed to be acting simultaneously on the structure." The 0.25g seismic loading used in the analyses is essentially the same as the 0.26g in the current Hanford Site criteria (HNF-PRO-97). The site criteria require two orthogonal horizontal directions, but for the radially symmetric DST, an axisymmetric

model used by Blume (Blume 1971) 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. Combined loads (vertical seismic and normal) were included in a later analysis of the AZ-101 tank that showed it to be 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 (Duke 1998b). Importantly, the BIO contains no reservations particular to the continued safe operation of the 241-AY 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 DST facilities (Duke 1998a). During these studies, state-of-the-art analyses were completed for the 241-AY concrete tanks with the resulting stresses meeting those allowed in more recent editions of the ACI Code (ACI 1992) and ASME Code (ASME 1994). Currently, the technical safety requirements authorize 8.3 feet of soil and a 100-ton concentrated load for AY and AZ DSTs, compared with 7.5 feet and 100 tons for the other DSTs. This attests to the adequacy of the AY/AZ concrete tank design.

A document review of AY/AZ analyses (Abatt 1998) has noted some concerns regarding certain variables pertaining to the tanks. Those concerns 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 with 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 usage 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 AY 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 analysis. Brevick (Brevick 1995a) reports the temperature history for the two tanks and shows low average temperatures with very modest variations. These values for AY-101 were 106°F (+48°F/-69°F) and 81°F (+43°F/-29°F) for AY-102.. This observed temperature cycling is considered to be of no significance. Operating conditions leading to more severe temperature cycling are not anticipated for these tanks.

The successful leak-free operation of the 241-AY tank system for 29 years demonstrates that the design is adequate for the intended service. A visual examination performed in 1993 of the annulus region showed no evidence of leakage or of any physical impairment

to the tank shells (Harris 1993). Additional confirmation is provided by the leak-free performance of the 26 additional DSTs of a very similar design that are operating at Hanford.

The 241-AY DSTs 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 fabricators' specifications and drawings and the quality control program ensured that these requirements were met during fabrication. The insulating concrete beneath the primary tank deteriorated around its periphery due to the stress relief cycle, but the suspect material was replaced with structural concrete. The specified 1,100°F stress relief cycle could not be attained, but additional corrosion tests were run to demonstrate the adequacy of a lower-temperature stress relief cycle.

Analysis methods more suitable to today's practices have been applied to the AY 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. 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.

The tanks are designed for a maximum temperature of 350°F in contact with sludge. As noted in Table 2, neither of the tanks have exceeded 247°F and are therefore well within design limits. Estimated corrosion rates suggest the design corrosion allowance of 0.050 in. for the 50-year life of the tank (Project-614 1968) is adequate.

The secondary tank is designed for a maximum of one week in contact with the waste.

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 were often 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.

Not all wastes contained within the tanks meet the Hanford corrosion specifications for corrosivity (Kirch 1984). Using the modeling done by Divine (Divine 1985), it can be seen the corrosion rates are still within the design limits. Future wastes are also expected to meet these standards.

The secondary steel liner would contain waste only if the primary tank fails. The maximum time the secondary steel liner is expected to contain waste will be one week.

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 (Project-614 1968) 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 evaluated in more 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 of the steel 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 liner. However, if rainwater has penetrated the concrete and reached the liner, relatively high, but unknown, corrosion rates could be attained. Nevertheless, these rates are not expected to impact the allowed one-week exposure time (Project-614 1968) of the secondary containment to the waste, which is only applicable if the primary tank 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 (Kirch 1984). There is a slight possibility

of pitting on the exterior of the steel liner, but even at the maximum forecast pitting rate, it will not impact its effectiveness to contain leaks.

Stress-corrosion cracking has been shown to be of minor significance because of the waste chemistry and the stress-relief anneal of the primary tank. 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 is not a significant concern at this time. 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 TANK AGE

The tanks are approximately 28 years old. The latter half of their service life has been as "inactive dilute receiver tanks." The maximum-recorded waste temperature is less than one-half the design temperature. 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 AY-101 and AY-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 DSTs 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 DSTs 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-102[1] did not allow UT examination (Jensen 1999d). However, due to the age of the tank, any stress-corrosion cracking occurring would likely have propagated through 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 (Anantatmula 1997). Both tanks had held waste for some period during their 10-year operation. AP-104 had contained flush water and decontamination waste (from N Reactor) for several months and then was at the 6-in. level for the following eight years. The thermocouple tree was examined by visual means just after removal from the 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 DSTs. 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-in. thick plate is >0.050 inches. 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

[1] Poured concrete used for the repair of the adjacent Kaolite pad left concrete adhering to the surface of the lower knuckle.

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 DSTs 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 DSTs.

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, AY-102 contained only water for the first five years and it did not show thinning in the vapor space. It has been suggested (Anantatmula 1999) that differences in air currents and relative humidity between the tanks at the start of operations might have led to enough condensation in tank AN-105 that resulted in the observed wall thinning in AN-105. 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 AY-101 and AY-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 DSTs remain structurally sound and are not corroding by thinning, cracking, or pitting to any appreciable extent.

6.0 RECOMMENDATIONS

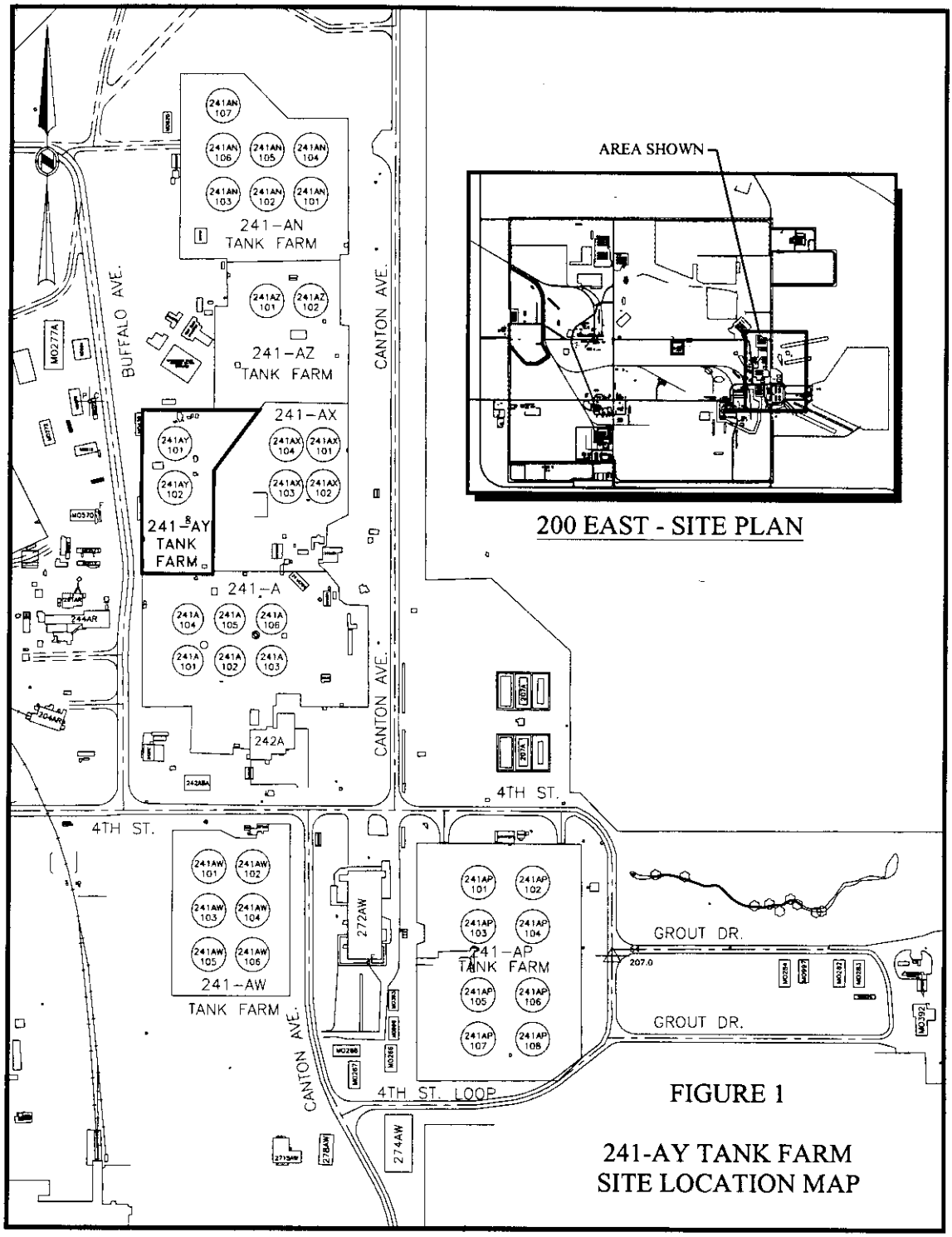
The following recommendations are made to help ensure the continued safe operation of the AY DSTs.

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. Tank AY-102 should be given special consideration for knuckle inspection because its waste-level history promotes relatively higher cyclic stresses as compared to other tanks. However, if the concrete on the knuckle cannot be removed, another tank should be selected that has a waste-level history that promotes high cyclic stresses.

3. Pursue the validity of the reported high sludge temperatures for AY tanks (Lawler 1983 and Bendixsen 1990) and assess any effects on existing thermal analyses (Vollert 1982) and long-term concrete properties. Amend the Brevick report (Brevick 1995a) as necessary regarding temperatures and date for first aging waste.

7.0 FIGURES


AREA SHOWN
200 EAST - SITE PLAN
241-AN TANK FARM
241-AZ TANK FARM
241-AX
241-AY TANK FARM
241-A
242A
BUFFALO AVE.
CANTON AVE.
4TH ST.
241-AW TANK FARM
272AW
241-AP TANK FARM
GROUT DR.
4TH ST. LOOP
274AW
FIGURE 1
241-AY TANK FARM
SITE LOCATION MAP

ZBAC0123

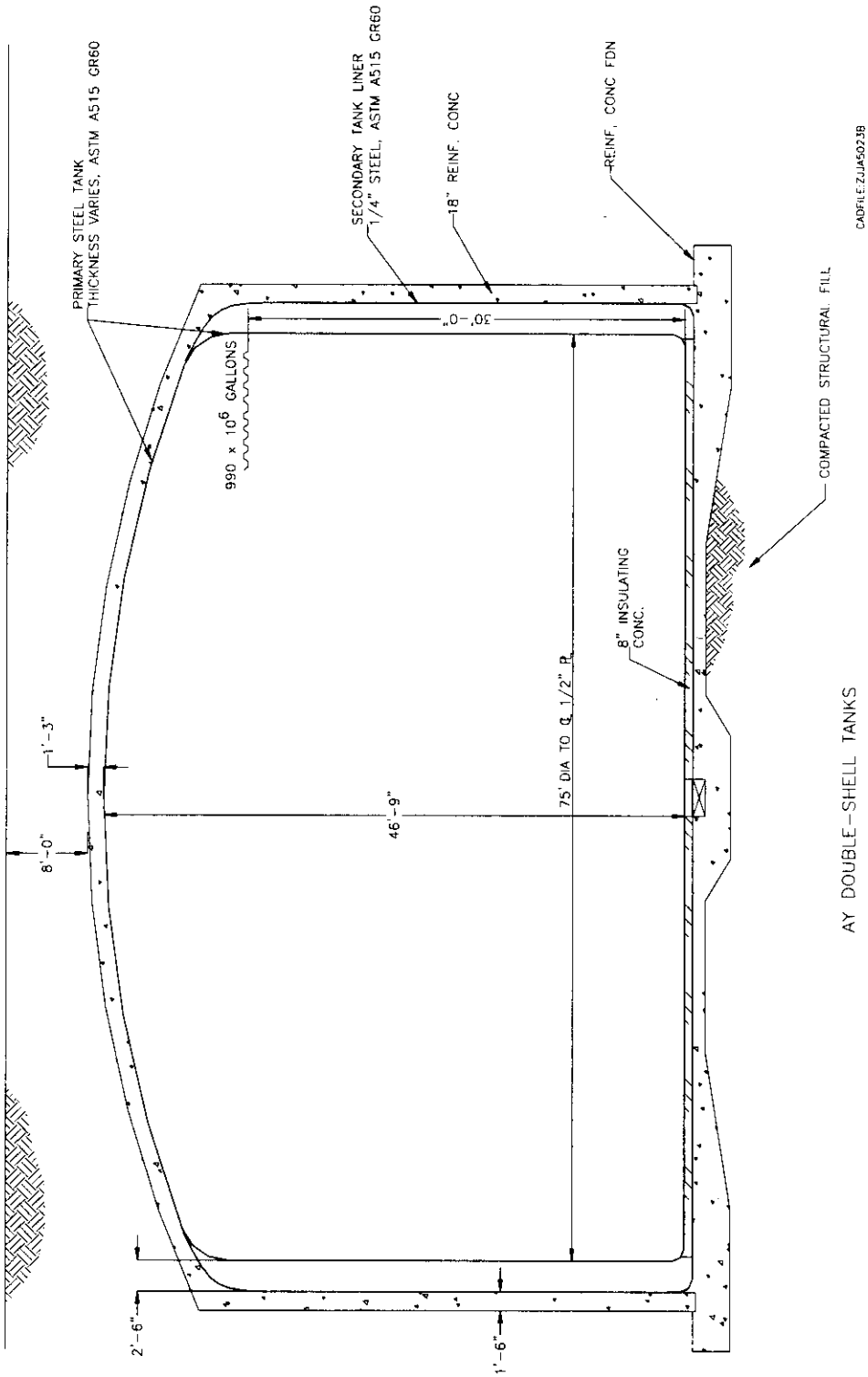

PRIMARY STEEL TANK
THICKNESS VARIES, ASTM A515 GR60
SECONDARY TANK LINER
1/4" STEEL, ASTM A515 GR60
18" REINF. CONC
REINF. CONC FDN
CADFILE:ZJJA5023B
COMPACTED STRUCTURAL FILL
30'-0"
990 x 10^6 GALLONS
8" INSULATING CONC.
75' DIA TO ℄ 1/2" R
46'-9"
1'-3"
8'-0"
2'-6"
1'-6"
AY DOUBLE-SHELL TANKS

Figure 2.

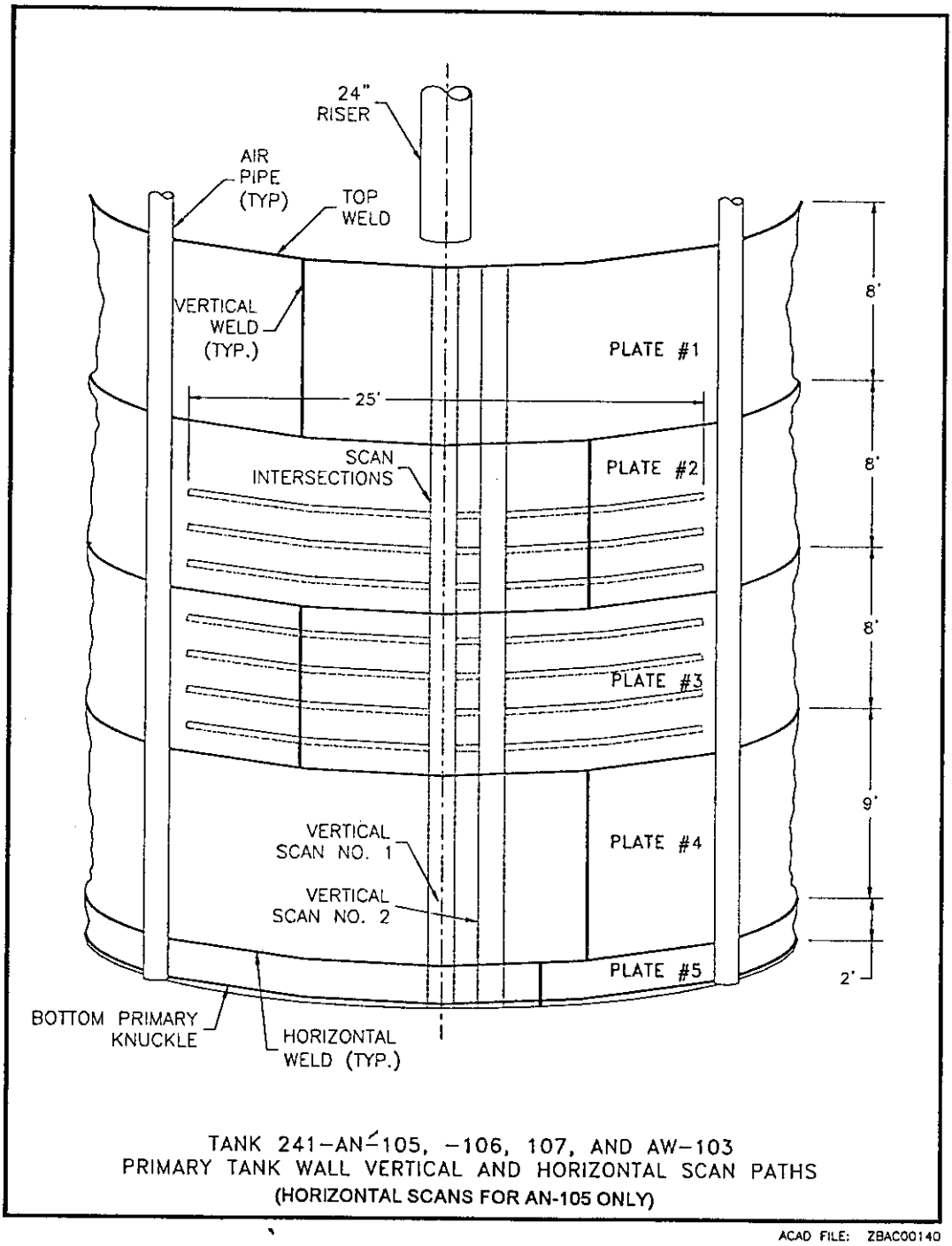

24"
RISER
AIR
PIPE
(TYP)
TOP
WELD
VERTICAL
WELD
(TYP.)
PLATE #1
25'
SCAN
INTERSECTIONS
PLATE #2
PLATE #3
PLATE #4
PLATE #5
VERTICAL
SCAN NO. 1
VERTICAL
SCAN NO. 2
BOTTOM PRIMARY
KNUCKLE
HORIZONTAL
WELD (TYP.)
8'
8'
8'
9'
2'
TANK 241-AN-105, -106, 107, AND AW-103
PRIMARY TANK WALL VERTICAL AND HORIZONTAL SCAN PATHS
(HORIZONTAL SCANS FOR AN-105 ONLY)
ACAD FILE: ZBAC00140

Figure 3.

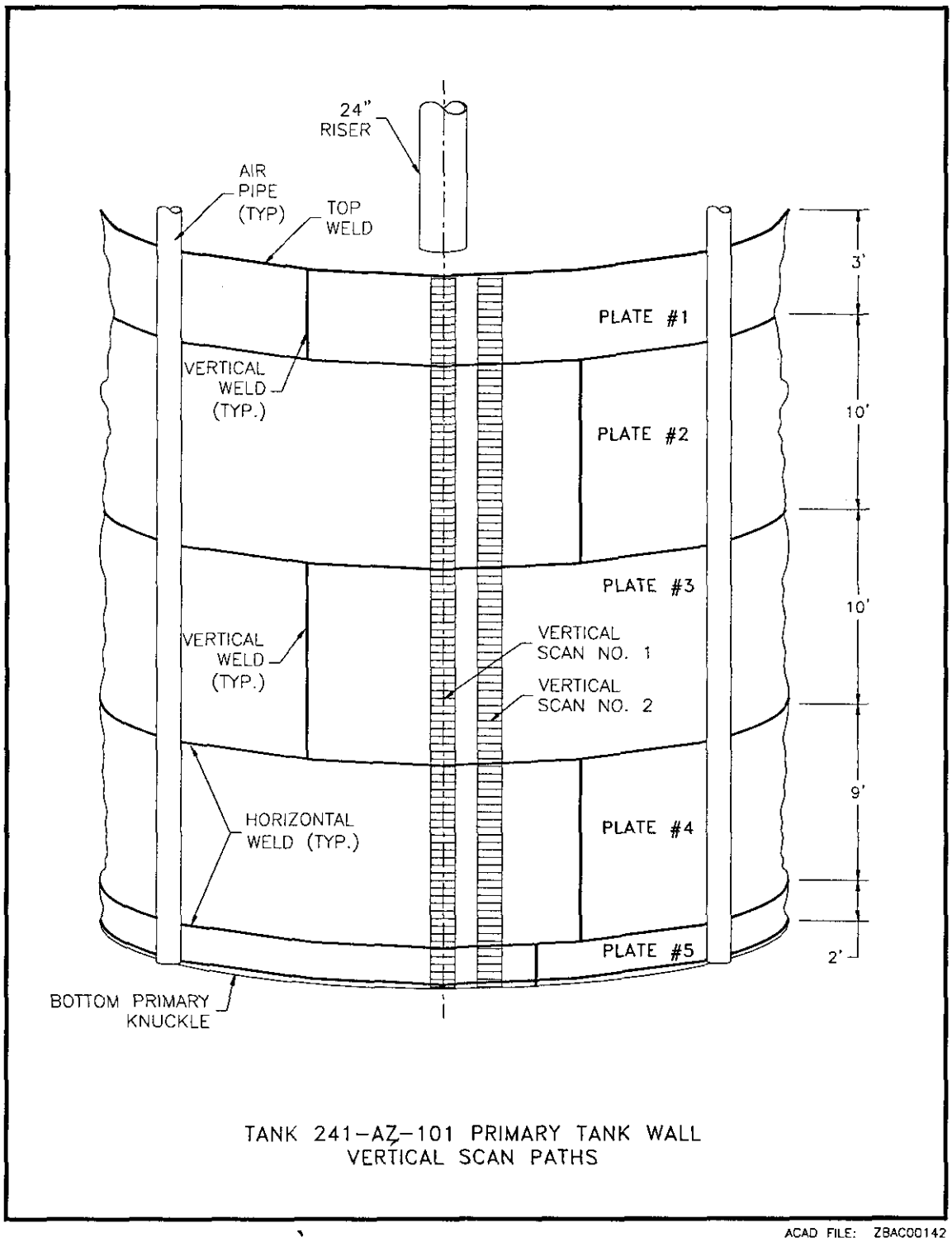

24"
RISER
AIR
PIPE
(TYP)
TOP
WELD
PLATE #1
VERTICAL
WELD
(TYP.)
PLATE #2
PLATE #3
VERTICAL
WELD
(TYP.)
VERTICAL
SCAN NO. 1
VERTICAL
SCAN NO. 2
HORIZONTAL
WELD (TYP.)
PLATE #4
PLATE #5
BOTTOM PRIMARY
KNUCKLE
3'
10'
10'
9'
2'
TANK 241-AZ-101 PRIMARY TANK WALL
VERTICAL SCAN PATHS
ACAD FILE: ZBAC00142

Figure 4.

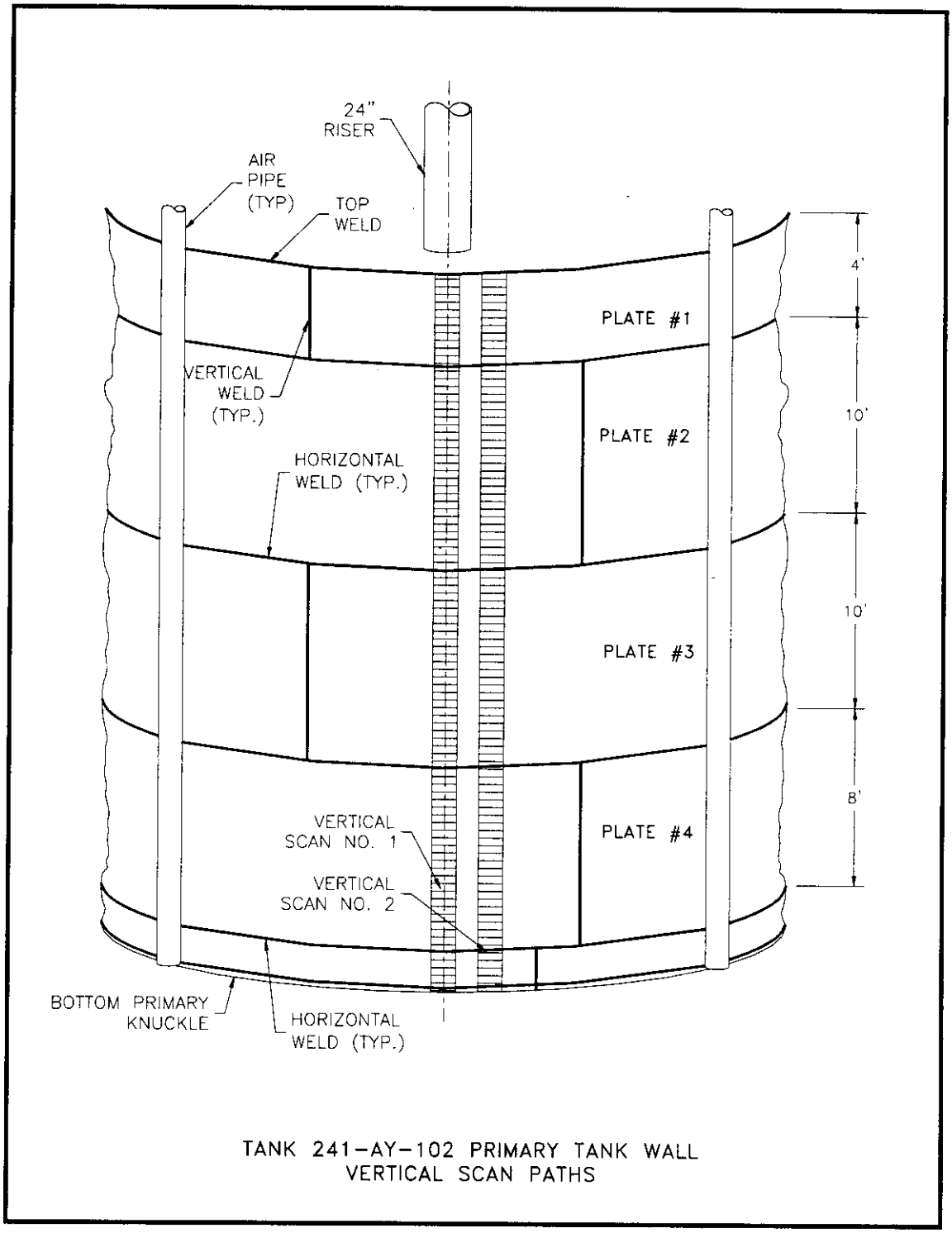

24"
RISER
AIR
PIPE
(TYP)
TOP
WELD
PLATE #1
VERTICAL
WELD
(TYP.)
PLATE #2
HORIZONTAL
WELD (TYP.)
PLATE #3
PLATE #4
VERTICAL
SCAN NO. 1
VERTICAL
SCAN NO. 2
BOTTOM PRIMARY
KNUCKLE
HORIZONTAL
WELD (TYP.)
4'
10'
10'
8'
TANK 241-AY-102 PRIMARY TANK WALL
VERTICAL SCAN PATHS
ACAD FILE: ZBAC00143

Figure 5

8.0 REFERENCES

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Specifications

HWS-7789	Primary and Secondary Steel Tanks
HWS-7790	Excavation and Tank Foundations
HWS-7791	Side Walls and Dome

Engineering Drawings

H-2-64306	Tank Foundation Plan
H-2-64307	Structural Insulating Concrete
H-2-64310	Concrete Tank Section
H-2-64311	Concrete Dome Reinforcement
H-2-64312	Concrete Dome Reinforcement at Annulus Access
H-2-64447	Tank Penetration Schedule
H-2-64448	Tank Penetration Details
H-2-64449	Tank Elevation and Details
H-2-35299	Modification of Insulating Concrete

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APPENDIX A - FABRICATION RECORDS

A1 Materials, Welding Processes, and Examination Requirements Specified for AY-101 and AY-102.

A2 PDM Steel Company Primary Tank Fabrication Drawings.

A3 Detailed Fabrication Sequence Followed for AY-101 and AY-102.

A4 Title III Inspector's Verification Sheets for Fabrication of AY-101/AY-102.

A5 Subassembly Fabrication at PDM Provo Shop.

A6 Excerpts from Kaolite Pad Repair.

A7 Excerpts from Stress-Relief Incident.

A1 Materials, Welding Processes, and Examination Requirements Specified for AY-101 and AY-102.

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

Primary and Secondary Tanks	Welded ASTM A515, GR 60 Carbon Steel Plates
Temporary Attachments Clips, etc. and Structural Steel Shapes	ASTM A53, Type E or S
Carbon Steel Welding Fittings	ASTM A234, GR WPB
Flanges	ASTM A181 GR I
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")
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, ± 1" of axial and lateral movement)	Bellows– 304,316, or 321 SS Pipe Ends-Sch 40 A106

B. The following welding methods were allowed.

Welding methods were limited to automatic submerged arc (SAW) or automatic gas metal arc (GMAW) for all tank floor plate-to-plate welds and all girth welds except the side plate-to-knuckle welds. (Manual SMAW was later allowed for tank floor welds due to distortion problems, Ref. Design Change 2124-7). All other welding could be manual SAW, manual GMAW, or manual shielded metal arc (SMAW). A removable copper backup was required for all automatic welding. 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 and no repair welding was allowed without customer approval.

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

* This information is taken from drawings and specifications issued to Project 614. The reader should review Specification HWS-7789 and Drawing Nos. H-2-64447, H-2-64448, and H-2-64449 for accurate referencing.

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.

Magnetic particle examination was required for:

1) all areas on either surfaces of primary tank or inside surface of the secondary tank where clips, lugs, etc., have been removed and all areas of plate repair except for surfaces of primary tank dome plates
2) the first and last pass on all tank penetrations
3) all repair weld passes where radiography cannot be performed.

Vacuum leak testing was required for:

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

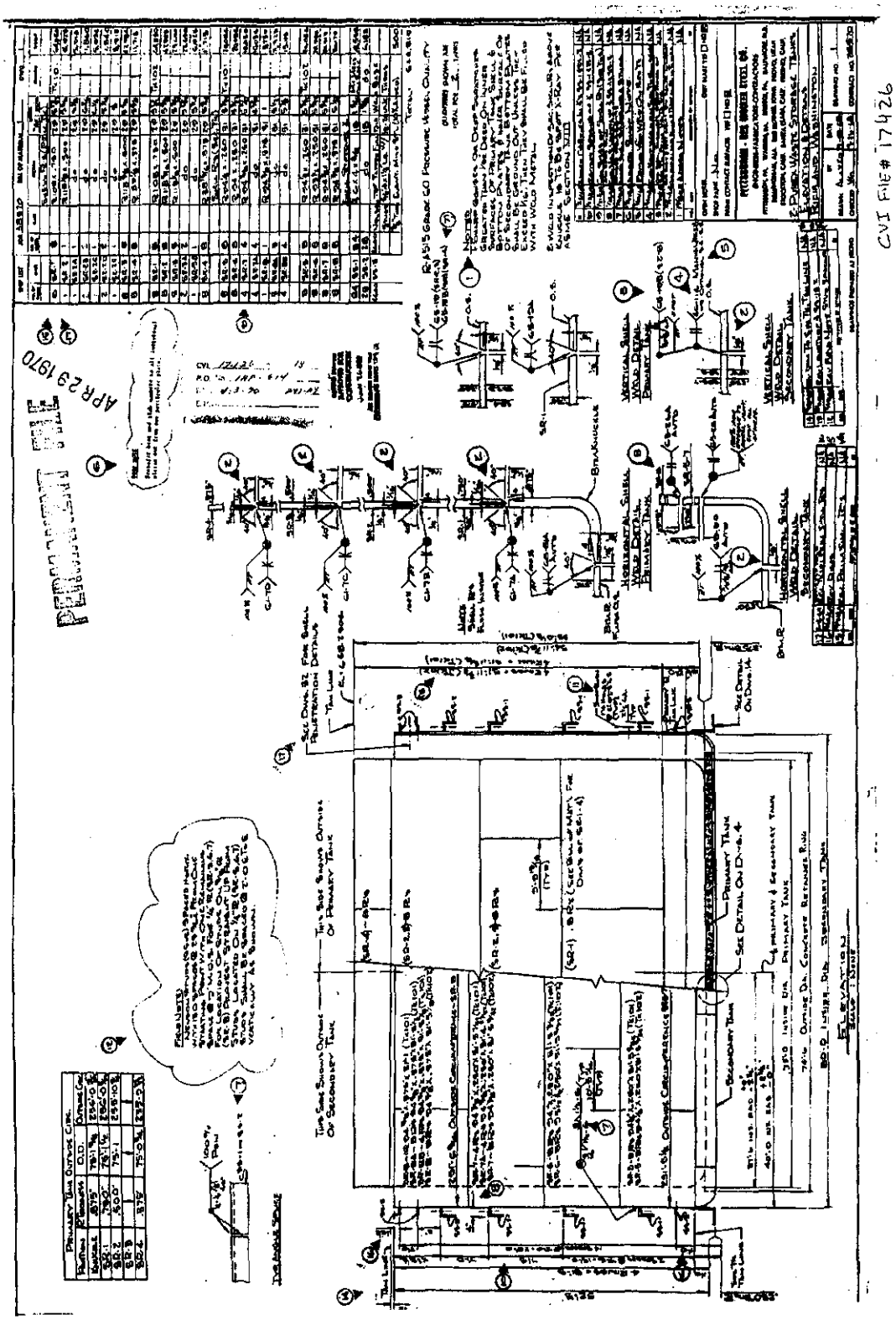
Liquid penetrant examination was required for:

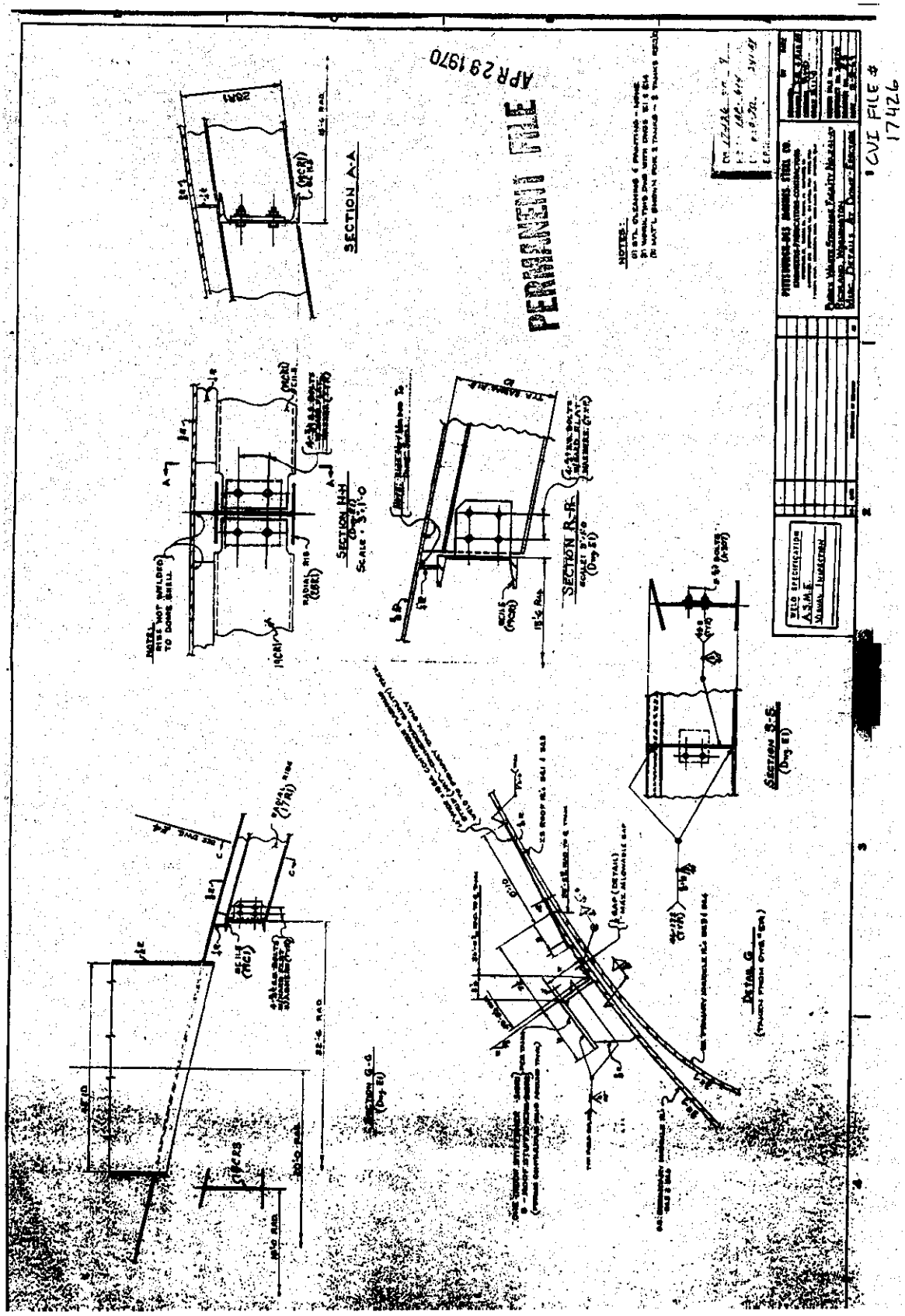
1) each pass of welds joining air lift circulators to dome penetration pipe stubs.

Visual inspection was required for:

1) all welds
2) all repair weld passes where radiography cannot be performed.

A2 PDM Steel Company Primary Tank Fabrication Drawings.

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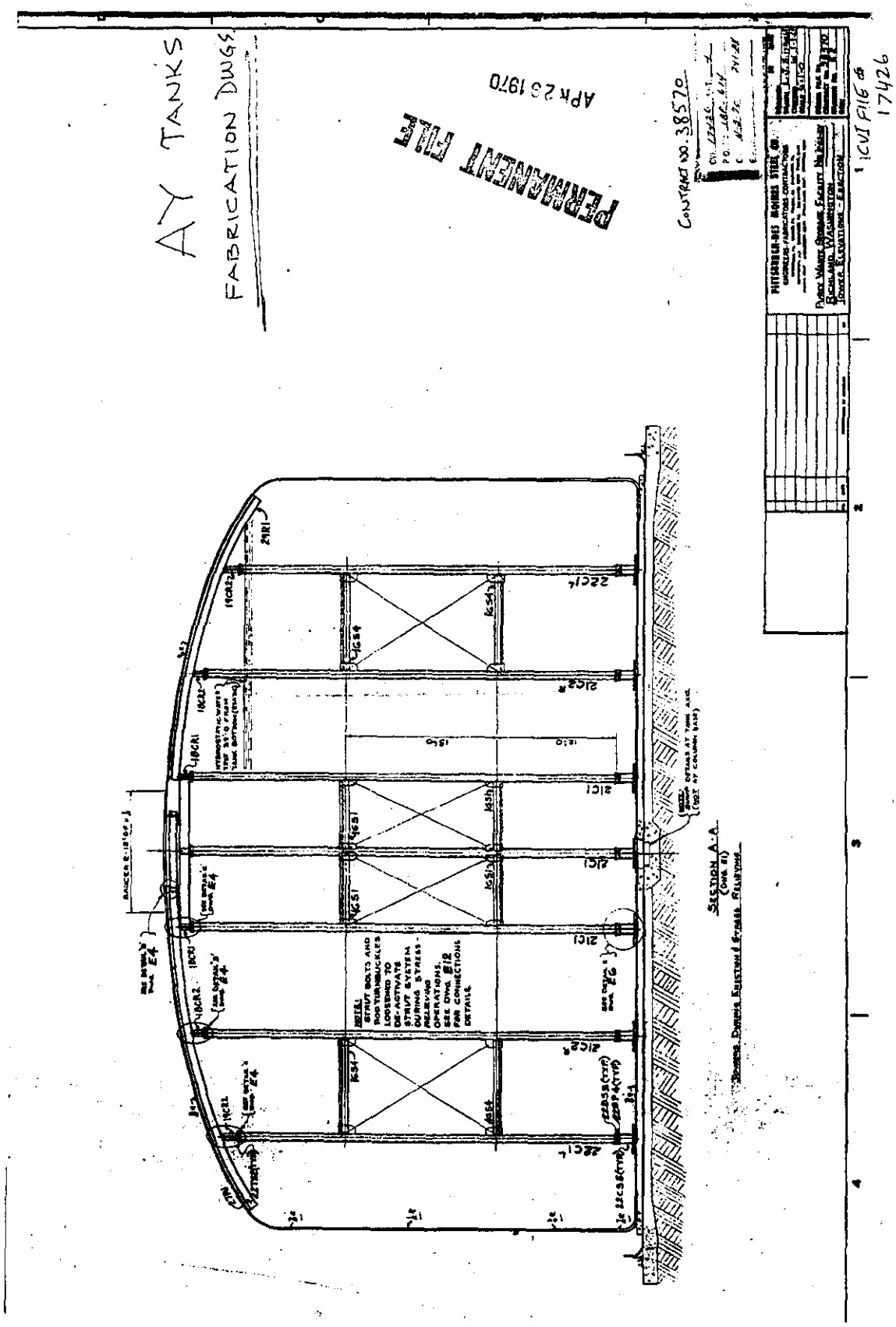
AY TANKS
FABRICATION DWGS.
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SECTION A-A
PITTSBURGH-DES MOINES STEEL CO.
PUBLIC WORKS DIVISION, FACILITY NO. 1
RICHLAND, WASHINGTON
TANK ELEVATIONS - ERECTION

A3 Detailed Fabrication Sequence Followed for AY-101 and AY-102.

CONSTRUCTION SEQUENCE ( ) Bop 247xx

1. Install protective cover over concrete foundation pad.
2. Assembly of secondary tank bottom up to top of knuckle plates.
3. Preparation of secondary tank bottom for radiography, magnetic particle and vacuum leak test.
4. Inspection (x-ray, magnetic particle, vacuum test), repair and retest of secondary tank bottom.
5. Cleanup and placement of secondary tank bottom; check for flatness.
6. Correction of secondary tank bottom of flatness tolerance.
7. Install air supply piping, thermocouple conduits and insulating retainer to be embedded in tank bottom insulation.
8. Install insulation over secondary tank bottom.
9. (1) Erection of secondary steel tank to elevation 654.83.
9. (2) Inspection of welding of secondary steel tank wall.

PRIMARY

10. (1) Install protective cover over insulating concrete.
10. (2) Assembly of primary tank bottom up to top of knuckle plates.
10. (3) Preparation of primary tank bottom for radiography, magnetic particle testing and vacuum leak test.
10. (4) Inspection (x-ray, magnetic particle, vacuum test), repair, and retesting.
10. (5) Cleanup and placement of primary tank bottom.
10. (6) Correction of tank bottom to flatness tolerance.
11. Placement of concrete shell to elevation 651.36'.
12. Backfill tank farm area TO 654.83'.
13. Erection of primary tank walls and wall penetrations.
14. Inspection (x-ray, magnetic particle) of all welds, repaired areas and penetrations above bottom knuckle plates. Repair and re-examination of all faulty welds.
15. Install shoring for tank dome erection and concrete support.
16. Erection of primary tank dome and dome penetrations
17. Inspection of dome and dome penetrations.

PRIMARY (continued)

18. Preparation of primary steel tank for stress relief, including installation of thermocouples and strain gauges.
19. Stress relief of primary steel tank.
20. Remove stress relief equipment and temporary insulation.
21. Hydrostatic test of primary tank.
22. Complete erection of secondary shell and penetrations.
23. Placement of concrete over tank dome.
24. Remove temporary shoring.
25. Install appurtenances in primary tank.
26. Install encasements and associated piping.

A4 Title III Inspector's Verification Sheets for Fabrication of AY-101/AY-102.

WITCO-RES QUALITY ASSURANCE

PROJECT IAP-614	Prepared by: E. S. Davis 10-3-
FEATURE 21 Hydrostatic test of primary tank. Tank 102.	Inspected by:
REFERENCES: PTM Drawing - F2	Date: Oct. 15, 196
	Distribution: WS Graves, CN Zangar, A. Short, QC File (2)
OTHER DATA: HWS 7789, paragraph 16.0	

Requirements	Acceptance Yes	Acceptance No
1. See that four vessel penetrations are blanked closed.	OK	
2. Fill tank to a depth of 39' ± 1". (39'-10")	OK	
3. Coat all accessible welds with blue chalk.	OK	
4. Inspect all coated welds for leakage after a holding period of 24 hours.	OK	
5. Note any new irregularities in tank configuration. (NONE)	OK	
KAOLITE INSULATING CONCRETE IS SOMEWHAT FRACTURED, PRESUMABLY FROM WEIGHT OF WATER USED IN HYDRO.		

REMARKS [illegible]

1. Wear hard hats, floves, and eye protection.
2. Check scaffolding in annulus before using.
3. Enter annulus only when other personnel are present.

VITRO-HEB QUALITY ASSURANCE

ECT IAP-614	Prepared by: E.S. Davis 10-3-69
URE 20 Removal of stress relief equipment and temporary insulation. (Tank 102)	Inspected by: A. Short
RENCES: PEM Stress Relieving Procedure	Date: OCT. 15, 1969
	Distribution: WS Graves, CN Zangar, A. Short, QC File (2)
R DATA: Specification HWS 7789, paragraph 14.0	

Requirements	Acceptance Yes	Acceptance No
Exercise care to prevent damage to permanent thermocouples and wiring. All wiring is to be returned to the original protective boxes. *	OK	
Require that all temporary insulation be removed from the annulus.	OK	
See that annulus space is thoroughly cleaned.		✓
Conduct critical examination of the interior of the tank.		
a. Excessive oxidation	OK	
b. Impingement of flame on metal surfaces		
c. Irregularities in tank configuration		
d. Cracks		
Witness survey of interior tank dimensions. (NOT WITNESSED)	OK	
Check propane tanks and lines for pressure and/or leakage.	OK	
* NUMBER 4 THERMOCOUPLE (IN THE TANK FOUNDATION) WAS DESTROYED DURING STRESS RELIEF BY A 110 V WIRE FROM PDM STRESS RELIEF EQUIP. BEING ALLOWED TO SHORT OUT ON THE THERMOCOUPLE SHEATH AND BURNING THROUGH IT.		

ARKS AND/OR SAFETY FEATURES

Wear hard hat, gloves, and eye protection.

Have assurance that air in tank is clean and safe to breath.

Check ladders and scaffolding for safe use.

Enter tank with care and always in the presence of another person.

A5 Subassembly Fabrication at PDM Provo Shop.

W. S. Graves Box 24745
M. Schulze
C. A. Sursaw/Cog./Spv. Eng.

Pittsburgh-Des Moines Steel Company

Engineers
Fabricators
Contractors

P. O. BOX 329 · SANTA CLARA, CALIFORNIA 95052 · (408) 296-0666

May 31, 1969

DISTRIBUTION:
cc: CR Kligfield, HES (2)
CW Cardwell, HES (2)
WC Armstrong, ARHCO (2)
E&C Off. File (Orig)
B Kirz
ML Elkins
GW Knoeber
DJ Squires
Field File

Contract 35570
Richland, Washington

U. S. Atomic Energy Commission
Post Office Box 550
Richland, Washington 99352

Attention: Mr. H. E. Eager - Building 2720E - Area 200E

Subject: Contract AT(45-1)2124 - Purex Waste Storage Facility
Hanford Works - Richland, Washington
Weekly Report per GC-21 - General Conditions

Gentlemen:

The following items are in progress:

1. Shop Progress
   A. Fabricate top knuckles and dome sections.
   B. Fabricate structural material.

The following target dates have been established:

6 - 2	Ship 4 knuckle assemblies and structural material.
6 - 9	Ship 4 knuckle assemblies, 18 dome plates and structural material.
6 - 16	Ship compression rings, remainder of the dome plates, rafters and the remainder of the structural material.

Yours very truly,

PITTSBURGH-DES MOINES STEEL COMPANY

Dean Bach

Dean Bach
Field Engineer

mw
cc: R. Wendlandt - Sea
J. Adams - Pgh
L. Colarossi - Pgh
R. deJong - Pro
J. Sermersheim - Pro
F. Wecks - SC
R. Kinghorn - SC

RECEIVED
JUN 6 1969
Vitro
Richland, Washington

A6 Excerpts from Kaolite Pad Repair.

Box 24744

HANFORD ENGINEERING SERVICES
DIVISION OF VITRO CORPORATION OF AMERICA

INTER-OFFICE MEMORANDUM

DATE November 3, 1969

TO W. S. Graves (LOCATION OR DEPARTMENT)

FROM D. G. Lien (LOCATION OR DEPARTMENT)

SUBJECT 241-AY TANK 102 - INSULATING CONCRETE
IAP-614

On October 17, 1969, Al Short and I visited the AY Tank Farm site and investigated the insulating concrete in Tank 102. At this time Tank 102 had been stress relieved and filled with water for the hydro test.

Visual examination of the insulating concrete at the base of the primary tank disclosed considerable cracking and spalling of the surface layer around the tank periphery. A couple of cracks were approximately 1/4" wide, several feet deep, and extended the full height of the insulating concrete. The concrete top surface felt spongy to the touch. Many of the air passage slots were partially blocked by spalled concrete.

There was no visual evidence of tank settlement or indication of large unsupported areas around the periphery of the primary tank. The bent plate ring around the insulating concrete was in place except for one break of approximately one inch at a plate splice. There was no indication of concrete spalling beyond the retainer plate.

It is my opinion that the surface cracking and spalling of insulating concrete was a direct result of stresses incurred during thermal stress relief of the primary tank. More specifically, tensile stresses in the periphery of the insulating concrete and stresses produced by skin friction from expansion and contraction of primary tank.

At this time I feel the insulating concrete is adequately supporting the primary tank but feel it would be wise to examine the concrete again after the primary tank hydro test water has been removed.

D G Lien
D. G. LIEN

DGL:hl

cc: M. H. Piskadlo
DGL/File

HES-60 (8-67)
SEC-2, RICHLAND, WASH.

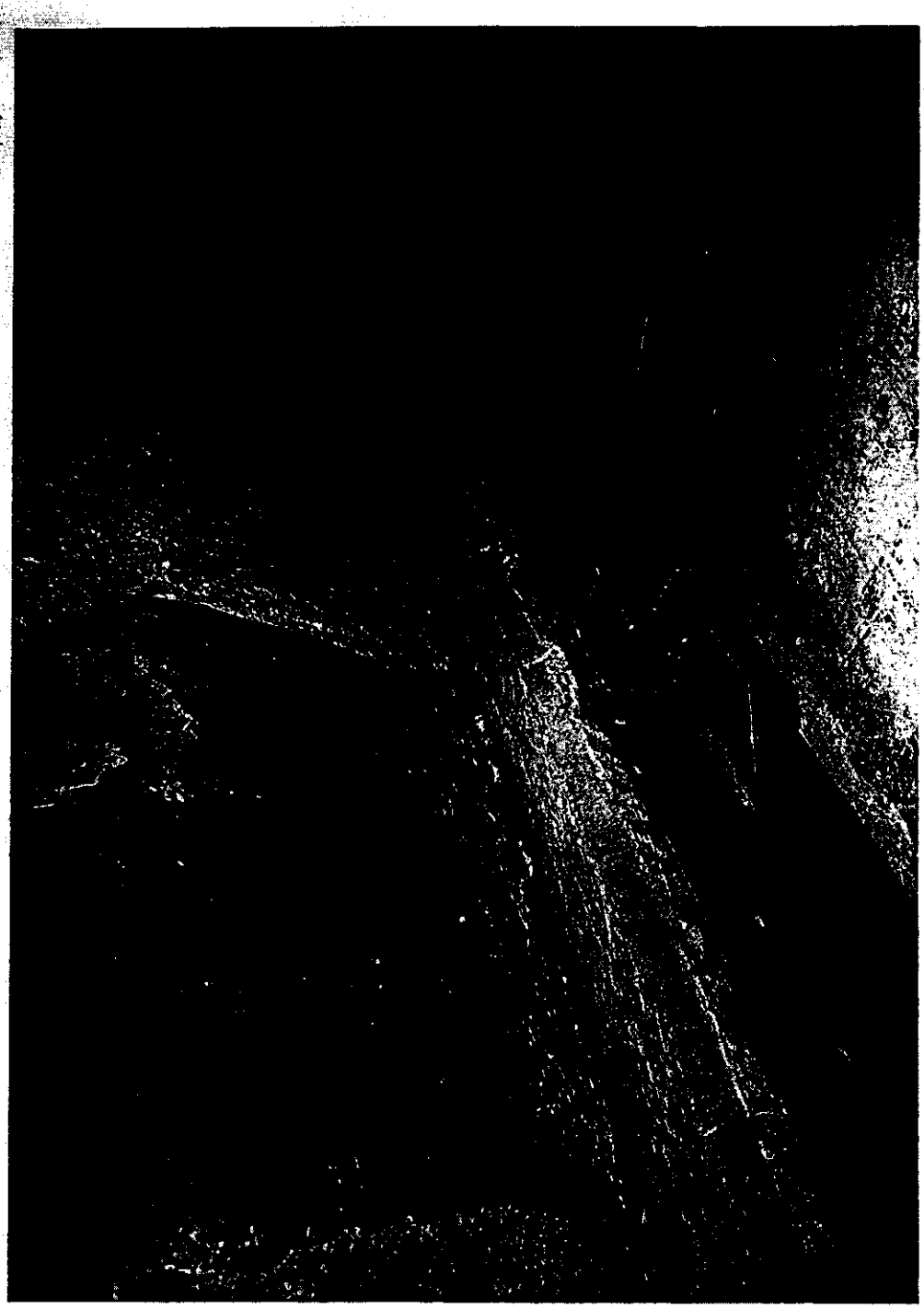
Roy 247558

PROJECT: IAP-614, Purex Tank Farm Expansion, 200-E Area
TAKEN: 8-3-70 No. 52788-7

UNCLASSIFIED - CLEARED FOR PUBLICATION

UNCLASSIFIED - CLEARED FOR PUBLICATION

Box 24758



PROJECT: IAP-614, Purex Tank Farm Expansion, 200-E Area
TAKEN: 8-10-70 No. 703856-2
SHOWING: Tank No. 101 - Connectors on concrete retainer

A7 Excerpts from Stress-Relief Incident

UNITED STATES
ATOMIC ENERGY COMMISSION
RICHLAND OPERATIONS OFFICE
P. O. BOX 550
RICHLAND, WASHINGTON 99352

September 28, 1970

To Files
THRU: B. Kirz, Director
E&C Division

CONTRACT AT(45-1)-2124, DESIGN, FABRICATION & ERECTION OF STEEL TANKS AND RELATED WORK FOR PUREX WASTE STORAGE FACILITY, 200-E AREA

Contract AT(45-1)-2124, dated 7-29-68, was awarded to the Pittsburgh-Des Moines Steel Company for the fabrication and erection of two steel waste tanks and related work. Part of the related work included stress relieving the tanks by heating them internally, holding the heat to 1150°F ± 50° for one hour per inch of steel plate thickness. It was also specified that the maximum temperature differential be 200°F throughout the tank, and that the rate of increase and decrease in temperature be limited, after attaining 600°F, to 100°F per hour.

Prior to entering into a contract for the construction of the two 241-AY steel tanks, a program was initiated whereby coupons of steel, of the same grade as that used for the tanks, were heated and exposed to $NaNO_3$ solution for determining the effectiveness of stress relieved steel. Some details concerning the above testing program are found in the second paragraph of Attachment I.

During discussions held between Vitro, ARHCO, and AEC personnel, which led to the finalization of Specification HWS-7789, all parties were made cognizant of the fact that stress relieving of steel can be accomplished by employing several combinations of temperature and holding period. In addition, the representatives were familiar with the applicable part of the ASME Boiler and Pressure Vessel Code which specifies that the maximum temperature differential shall not be more than 250°F within any 15-foot length; the maximum temperature rise and reduction between 600°F and 1100°F be 400°F per hour; and the following combinations of temperature and holding period as acceptable stress relieving:

Minimum Temperature	Time per inch Thickness
1100° F	1 hour
1050° F	2 hours
1000° F	3 hours

All of the participants, having satisfied themselves that different combinations of the above criteria could result in providing a completely satisfactory job of stress relieving, agreed that the ideal situations should be made a part of the specifications so that the contractor would make the maximum effort to comply, but that each would be satisfied with the best results that the contractor could attain provided they were within the provisions of Section VIII of the ASME Boiler and Pressure Vessel Code.

During the stress relieving activities on both tanks, the heating cycle was significantly longer than envisioned or desirable, and because of equipment limitations, the attainment of minimum holding temperatures of 1100°F were uncertain. In consideration of the alternatives available at the time, the decisions were reached to accomplish the stress relieving by maintaining minimum temperatures of 1000°F for at least three hours. The thinking here is that less harm is done to the steel fibers by accepting a longer holding period once than to allow the tank's temperature to drop below 600°F and repeat the process, perhaps more than once. The possibility of detrimental distortion of the dome during extended holding periods was reviewed and judged to be unlikely.

Attachments II and III discuss the conditions and considerations relevant to the actual stress relieving activities. Attachment IV shows the comparison of the actual conditions with those required in the ASME Boiler and Pressure Vessel Code.

It is the consensus judgment of ARHCO, HES and RL that the AY Tanks were adequately stress relieved and that their integrity was in no way compromised by the modified specification conditions which were allowed.

John H Slaughter

John H. Slaughter
Contract Administrator

Attachments:
- No. I, Ltr frm EL Moore/JH Slaughter dated Sept. 22, 1970
- No. II, Memo frm M Schulze/File dated Oct. 6, 1969
- No. III, Memo frm WC Armstrong/File dated Feb. 2, 1970
- No. IV, Memo frm HE Parker/GB Pleat dated Jan. 16, 1970

Atlantic Richfield Hanford Company
Federal Building
Richland, Washington 99352
Telephone 509 942 1111

September 22, 1970

U. S. Atomic Energy Commission
Richland Operations Office
Richland, Washington

Attention: Mr. J. H. Slaughter

Subject: STRESS RELIEVING AND STRESS CORROSION CRACKING OF ASTM A515, GRADE 60 CARBON STEEL - Contract AT(45-1)-2130

Gentlemen:

There apparently is still some concern as to whether or not the recently constructed AY Tanks were adequately stress relieved since the contractor was allowed to stress relieve at 1000 F. rather than 1100 F. as specified by Vitro. As you know, the ASME Boiler and Pressure Vessel Code allows one to stress relieve at temperatures less than 1100 F. for appropriately longer periods of time. This recourse was taken during the stress relieving of the AY Tanks. It is my opinion that an adequate stress relief was accomplished by PDM by their following the ASME code. Results of corrosion tests conducted here in the 200 Area give further confidence in the stress relief. These tests are described below for your information.

Prior to the construction of the AY Tanks, a program was conducted to evaluate the effectiveness of stress relieving as a means of eliminating nitrate stress corrosion cracking of ASTM A515, Grade 60 carbon steel weldment coupons. Weldment coupons were fabricated from 3/8 inch and 7/8 inch plate. Finished dimensions of the coupons were one foot by three feet. After

A. E. C. RL. OFFICE
SEP 23 1970
PROJECT ENGR. BR.

ATTACHMENT I

Atlantic Richfield Hanford Company

U. S. Atomic Energy Commission
Attention: Mr. J. H. Slaughter
Page 2
September 22, 1970

fabrication, sets of eight coupons were subjected to a stress relief for one hour at either 1100 F. or 600 F. One set of coupons received no stress relief treatment. After eight weeks exposure to 5 M $NaNO_3$ solution at 190 F., cracks had developed at the welds in coupons that had received no stress relief. Slight cracking had occurred in two coupons from the set that had been stress relieved at 600 F. No cracking had occurred in the set that had received a 1100 F. stress relief.

Following the stress relieving of the two AY Tanks, three additional coupons were fabricated in the same geometry as those above. One received no stress relief, one was stress relieved at 950 F. for five hours per inch of thickness and one for three hours per inch of thickness at 1000 F. in accordance with Section VIII, Paragraph UCS-56 of the ASME Boiler and Pressure Vessel Code. These coupons were then exposed to boiling 5 M $NaNO_3$ solution. Cracking occurred after four weeks exposure in the coupons that had received no stress relief. The remaining two coupons did not crack during a five month exposure.

Very truly yours,

E L Moore

E. L. Moore
Principal
Metallurgist

ELM:ser

cc: OJ Elgert

October 6, 1969

FILE

Max Schulze

IAP-614 - AY Tanks
Stress Relieving of TK 102 Tank on 9-30-69

On Tuesday, 9-30-69, I was called at home by Dave Squires several times between 7:00 and 11:30 p.m. regarding progress and problems during stress relief of Tank 102. After the second call, about 8:30 or 9:00, I tried to call Sarge Graves to see if he wanted to go out to the tanks but could not raise him.

Squires called about 11:30 p.m. to tell me that he and the ARHCO people, Bill Armstrong, Paul Hatch, and Ernie Moore, had had a conference regarding rate-of-rise and time-at-temperature. Hatch was concerned with possible bad effects on Kaolite subjected to a high temperature for any length of time. They had decided to hold for three hours at 1000 F rather than go for the full 1100 F minimum for one hour. Squires was concerned about possible contractual effects and "making of the precedent, 1969". I examined the alternates. Suppose the rate-of-rise was too slow, should we tell them to shut the whole job down and start from scratch with a different system? This was unacceptable to Hatch as being even worse. [I pointed out that if, indeed, they couldn't reach 1100 F minimum they would be proposing a lower temperature and longer time in accordance with ASME Code. We would be hard put to deny their request only on the basis of "our spec says" in that the spec is written around ASME Code. Also, when the spec was written, discussion about this very problem had taken place and it was decided to keep this option in the hip pocket rather than allow it out in the spec. It may be of interest to note that Savannah River had this option in their spec.] In view of the fact that Squires had tried to call both Kligfield and Graves and could get no response, I told Squires I would get out there right away.

I arrived at the tank farm at about 12:30 a.m. and talked at some length with Squires about the progress and we read the charts. Squires left at about 3:30 a.m. after having recorded the readings every hour.

The rate-of-rise through the midnight to 4:00 a.m. area was 40 F per hour and was the same for thermocouples at all points in the tank. The thermocouples in the tank bottom were performing erratically with the exception of numbers 15, 16, 21, and 23 which were fairly constant and agreed with the two thermocouples fastened to the knuckles. Temperature in the base concrete was 180 F consistently.

I talked with Stein and he was not in favor of the 1000 F for three hours but wanted to stay with the original spec to stay with the 1100 F for one hour. I told him this would be fine if he would hold the 40 F per hour rise and that this would be only 1/2 hour over the new agreement and I could see no problem there.

ATTACHMENT II

During this time the ARHCO people checked at intervals until about 4:00 a.m. when Bill Armstrong came down to stay. At that time we were getting very close to the 1000 F in the bottom with readings of 915, 935, 960 and 1030 F, the knuckle reading being 970 and 980. Dome temperature at that time was in the 1080-1170 range. At 4:30 a.m. we decided that we would accept the bottom as being at 1000 F and started the three hour count at that time although Stein still had the option of going up per the original spec if he could. In the event temperature rise from 4:00 a.m. on was extremely slow and it was obvious that we had peaked out. Thus, while the decision to go for the option of three hours at 1000 F was made for a different reason, it would have had to be made on the basis of the actual performance.

Stein called Tom Gordon at about 6:30 a.m. to advise him of events and ~~get~~ to get him out by 7:30 a.m. to start the reduction part of the cycle. He showed up at about 8:00. Herb Eager arrived in the morning and wanted to document all happenings. While I was giving him my account of the peaking-out Tom Gordon interrupted and strenuously objected to any idea that his equipment could not have continued beyond the points reached. He also blamed the original long delay at heat-up of the tank bottom to our thermocouples stating that it was his belief that these thermocouples were lying in water in the Kaolite and were not recording tank bottom temperature. It escapes me how tank bottom temperature could have been over 200° if there was any water in the Kaolite for the thermocouples to lay in.

Upon return to Richland, a meeting was held in Ben Kirz' office with Krema, Kirz, Elkins, Knoeber, Kligfield and Graves. I was asked how I was sure the tank was stress relieved and I stated that minimum temperatures were based on the correlation between the four bottom thermocouples and the ones in the knuckle. Graves stated that ASME Code allowed stress relieving at 100 F less (1000 F) for three hours. Elkins asked about any further reduction and consequent time. A check in the Code book showed that for 50 F more reduction (950 F) five hours at temperature would be required. A quick check of my notes showed that readings from 3:00 a.m. to 8:00 a.m. confirmed that this condition was met also.

Upon completion of the meeting, Kligfield and I talked to John Adams, PDM, Director of Research, and requested that he come out to Hanford as soon as possible to discuss new stress relief procedures for TK-101 and to see the internal support system so that he could better appreciate the problems we anticipate in the removal of the supports. Adams stated that he would be unavailable through the middle of the week of 10/6 and wanted to see the curves for stress relief of TK-102 and talk with Tom Gordon prior to coming out. We later talked to Bob Wendlant, PDM, Bellevue, Washington, to impress him with the urgency of a visit by Adams.

One small item of interest was the near failure of one of the springs on the insulation holding bands. The spring had been located so that it straddled a gap between batts in the insulation and was thus exposed to tank shell temperature. That area of the spring was annealed and quite relaxed. Insulation was stuffed into the crack behind the spring. I pointed this out to Al Short in the morning so that on TK-101 this could be prevented.

MS:ds

Date: February 2, 1970

To: File

From: W. C. Armstrong WCA

Subject: PROJECT IAP-614 - PUREX TANK FARM EXPANSION
POST WELD HEAT TREATING - TANKS 241-AY-101 AND 102

The post weld heat treating was accomplished by introducing the flame from two propane gas fired burners of 10,000,000 Btu per hr. capacity directly into the tanks. The tanks, which rest on 8" of kaolite insulating concrete, were insulated on the sides and dome with 3" of mineral wool batting. Monitoring of the tank wall temperatures was by means of uniformly spaced thermocouples connected to continuous strip chart recorders. Tank 241-AY-102 was heat treated before 241-AY-101 due to its earlier completion. The following is an account of the post weld heat treating of the two tanks:

Tank 241-AY-102

Immediately prior to lighting off the burners the propane supply line was pressurized and inspected with the aid of soap solution. After several small leaks were repaired, the line was approved for use. All recorders were reading the same ambient temperature.

The first burner was lit at approximately 4:30 p.m., 9/26/69. In the immediately ensuing period a significant amount of firing system trouble was experienced by the contractor performing the work. The most serious trouble was the persistent blowing out of the pilot lights by the main fuel stream. Of the two burners the one in the northwest quadrant gave the most trouble. This caused the safety valve which was actuated by the flame rod at the pilot light to shut off the fuel supply to the burner. Persistent trouble with the pilot lights and other equipment occurred for the first three days and sporadically during the whole heat treating period.

As evidenced by escaping steam, free water boiling off in the insulating concrete upon which the tank rested prevented the tank bottom temperature from rising above approximately 210° until the night of 9/28/69.

ATTACHMENT III

After a very slow rise in temperature the contractor proposed to increase the heat at a maximum rate of 100°F per hour until the two dome thermocouples nearest the burners read 1000°F to get the benefit of more radiant heat at the tank bottom. It had been apparent since fire up that these two thermocouples were not representative of the other dome thermocouples, but always lead because of their proximity to the burner flames. It was determined by ARMCO's metallurgist, Dr. Moore, that metallurgically no harm would be done. By consensus of ARMCO, Vitro and AEC, the matter was referred to the contractor's engineering headquarters in Pittsburgh, Pa., for guidance. During this time cycling on and off of the burners was required to hold the spread between all temperatures within tolerance. After a stress analysis the contractor's chief engineer, John Adams, approved the above increase to 1000°F with the proviso that the temperature difference between the bottom and top of the lower knuckle be held to a maximum of 220°F. He also confirmed the ARMCO metallurgical approval.

At approximately 10:00 a.m., 9/30/69 the heat was increased within the 100°F per hr. rate to 1000°F at the two control thermocouples nearest the burners.

At approximately 12:00 midnight 9/30/69 it appeared that due to limits of heat transfer it would be impossible to reach 1100°F (the Spec. minimum) in all sections of the tank in any reasonable time, if ever. It was agreed by E. L. Moore, ARMCO; P. Hatch, ARMCO; D. J. Squires, AEC; W. C. Armstrong, ARMCO and via telecon H. Schultze, Vitro, that a holding time of three hours at 1000° in accordance with ASME Boiler and Pressure Vessel Code, Section VIII UCS-56 would be accepted. It was considered that this was preferable, especially in view of the extended heating period, to continued extended heating with its attendant oxidation just for the sake of trying to meet specifications.

At approximately 4:30 a.m., 10/1/69, the tank bottom temperature reached 1000°F while the maximum dome temperature was 1150°F. These temperatures were held until 7:30 a.m. when controlled cooling was commenced. At approximately 4:30 p.m., 10/1/69, after a steady rate of decline well within the maximum of 100°F/hr., the 600°F non-critical temperature was reached.

Tank 241-AY-101

The venting of this tank was from the bottom rather than from the top as in Tank 102-AY. Ten 4" vent pipes were extended to near the bottom of the tank to aid in narrowing the spread between the dome and bottom temperatures by using convection heating more effectively. Temporary thermocouples were installed on the inside face of the tank bottom to aid in correctly monitoring bottom temperatures.

The burners were fired off at 4:30 p.m., 10-31-69. At 9:00 p.m. dome temperatures were 500°F. This temperature was held during the night while the base insulating concrete dried out.

At 7:20 a.m., 11/1/69, the controlled heating period was started; i.e., 100°F per hr. rise with Max-Min difference of 200°F. at 7:00 p.m. dome temperatures were 900°-950°F.

At approximately 9:00 one burner stopped firing due to low gas pressure caused by icing up of the propane storage tanks. The ice was washed off the tanks and enough vapor pressure was obtained to fire both burners but there was not enough pressure to provide adequate flow to increase the firing rate. A temperature of approximately 900°F maximum was maintained until 4:30 p.m. 11/2/69 when steam was applied to the propane tanks. This increased the line pressure to 40 psi, well over that required for full firing.

At 9:00 p.m. all base temperatures were over 1000°F and dome temperatures were 1030°F to 1115°F. There was little temperature increase after 10:00 p.m., 11/2/69. A heat transfer equilibrium seemed to have been reached. At 12:00 a.m., a burner cut off because of electrical control difficulties. The dome temperature dropped about 30°F before re-ignition while the other surfaces of the tank were barely affected.

As with Tank 102-AY, it was decided to invoke the ASME Code Sec. VIII rules for 1000°F holding temperature. The holding period was concluded at 1:20 a.m. 11/3/69. Controlled cooling was maintained at a rate of approximately 50°F per hour. The non-critical 600°F temperature was reached at 11:00 a.m., 11/3/69.

During the post weld heat treating of both tanks, the concrete foundations never attained a temperature of 200°F. The Kaolite insulating concrete was intended to protect the foundation concrete from temperatures above 500°F. Although the specification requirement of holding the tanks at 1150°F ± 50° for one hour was not met, the holding of the tanks at 1000° for three hours is in full agreement with the provisions of the ASME Boiler and Pressure Vessel Code and assures a positive post weld stress relief to combat stress corrosion cracking.

WCA:mwo

cc: DR Gustavson
HP Shaw (6)

G. B. Plest, Assistant Director
Reactor Products, Division of Production, HQ

STRESS RELIEVING OF AY TANKS

This responds to your teletype of January 15, 1970, PRC:JWP, and confirms information furnished to J. W. Pollock by phone regarding deviations from specifications which were allowed during stress relieving of AY tanks. The following table describes all such deviations and shows the actual conditions obtained:

	Specification	Modified Specification	Actual Performance	ASME Boiler and Pressure Code Sec. VIII, 1965 ed.
Holding temperature for stress relieving	1150 F. ± 50 F. for 1 hour per inch of thickness	1000 F. min. for 3 hours per inch of thickness	Tank 101* 1020 F. min. for 3.3 hours Tank 102* 1020 F. for 4.2 hours	1100 F. min. for 1 hour per inch of thickness or 1050 F. min. for 2 hours per inch of thickness or 1000 F. min. for 3 hours per inch of thickness
Maximum temperature differential in tank	200 F. between highest and lowest temperature points	Tank 102 220 F. between bottom knuckle and bottom plate	**70 F. between bottom knuckle and bottom plate	250 F. within any 15 foot interval of length

*Maximum plate thickness is 1".
**Distance between high and low temperature thermocouples was 31 feet. (Tank 102).
Maximum temperature differential on Tank 101 - 180°F

H. E. Parker
Assistant Manager
for Technical Operations

bcc: E&C Official File
E&C Reading File
Proj. Engr. O. J. Elgert
GWK/File H. E. Parker

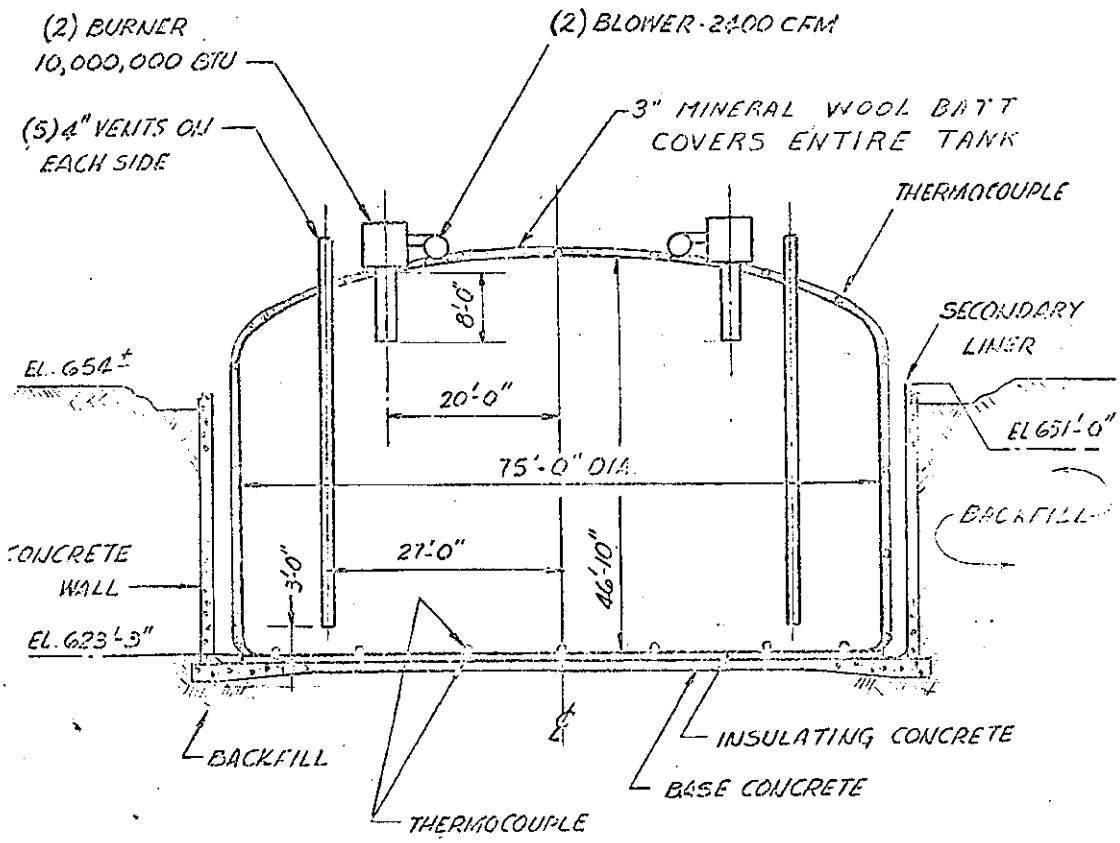
CHEM.PROC.

E&C DIV	E&C DIV	CMS DIV	LEGAL	ASST.MGR.TO
SQUIRES:jf	NIPZ			ELGERT
KNOWLER	KREMA	TOMLINSON	DECAN	PARKER

1/16/70

ATTACHMENT IV

	Specifications	ASME Boiler and Pressure Vessel Code, Section VIII, 1965 Edition	Modified Specification	Performed by the Contractor TK-101	Performed by the Contractor TK-102
Soaking Temperature	1150°F ± 50°F per inch of thickness.	1100°F per hr. per inch of thickness. 1050°F for 2 hrs. per inch of thickness. 1000°F for 3 hrs. per inch of thickness. 950°F for 5 hrs. per inch of thickness.	1000°F min. per hr. per inch of thickness.	1080°F for 3.3 hours.	1020°F for 4.2 hours.
Max. rate of temperature rise & reduction between 600°F and 1100°F	100°F per hr.	400°F per hour.		50°F per hr.	50°F per hr.
Maximum temp. differential in tank.	200°F between high & low for all parts of the tank above 600°F.	250° within any 15 ft. interval of length.	220°F between top of bottom knuckle and bottom plate for TK-102.	180°F	70°F



TANK 101

SET UP FOR STRESS RELIEVE

RECORD
BOX 5293K

IAP-614 V/HES-R-75

SUMMARY OF

AY TANK STRESS RELIEF

September 1969

HANFORD ENGINEERING SERVICES
A DIVISION OF VITRO CORPORATION OF AMERICA
P. O. BOX 296, RICHLAND, WASHINGTON 99352

SUMMARY OF

AY TANK STRESS RELIEF

Introduction

This summary describes basic stress-relief procedures being applied to two waste storage tanks (AY Tanks) that are being erected in 200-East Area; the new tanks are an expansion of the Purex Tank Farm high-level, radioactive-waste storage capacity.

Stress-relief activities of the Pittsburgh-Des Moines Steel Company are outlined here. Also included are the observation and monitoring of these activities by Vitro/Hanford Engineering Services.

Preliminary Requirements

The Contractor shall notify the Commission in writing when each tank is ready for stress relieving. The stress-relief notification must certify that all welding and thermal cutting work on the tank is complete.

Upon receipt of a stress-relief notification, the Contractor and the Commission shall make a joint inspection of the tank. Defects, discrepancies, omissions, etc., revealed in this inspection shall be corrected as requested by the Commission.

Insulation

All exposed vessel surfaces will be completely covered with three-inch nominal thickness mineral wool insulation, U.S. Gypsum Co. SF252 Thermafiber mineral wool.[5,15] Chloride content of the insulation will not exceed 0.10%.[17] Attachment will be in such a manner as to insure coverage without voids and to allow for vessel expansion.[5]

Thermocouples & Recorders

The nine iron-constantan thermocouples, TE-102-29 through TE-102-37 per Vitro Drawing H-2-64374, permanently located in the structural concrete base slab, will be monitored throughout the operation on a Foxboro Strip Recorder Model ERB-12-30-23, range 0°-1200°F, chart speed 100mm/hr (4"/hr approx.), 12 point capacity.

Twenty-four of the twenty-five iron-constantan thermocouples, TE-102-1 through TE-102-25 per Vitro Drawing H-2-64372, permanently located against the tank bottom, will be monitored on a Leeds & Northrup Strip Recorder Speedomax G Model S-60374-1308, range 0°-1200°F, chart speed 4"/hr, 24 point capacity.

The shell and roof thermocouple locations are at 15-ft intervals as shown on PDM Drawing 38570-EL1. The forty-eight shell thermocouples TC-1 through TC-48 will be monitored on two Leeds & Northrup Strip Recorders Speedomax G Model S-60374-1466, range 0°-1200°F, chart speed 4"/hr, 24 point capacity each.

The twenty-four roof thermocouples, TC-49 through TC-72, will also be monitored on an L & N Recorder.

Temporary thermocouples on the shell and roof will be Chromel-Alumel ISA Type K, AWG No. 20. Thermocouple junctions will be welded per ASA C96 1-1964 (Old ISA spec.). Thermocouple junctions will be in contact with the tank surface by using steel compression strips tack welded to the surface. After stress relieving, these strips will be ground off so as not to mar the vessel surface. These thermocouples will be attached to the vessel after all other stress-relieving preparations are complete and just prior to start up.

The strip charts recorded shall be certified by PDM and furnished to the Commission at the finish of each stress-relief operation.[10]

Firing Equipment

The stress-relieving equipment will consist of two 10,000,000 Btu/hr Tate-Jones, propane-fired burners.[5] The burners will each be bolted to a 48 x 48 x 3/8 inch steel adaptor plate. The adaptor plates will be tack

welded to Penetrations 7 & 24 and these tacks will be ground off when the equipment is removed.[5] Each burner weighs approximately 450 lb., and this weight was considered in the design of the support structure.[10]

Two 24,000 CFM North American or Eclipe Centrifugal blowers will supply the combustion air. The correct combustion mixture will be assured by using a Pyronics Ratio Regulator on both the main and pilot supplies of each burner individually.[5]

Pilot flames will be ignited by using a high tension spark ignition electrode.[5]

The air-gas mixture will enter the vessel at 16 inches of water pressure (0.58 psig). Venting will be accomplished by using a temporary sliding cover on Penetration 6. This cover will be adjusted to obtain a good forceful exhaust. The actual internal pressure is of no use except to know that it cannot exceed 0.58 psig.

Burner regulation will be as stated in Item 12, Operation. The valve will be on top of the tank roof close to the burner as will be the man that operates the valve.

The flame will be about 15 feet long and observation of the flame will be through ports located on the burner. The ports do not allow full sight of the flame in the tank. When compared to the distance from the burner mounting to the bottom of the tank, approximately 45 feet, the flame will not impinge on the tank surface.

Excess air mixtures will be used only at the lower vessel temperatures during cycling to obtain even vessel temperatures. At the higher temperatures, complete combustion mixture with little or no excess air is contemplated.

In the event of a flame-out, each burner is equipped with a Honeywell RA890F Protectorelay control and flame rod; which in turn will actuate a solenoid-operated manual-reset shut-off valve on the gas supply line.[5] Should a flame failure occur, the gas supply is automatically cut off. In the event the automatic cut-off fails, all equipment will be shut down as soon as possible, and air will be blown into the tank until the atmosphere in the tank is diluted to assure a non-explosive condition.[14]

Propane Supply

Propane supply tanks will be located approximately as shown on PDM Drawing SR-2-38570.[18] Propane lines shall run east of Tank 101.[16] Vehicle traffic will not be allowed in the vicinity of the lines.[14]

10 The propane gas lines will be screwed steel pipe 2" diameter. There will be a short section of rubber hose with screwed-end connections to take the piping load, due to vessel expansion, off the equipment. Connecting lines from the propane tanks will be manifolded into the 2" gas line with copper tubing. Separate lines will be run to each of the two burners.

14 The entire propane feed system will be tested prior to tie-in to the burners to assure that there will be no leaks. PDM will pressurize the propane lines with air and soap bubble test.

The pressure between the first regulator and the ratio regulator will be two pounds per square inch.[14]

Requirements

The temperature requirements of this stress-relieving operation are as stated in Vitro Specification HWS-7789 (as revised by contract amendment No. 2).[6]

Holding temperature - 1150°F ± 50°F

Holding period - 53 minutes minimum

Rate of temperature rise; ambient to 600°F - no restriction

Rate of temperature rise ~~about~~ above 600°F - 100°F/hr with a total maximum variation of 200°F between the highest and lowest thermocouples

Cooldown rate (after holding period) - not to exceed 100°F/hr above 600°F

Insulation may be removed after the vessel temperature drops below 600°F

Operation[5]

The starting sequence for burner operation is as follows:

1. Connect gas lines from the propane supply into the burner gas lines. The connection will be made just prior to start-up; and, if for any reason start-up is delayed, these lines will be redisconnected.

2. Open valves on propane supply tanks after making certain all other valves on the burner equipment are closed.

3. Start the blower with the blast gate #7 in the closed position.

4. Energize the ignition transformer and observe the spark through the burner viewport.

5. Simultaneously open valves #9 and #11. #11 may be opened all the way but #9 should be opened about a quarter turn. The pilot flame should now be lighted - observe.

6. Observe the pilot flame and adjust valve #9 so that the pressure on gauge #13 reads about 10 inches of water pressure. Note: This will have to be readjusted after the blast gate #7 is opened.

7. Check solenoid valve #14 which should now be in the open position.

8. Open ball valve #10 and immediately thereafter open the blast gate #7 about half way. The main burner flame is now in operation - check.

9. Continue to open the blast gate until 16 inches of water pressure is read on gauge #13.

10. Observe the main flame and adjust the burner mixes so that a semi-luminous flame is obtained.

11. Start the second burner in the same manner.

12. Heat input will be controlled by regulating the main burner input valve #10 and not the input air volume.

Safety Precautions

Pittsburgh-Des Moines personnel will be in attendance at all times during the stress-relieving period. Even though safety equipment is employed on the burners, constant human surveillance is considered necessary.

In the event of a flame failure on either or both burners, all equipment will be shut down and the propane supply lines disconnected. The air

volume in the vessel will be allowed to stratify for a period of one-half hour and the internal atmosphere will be tested for explosive potential using a Mine Safety Explosion Meter at all levels. If an explosive atmosphere should exist, the blowers will be put into operation with all vents open until this concentration is removed.

PDM will have available instruments to sample the annulus atmosphere for an explosive potential and blow out any excess propane gas should it exist.[14]

Title III Functions

- Witness air/soap test of lines.
- Assure no vehicle traffic near tanks/lines.
- Witness-check each thermocouple to assure each is operating and correctly connected (prior to startup).
- Inspect insulation to see that all is covered.
- Make frequent observations of strip charts during stress relieving.
- Obtain certified strip charts.

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