TOC-PRES-14-0423 -VA
Revision 0

Double-Shell Tank AY-102 Radioactive Waste Leak Investigation

14178 - Session 116, Storage and Retrieval of HLW

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-08RV14800

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D. J. Washenfelder
Washington River Protection Solutions

Date Published
March 2014

To be Presented at
Waste Mangement 2014

Waste Management Symposia
Phoenix, Arizona

03/02/2014 - 03/06/2014

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APPROVED
By Janis D. Aardal at 3:30 pm, Apr 10, 2014

Release Approval | Date

Printed in the United States of America

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Washington River Protection Solutions LLC / AEM Consulting LLC

March 6, 2014

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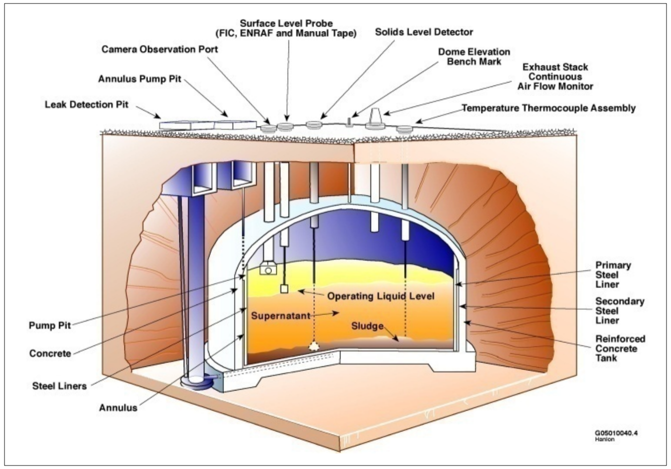
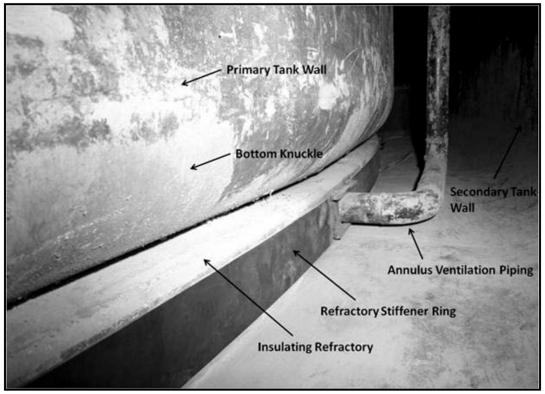
Agenda

- Describe Effort to Determine Whether Tank AY-102 Leaked
- Review Probable Causes of the Tank AY-102 Leak
- Discuss Influence of Leak on Hanford's Double-Shell Tank Integrity Program

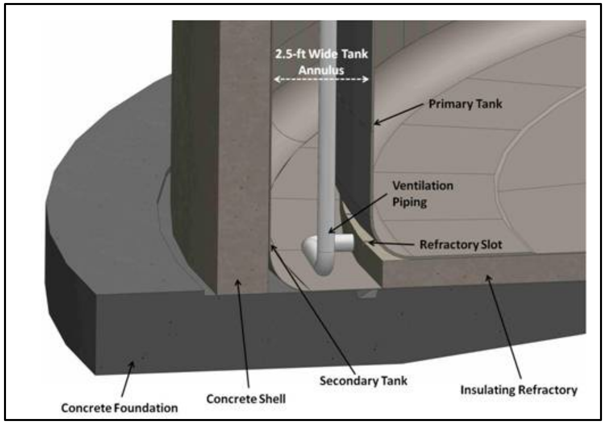
Hanford Double-Shell Tanks

At Hanford 28 double-wall tanks built in six generations between 1968 – 1986 contain ~ 27 million gallons radioactive waste





- **Tank AY-102 was the first double-shell tank constructed at Hanford**



Double-Shell Tank Annulus Detail

Hanford Double-Shell Tank Integrity Program

- DOE developed integrity requirements for high level waste storage tanks with Brookhaven National Laboratory expert panels
  - BNL-52361, Structural Analysis Guideline Panel proceedings (1995)
  - BNL-52527, Tank Structural Integrity Panel proceedings(1997)
  - DOE G 435.1-1 incorporated the Panels' recommendations
  - Series of Hanford Tank expert panels refined these requirements
- Double-Shell Tank Integrity Program Elements
  - Primary Tank Wall Ultrasonic Inspection / 8-10 year cycle
  - Primary and Annulus Tank Visual Inspection / 5-7 year cycle
  - In-Tank Corrosion Monitoring / Real Time
  - Waste Chemistry Corrosion Control program
  - Structural Analysis and evaluations of thermal, operating, and seismic loads

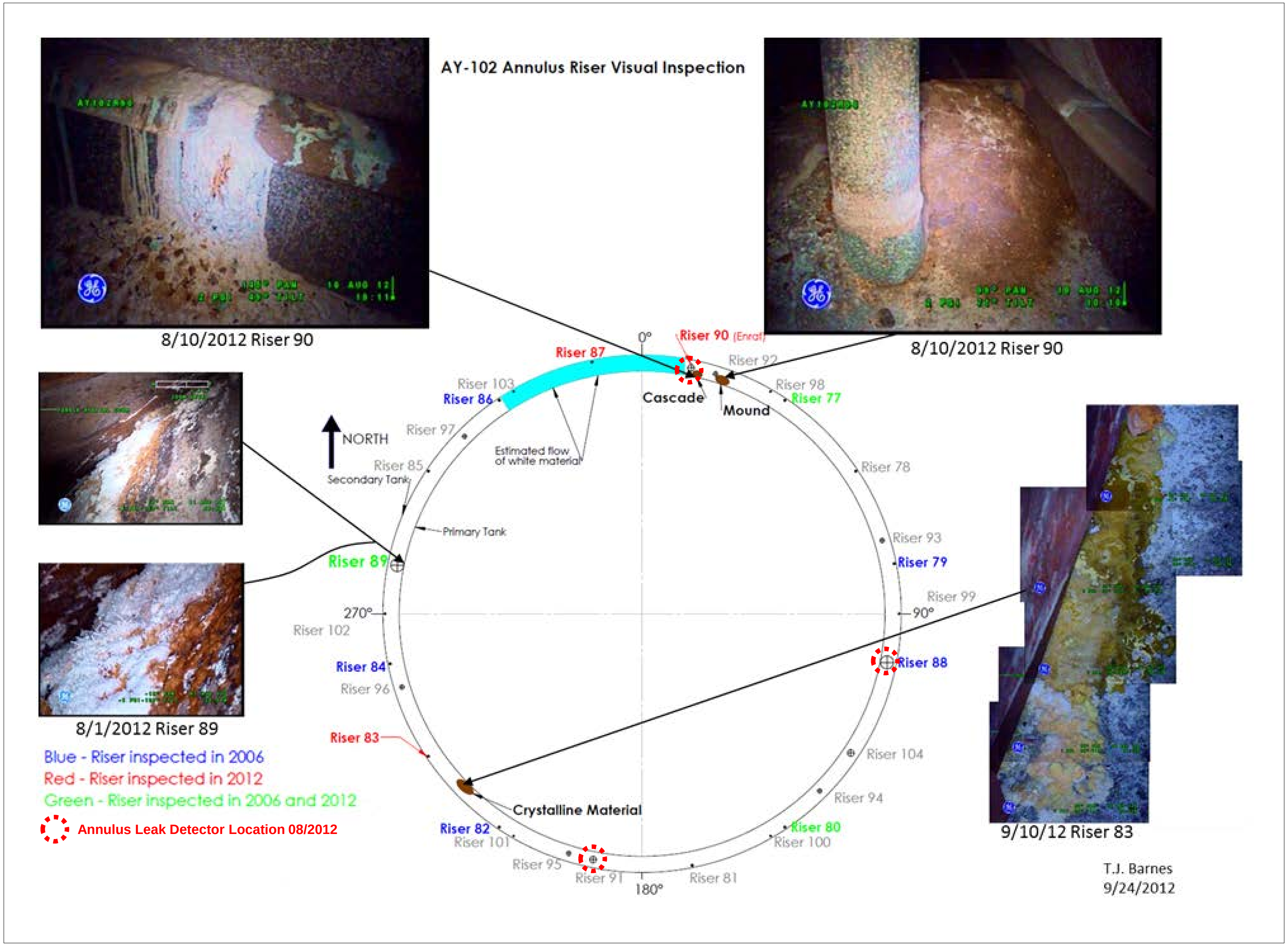
Tank AY-102 – First Hanford Double-Shell Tank

- Prior to August, 2012 no suggestion of incipient tank leakage
  - No primary tank wall loss from corrosion
  - No tank annulus video inspection anomalies
  - In-tank corrosion probe results within limits
  - Waste chemistry within corrosion control limits
  - Tank operated within allowable thermal and operating load limits

Tank AY-102 Leak Discovery

Date	Event
Jan-2007	Last annulus video inspection
Jan-2007	Last primary tank ultrasonic wall inspection
Aug 1, 2012	Annulus video inspection commences; Floor anomaly found below Riser 87
Aug 5, 2012	“Brown Mound” found beyond Riser 77
Aug 10, 2012	“Frozen Cascade” found below Riser 90; Swabs indicate high levels of contamination
Aug 20, 2012	Leak Assessment initiated
Aug 29, 2012	Liquid accumulation discovered below Riser 83
Sep 26, 2012	Riser 83 material sampled
Oct 10 & 15, 2012	Riser 90 Brown Mound and Cascade sampled
Oct 19, 2012	Tank declared “Assumed Leaker”
Oct-2012 / Present	Video surveillance of Riser 83 and 87 leak sites

Tank AY-102 Annulus Video Inspection: Sites with Floor Material

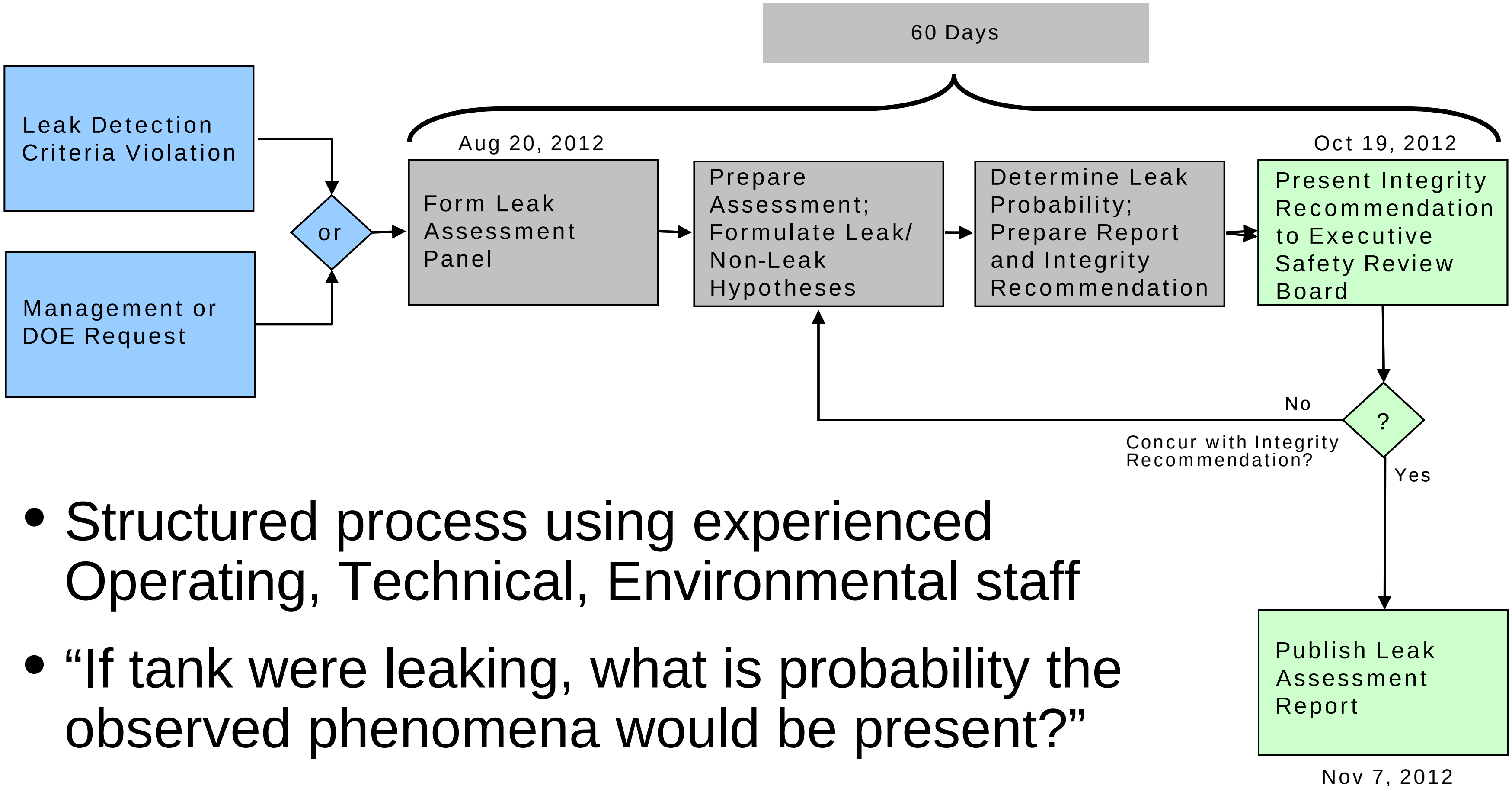


Tank AY-102 Annulus Riser 83 and Riser 90 Sample Results

- Annulus Floor Material near Riser 83, September 26, 2012:
  - 45 mR/hr dose rate
  - Principal Chemical Constituents: $NaNO_3$, Na_2CO_3, $NaNO_2$, KNO_3[1]
  - Principal Radionuclide Constituents: Sr-90; Cs-137
  - Conclusion: Tank Waste
- Annulus Floor Material near Riser 90, October 10 & 15, 2012:
  - "Brown Mound": Feldspar and quartz – "Hanford Soil"
  - "Cascade": Tank Waste

[1] In 1994, 4,000 gallons of KOH containing about 2,600 pounds of potassium were added to tank AY-102 to increase the pH. The tank AP-101 supernatant transferred into tank AY-102 in 2007 contained a significant potassium inventory. Tank AY-102 has second highest potassium inventory of any Hanford waste tank.

Hanford Tank Leak Assessment Process



- Structured process using experienced Operating, Technical, Environmental staff
- "If tank were leaking, what is probability the observed phenomena would be present?"

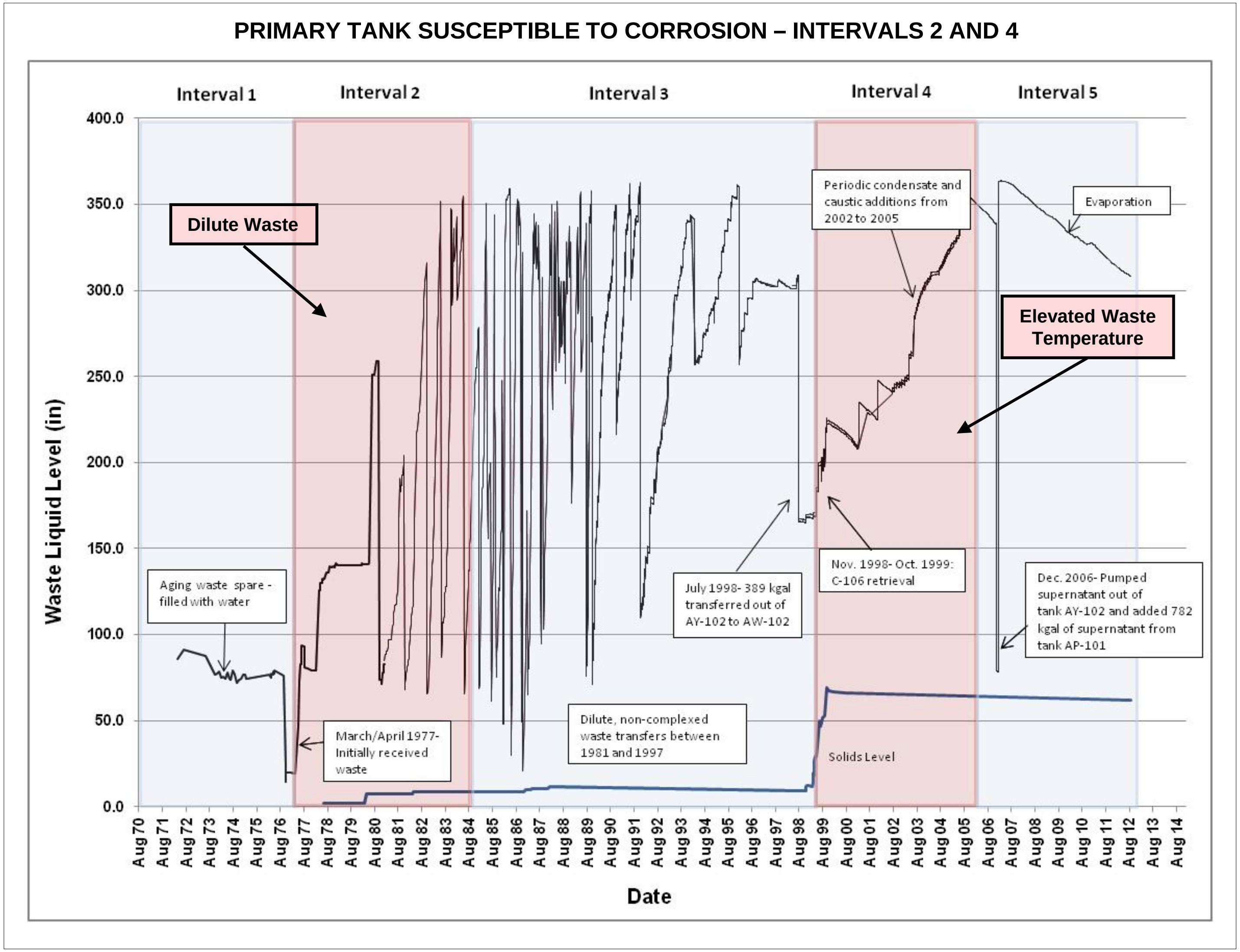
Tank AY-102 Leak Assessment – Lines of Inquiry

Lines of Inquiry	Yes	No
Chemistry	**X**	
Tank Construction	**X**	
Liquid Level Changes		X
In-Tank Corrosion Probe		X
Primary Tank Ultrasonic Wall Inspections		X
Waste Temperature		X
Tank Dome Deflection and Tank Settlement		X
Fill Cycle Fatigue		X

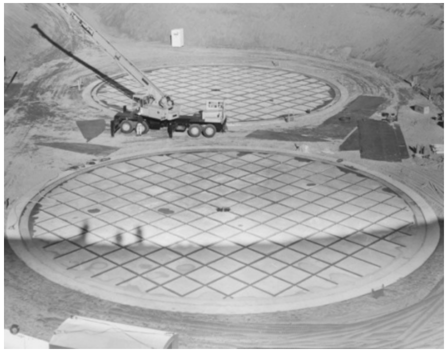
Tank AY-102 Waste Chemistry History

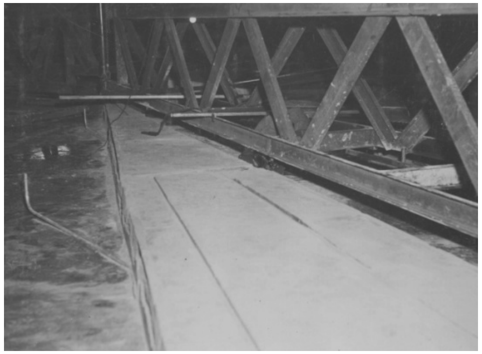
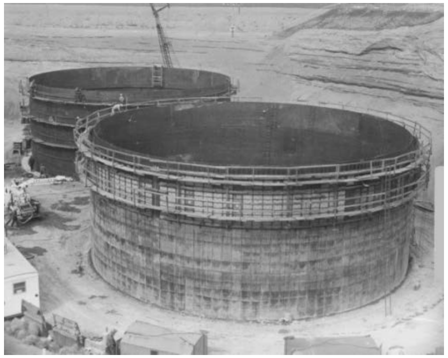
- Parameters influencing corrosion of carbon steel liner:
  - Aggressive ions (Nitrate, Carbonate, Chloride)
  - Inhibitory ions (hydroxide and nitrite)
  - Temperature
- Two main corrosion concerns for Hanford waste:
  - Stress Corrosion Cracking in presence of high nitrate ion or carbonate ion concentrations
  - Pitting Corrosion in presence of nitrate or chloride ion concentrations
- Five chronological chemistry phases in Tank AY-102 based on susceptibility to corrosion:
  - The first solids layer deposited in tank AY-102 in 1977 – 1984 ("Interval 2") have the characteristics which cause pitting corrosion when subjected to higher temperatures experienced after 1999 ("Interval 4")

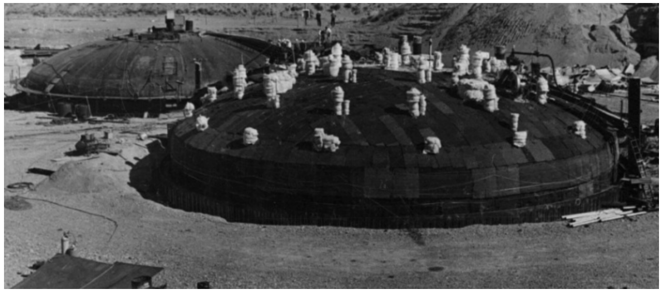
Tank AY-102 Waste Chemistry History *(cont.)*



Tank AY-102 Construction Sequence



Tank AY-102 Tank Construction

- First-of-a-Kind Construction at Hanford
  - Secondary Liner Warpage
  - Insulating Refractory Cracking
  - Primary Tank Bottom Plate Weld Rejection
  - Insulating Refractory Damage from Stress Relief and Hydrostatic Testing of Primary Tank

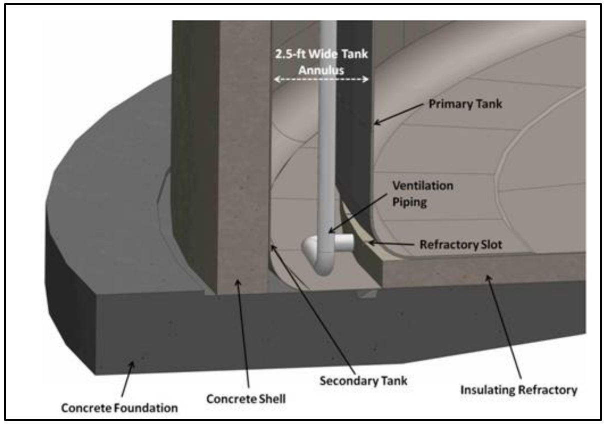
Welding Tank AY-102 Secondary Tank Bottom (8051-1-Photo)

- Secondary Liner Warpage
  - Use of thin ¼-inch plates complicated by work in extreme cold (-20ºF to -10ºF) caused liner warpage. As plates were preheated and welded, convex bulges and wrinkles appeared.
  - Flame heating and water fast quench partially eliminated wrinkles. But when plates were heated by the sun new wrinkles appeared.
  - February, 1969 survey found 22 liner locations exceeding allowable 2-inch convexity. Root-to-crown slopes up to 1-inch per foot were present, exceeding allowable 3/8-inch per foot.
  - These were eventually accepted for placement of the insulating refractory.

Example of Warped Secondary Tank Bottom Knuckle (8074-Photo)

Tank AY-102 Construction *(cont.)* Insulating Refractory Placement

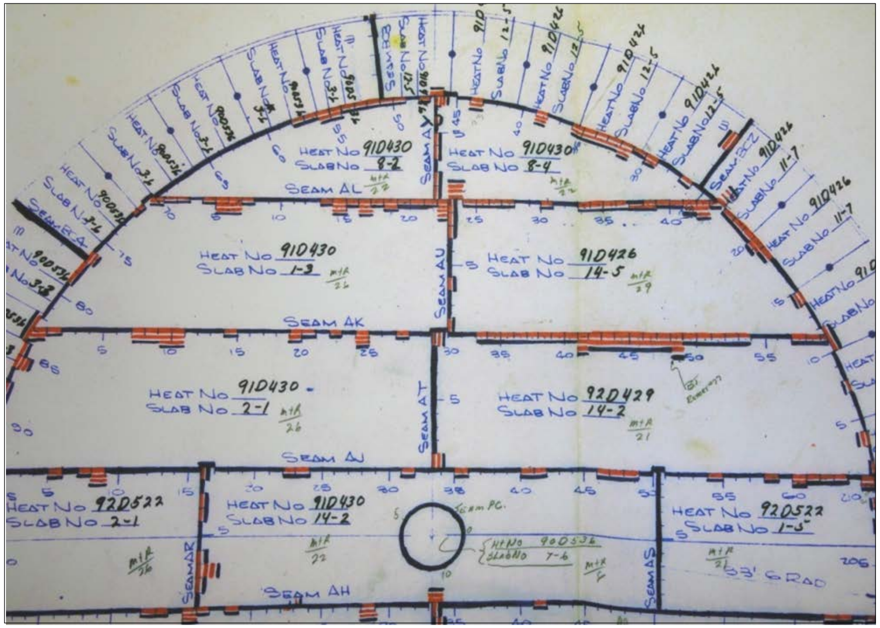
- Insulating Refractory Placement on Secondary Liner
  - The insulating refractory pad is sandwiched between the bottom of the primary tank and the secondary liner. It supports the primary tank, and protects the structural concrete foundation under the secondary liner from high-temperature damage during post-weld stress relief and from tank contents.
  - Cracks 1 to 2-inches deep and up to 7-feet long appeared in cured refractory as pours continued. These were blamed on flexing of the secondary liner from movement of the bulges.
  - The cured surface was not flat or level in some locations. In March, 1969, 25 locations were identified with variations up to 1-1/4-inches between the high points and low points. These were corrected.



Double-Shell Tank Annulus Detail

Tank AY-102 Construction *(cont.)* Primary Tank Bottom Weld Rejection Rate

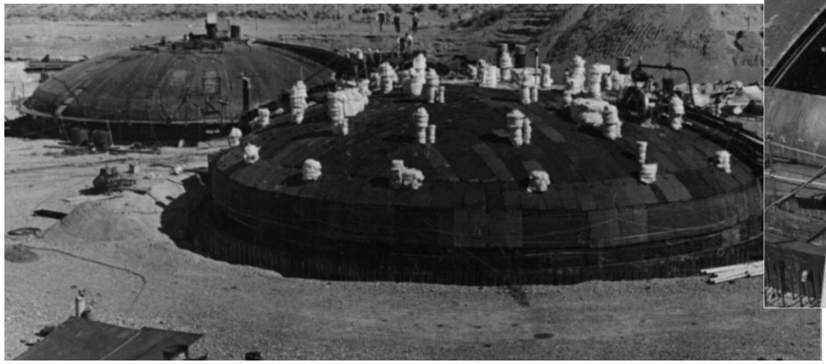
- Primary Tank Bottom Weld Rejection Rate
  - Weld quality was a continuing concern. The floor plate weld rejection rate was ~ 36%. Many welds were repaired several times before passing radiographic examination.



Primary Tank Bottom Plate Weld Map for northern section of tank showing rejected welds in red, and accepted welds in blue. The weld map shows instances of welds being repaired several times before passing inspection.

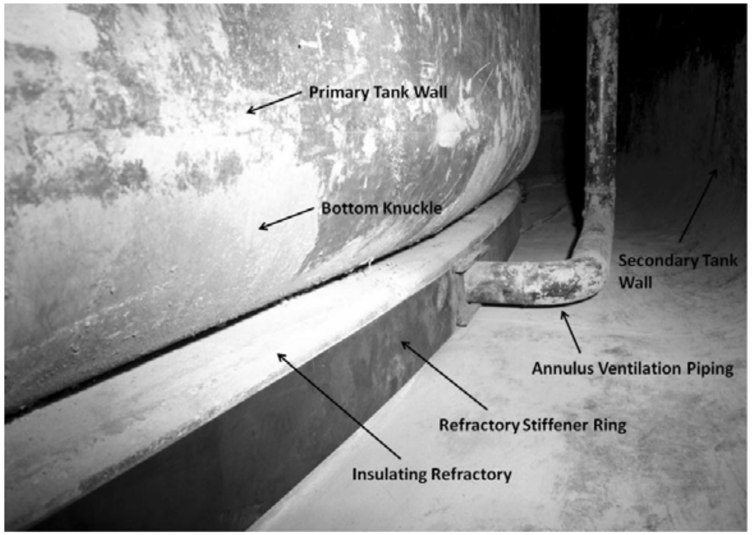
Tank AY-102 Construction *(cont.)* Insulating Refractory Damage

- Rainwater saturated the insulating refractory pad in the weeks before the primary tank was scheduled for post-weld stress-relief.
- During stress relief, the tank bottom temperature could not be raised above 210°F for two days, while steam escaped from the water-soaked refractory.
- The tank temperature eventually reached the required annealing temperature and was held at temperature for the required time.



Tank AY-102 Construction *(cont.)* Insulating Refractory Damage

- Insulating refractory damage from stress-relief and hydrostatic test of primary tank
  - Full depth cracks ¼-inch wide extending several feet under primary tank
  - Spongy top surface; affected depth increased as outer lip approached
  - Air passages blocked with spalled refractory
  - Thought to result from skin friction as primary tank expanded and contracted across surface of refractory concrete pad during stress-relief, and “oil-canning” of the tank on the outside perimeter of the pad

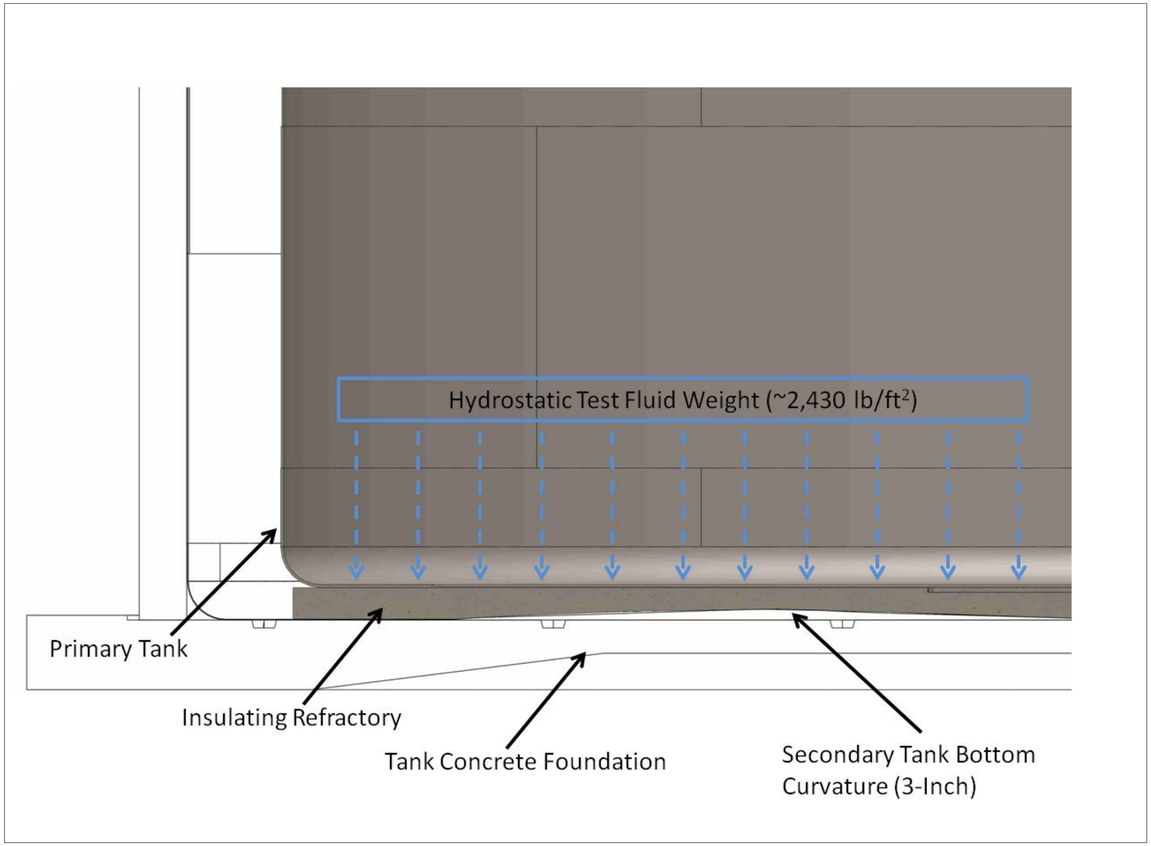


Tank AY-102 Construction *(cont.)*
Insulating Refractory Damage Repair

Preparing Insulating Refractory for modification with use of reinforced concrete

Tank AY-101 Primary Tank Gap over Insulating Refractory (52788-8-Photo). Gaps in Tank AY-102 were reported to be larger.

Summary Effect of Construction Difficulties



Tank Configuration with 3-Inch Secondary Tank Convex Bottom Curvature during Hydrostatic Test.

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Tank AY-102 Probable Leak Cause

- Corrosion at high waste temperatures in a tank whose waste containment margins had been reduced by construction difficulties.
  - During 1977 – 1979 and 1983 – 1984 waste with insufficient $NaNO_2$ corrosion inhibitor probably came into contact with tank bottom. The corrosion situation was exacerbated by introduction of high-temperature tank C-106 sludge during 1998-1999.
  - Secondary floor liner bulges and primary tank post-stress relief condition created untenable performance demands for insulating refractory and primary tank bottom.

Tank AY-102 Leak Influence on Double-Shell Tank Integrity Program

Tank AY-102 Primary Tank Leak

- Primary Tank Ultrasonic Inspections
- Primary Tank & Annulus Video Inspections
- In-Tank Corrosion Monitoring
- Waste Chemistry Corrosion Control
- Structural Analysis of Thermal, Operating, Seismic Loads
- Tank AY-102 Annulus Liner Corrosion Failure Mechanism
- Enhanced DST Annulus Video Inspections with > 95% Coverage
- DST Annulus Video Inspection Frequency Increase
- DST Integrity Program Elements Expert Panel Review
- DST Construction Extent of Condition Reviews

Existing Double-Shell Tank Integrity Program Elements

Changes Resulting from Tank AY-102 Primary Tank Leak

QUESTIONS?