Tank 241-AY-102 Leak Assessment Report

J.K. Engeman, C.L. Girardot, D.G. Harlow & C.L. Rosenkrance
Washington River Protection Solutions
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-08RV14800

EDT/ECN:	DRF	UC:	N/A
Cost Center:	2KE00	Charge Code:	201334
B&R Code:	N/A	Total Pages:	448

Key Words: DST, 241-AY-102, leak assessment, leak, tank construction

Abstract: A formal leak assessment of the first Double-Shell Tank built at Hanfrord, 241- AY-102, was performed to determine the source of an accumulation of material discovered at two locations on the floor of the annulus that separates the primary tank from the secondary liner discovered in August 2012. There was consensus agreement among the leak assessment team members that the radioactive material on the annulus floor was the result of waste leaking from a breach in the bottom of the primary tank. The probable leak cause was identified as corrosion at high temperatures in a tank whose waste containment margins had been reduced by construction difficulties. The impacts that the tank bottom may have received from the dropped core sample drill string or the corrosion probe installation were judged to have negligible effect.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

APPROVED
By Julia Raymer at 7:39 am, Nov 07, 2012

Release Approval Date

DATE:
Nov 07, 2012
HANFORD RELEASE

Release Stamp

Approved For Public Release

RPP-ASMT-53793
Revision 0

Tank 241-AY-102 Leak Assessment Report

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

P.O. Box 850
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

Tank 241-AY-102 Leak Assessment Report

J. K. Engeman
C. L. Girardot
D. G. Harlow
C. L. Rosenkrance
Washington River Protection Solutions

Date Published
October 2012

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

P.O. Box 850
Richland, Washington 99352

APPROVED
By Julia Raymer at 7:40 am, Nov 07, 2012

Release Approval Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

ACKNOWLEDGMENTS

The following contributors provided their expert input in preparing this report:

Washington River Protection Solutions, LLC

T. J. Barnes
K. D. Boomer
G. A. Cooke
B. L. Duffy
D. L. Dyekman
J. G. Field
S. J. Harrington
C. C. Joslyn
J. E. Meacham
K. J. Peltier
A. C. Prince
R. S. Rast
R. P. Tucker
T. J. Venetz
J. A. Voogd
D. J. Washenfelder

Independent Consultants

J. A. Beavers, Det Norske Veritas (U.S.A.), Inc.
M. E. Johnson, CH2M Hill Plateau Remediation Company
W. H. Nelson, AREVA Inc.
A. E. Petermann, AEM Consulting, LLC.
L. M. Stock
B. J. Wiersma, Savannah River National Laboratory

EXECUTIVE SUMMARY

Tank AY-102 was the first double-shell radioactive waste storage tank constructed at Hanford. The tank was completed in 1970, and entered service in 1971. It currently stores the Waste Treatment and Immobilization Plant hot commissioning feed.

In August 2012, an accumulation of material was discovered at two locations on the floor of the annulus that separates the primary tank from the secondary liner, and at a third location on the primary tank dome above the waterline. None of the material was present during inspections completed in December 2006 and January 2007.

A formal leak assessment team was established August 10, 2012, to review Tank AY-102 construction and operating histories, and determine whether the material found on the annulus floor resulted from a primary tank leak. The panel consisted of Engineering, Base Operations, and Environmental Protection individuals representing a broad cross-section of the company. The team met between August 28, 2012 and October 10, 2012, to gather and analyze information, formulate tank leak and non-leak hypotheses, and reach a consensus on the source of the floor material.

Tank AY-102 construction records detail a tank plagued by first-of-a-kind construction difficulties and trial-and-error repairs. The result was a tank whose as-constructed robustness was much lower than intended by the double-shell tank designers. For example:

- Bulges created in the secondary liner from welding the thin floor plates, and from reworking rejected welds, were eventually accepted so construction could proceed. The rigid insulating refractory cast on top of the secondary liner cracked as the bulges moved, leaving the pad bridged in places.
- The primary tank floor plate weld rejection rate was 36 percent. Weld maps show welds being reworked as many as four times before passing radiography examination.
- 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.
- After stress relief and the hydrostatic leak check, part of the insulating refractory pad was found to be too damaged to be used. The outside 21 in. of the refractory were excavated from beneath the primary tank and replaced with structural concrete. Pieces of Styrofoam were used to fill gaps between the primary tank bottom and the refractory surface further under the tank when they were found.

  The initial pours of the structural concrete filled the area under the primary tank knuckle, but did not flow to the back of the excavation. The slump was increased on later pours to ensure that the primary tank bottom was supported.

Between 1977 and 1984, the tank received a variety of supernatant wastes. A thin layer of sludge formed on the tank bottom during 1977 – 1979, and probably 1982 – 1984. The interstitial liquid associated with the sludge may have been mildly corrosive based on derivation of its composition from the limited number of sample analyses that are available. It is possible that the interstitial liquid began to incrementally corrode the tank bottom during this time.

In 1998 and 1999, high temperature sludge from Tank C-106 was transferred into Tank AY-102. The sludge formed a blanket over the existing sludge and increased its temperature dramatically. It is likely that the corrosion rate accelerated after the temperature increase.

In 2005, a segment of core sample drill string was dropped back into the tank during its removal; and in 2009, the tank bottom was repeatedly bumped during installation of a corrosion probe. Review of these events suggests that neither materially damaged the tank.

During September and October 2012, samples from both annulus floor locations were collected and analyzed. The material was radioactive and its composition was consistent with Tank AY-102 waste, including a high concentration of potassium. Potassium is a unique chemical marker because it is contained in only a few tanks.

There was consensus agreement among the leak assessment team members that the radioactive material on the annulus floor of Tank AY-102 was the result of waste leaking from a breach in the bottom of the primary tank. The probable leak cause was identified as corrosion at high temperatures in a tank whose waste containment margins had been reduced by construction difficulties. The impacts that the tank bottom may have received from the dropped core sample drill string or the corrosion probe installation were judged to have negligible effect.

The Tank AY-102 leak volume was estimated to be between 190 to 520 gal. A significant portion of the liquid has evaporated, leaving about 20 to 50 gal of drying waste.

The results of the leak assessment were presented to the Washington River Protection Solutions, LLC. Executive Safety Review Board on October 19, 2012, with a recommendation to change the Tank AY-102 leak integrity classification from “sound” to “assumed leaker.” The Board concurred with the recommendation.

The leak assessment team considered the possibility that Tank AY-102 is an outlier among the Hanford double-shell tanks. Construction difficulties and trial-and-error repairs left the primary tank bottom with residual stresses that could not be foreseen by the designers. These provided a fertile incubator for sustained corrosion to take place. With the construction improvements already evident in Tank AY-101 as Tank AY-102 was being completed, and the design changes implemented in the second and subsequent generations of double-shell tanks, it seems unlikely that the other double-shell tanks in similar circumstances would have been similarly affected. Additional Extent of Condition inspections scheduled for the other double-shell tanks will determine the validity of the team’s conclusion.

This report summarizes the forensic lines of inquiry prepared by the leak assessment team and supporting technical staff during the Tank AY-102 leak determination.

CONTENTS

1.0 INTRODUCTION 1-1
1.1 Tank Description 1-1
1.2 Description of Event 1-2
1.2.1 Event Response and Results 1-2
1.2.2 Prior Annulus Conditions 2011 and 2012 1-3
1.2.3 2012 Inspections and Sample Results 1-5
1.3 Report Content 1-6

2.0 METHOD OF ANALYSIS 2-1

3.0 TANK AY-102 CONSTRUCTION 3-1
3.1 Construction Summary 3-1
3.1.1 Construction Sequence 3-1
3.1.2 Concrete Foundation 3-2
3.1.3 Secondary Liner Bottom 3-2
3.1.4 Refractory 3-3
3.1.5 Secondary Liner Wall Fabrication – Vertical Concrete Shell – Partial Backfill 3-5
3.1.6 Primary Tank Bottom 3-7
3.1.7 Primary Tank Wall Fabrication - Tank Dome Shoring - Tank Dome Fabrication 3-8
3.1.8 Nondestructive Examination 3-11
3.1.9 Primary Tank Stress Relieving 3-12
3.1.10 Primary Tank Hydrostatic Test 3-13
3.1.11 Complete Secondary Liner Wall and Tank Penetrations 3-13
3.1.12 Place Concrete over Tank Dome – Remove Tank Dome Shoring 3-14
3.1.13 Tank Appurtenances Installation 3-15
3.2 Construction Issues 3-16
3.2.1 Secondary Liner Bottom Construction 3-16
3.2.2 Refractory Construction 3-20
3.2.3 Primary Tank Bottom Construction 3-26
3.2.4 Stress Relieving of the Primary Tank 3-31
3.2.5 Evaluation of Refractory after Tank Hydrostatic Test 3-35
3.3 Refractory- Waste Compatibility 3-45
3.3.1 Waste Compatibility Testing 3-45
3.3.2 Summary of Chemical Resistance 3-54
3.4 Dome Elevation Survey and History 3-55
3.4.1 Dome Load Controls 3-55
3.4.2 Tank AY-102 Dome Survey Benchmarks 3-55
3.4.3 Tank AY-102 Dome Survey Results 3-57
3.5 Temperature Analysis – Dome, Refractory, Concrete Pad 3-57
3.5.1 Thermocouple Layout and Description 3-57
3.5.2 Tank Concrete Temperature Operating Specifications 3-61
3.5.3 Temperature History Data 3-62
3.5.4 Annulus Ventilation Outages and Temperature Rise 3-65

3.5.5 Tank AY-101 and AY-102 Thermocouple Failure Patterns 3-66
3.6 Structural Upgrades History 3-69

4.0 TANK AY-102 OPERATIONAL HISTORY 4-1
4.1 Primary Tank 4-1
4.1.1 Waste Transfers and Liquid Level 4-1
4.1.2 Tank AY-Evaporation Rates 4-6
4.1.3 Temperature 4-7
4.1.4 Chemistry 4-13
4.1.5 Primary Ventilation 4-28
4.1.6 Corrosion Probe 4-31
4.1.7 Primary Tank Visual Inspection 4-37
4.1.8 Tank AY-102 Ultrasonic Testing 4-38
4.1.9 Occurrence Reports 4-44
4.2 Annulus History 4-47
4.2.1 Annulus Description 4-47
4.2.2 Annulus Ventilation 4-49
4.2.3 Water Intrusion 4-55
4.2.4 ENRAF Leak Detector Liquid Level 4-59
4.2.5 Continuous Air Monitor (Alarms and Decay Count) 4-64
4.2.6 Video Inspections 4-70
4.2.7 Samples 2012 4-98
4.2.8 Occurrence Reports 4-115
4.2.9 Leak Volume Estimate 4-116
4.3 Leak Detection Pit History and Evaluation 4-120
4.3.1 Leak Detection Pit Description 4-120
4.3.2 Leak Detection Pit Operating Specification Limits and Basis 4-122
4.3.3 Leak Detection Pit Liquid Levels 4-123
4.3.4 Radiation Detection Well 4-128
4.3.5 Leak Detection Pit Sample Results 4-128
4.3.6 Leak Detection Pit Water Accumulation at a Constant Fill Rate - Measured and Predicted Liquid Level Increase 4-130
4.3.7 Inspections of Tank AY-102 Leak Detection Pit 4-133
4.3.8 Occurrence Reports 4-141
4.3.9 Conclusions 4-142
4.4 Regulatory Notifications 4-143

5.0 LEAK EVALUATION 5-1

6.0 HYPOTHESES 6-1

7.0 CONCLUSIONS 7-1

8.0 REFERENCES 8-1

APPENDICES

Appendix A – Tank Leak Probability Calculation Methodology ..... A-i
Appendix B – Liquid Level Increase 2010-2011 – Thermal Expansion of the Liquid Waste Calculation ..... B-i
Appendix C – Tank AY-102 ENRAF Leak Detector Liquid Level 2004-2011 ..... C-i
Appendix D – Tank AY-102 Continuous Air Monitor Sample Results ..... D-i
Appendix E – Tank AY-102 Regulatory Notifications 2000-2012 ..... E-i
Appendix F – Tank AY-102 Formal Leak Assessment Meeting Minutes ..... F-i
Appendix G – Tank AY-102 In-Tank and Ex-Tank Data ..... G-i
Appendix H – Tank AY-102 Leak Assessment Team Expert Elicitation Forms ..... H-i
Appendix I – Executive Safety Review Board Briefing ..... I-i

FIGURES

Figure 1-1. Double-Shell Tank 1-1
Figure 1-2. Tank AY-102 Annulus ENRAF 152 Liquid Level 2011 1-4
Figure 3-1. Concrete Foundation Cross Section 3-2
Figure 3-2. Concrete Foundation Complete and Preparing the Placement of Secondary Liner Bottom Plates (8041-1-Photo) 3-2
Figure 3-3. Secondary Liner Bottom Assembly Resting on Concrete Foundation (8056-1-Photo) 3-3
Figure 3-4. Secondary Liner Bottom Assembly on Cribbing to Support Welding Efforts (8067-1-Photo) 3-3
Figure 3-5. Secondary Liner Bottom Assembly With Lifting Beams to Support Lifting (8069-Photo) 3-3
Figure 3-6. Crews Installing Ventilation Piping to Center Air Distribution Ring (8098-1-Photo) 3-4
Figure 3-7. Diagram of Ventilation Flow Path Into and Out of the Refractory 3-4
Figure 3-8. Weather Enclosure Installed on Tank AY-102 for Refractory Installation in Photo Background (8100-1-Photo) 3-5
Figure 3-9. First Completed Refractory Section on Tank AY-102 With Screed Located Adjacent (8118-Photo) 3-5
Figure 3-10. Nearly Completed Refractory on Tank AY-101 With Screed in Background (8124-Photo) 3-5
Figure 3-11. Secondary Liner Wall Installation Up to Course 4 to Support Concrete Shell Pours and Backfill 3-6
Figure 3-12. Vertical Concrete Shell Pour In Progress on Tank AY-102 (8113-Photo and 8135-Photo) 3-6
Figure 3-13. AY Farm Backfill (8159-Photo and 8173-Photo) 3-7
Figure 3-14. Primary Tank Bottom and Knuckle Assembly Thickness and Location 3-7
Figure 3-15. Primary Tank Bottom Welding Progress and Lifting Beam Arrangement for Raising/Lowering onto Refractory (8123-Photo and 8172-Photo) 3-8
Figure 3-16. Welding of Primary Tank Wall Course 1 to Bottom Transition Plate (8179-Photo) 3-8
Figure 3-17. Primary Tank Wall Plate Configuration and Thickness 3-9
Figure 3-18. Installation of Column Footings on Metal Grating Along Primary Tank Bottom to Facilitate Tank Dome Installation (50281-5-Photo and 50281-17-Photo) 3-9

Figure 3-19. Tank Prior to Installation of Tank Dome Fabrication Support Structure (A) (50281-18-Photo), Dome Fabrication Support Columns Installed (B) (50350-1-Photo), Dome Plate Assembly (C) (50725-19-Photo), and Column Support Structure During Dome Assembly (D) (50725-24-Photo) 3-10

Figure 3-20. Tank Dome Plate Subassembly Fabrication for AY Farm (A) and SY Farm (B) 3-11

Figure 3-21. Insulation Being Installed Into Annulus for Stress Relieving (A) (50618-3-Photo), Tank AY-102 Completely Insulated (B) (50725-18-Photo), Thermocouple Strip Charts and Thermcouple Wiring (C) (50725-22), Propane Burner Installed in AY-102 Riser Penetration (D) (50725-20-Photo) 3-12

Figure 3-22. Installation of Secondary Top Knuckle During SY Farm Construction (A), Fabrication Detail Used for AY Farm Construction 3-13

Figure 3-23. Tank Fabricator Installing Reinforcing Steel (51084-1-Photo) 3-14

Figure 3-24. Tank AY-102 After Completion of Tank Dome Concrete Pours (51305-14-Photo) 3-14

Figure 3-25. In-Tank Equipment Installation in Tank AY-102 (51660-15) 3-15

Figure 3-26. Welding of Tank AY-102 Secondary Liner Bottom (8051-1-Photo) 3-16

Figure 3-27. Example of Warped Secondary Liner Bottom Knuckle (8074-Photo) 3-17

Figure 3-28. Tank Bottom Flatness Variables 3-19

Figure 3-29. Tank SY-103 Primary Tank Flatness Stress Example 3-19

Figure 3-30. Construction Section View of Refractory and Stiffener Ring Position 3-22

Figure 3-31. Refractory Pour in Tank AY-102 Showing Evidence of Tank Bottom Bulge (8119-Photo) 3-22

Figure 3-32. Primary Tank Bottom Cleats Engaged in Container Ring 3-24

Figure 3-33. Primary Tank Bottom Cleat Design Change Summary 3-25

Figure 3-34. Completion of Refractory Section Pour in Tank AY-102 (8118-Photo) 3-26

Figure 3-35. Placement of Tank AY-101 Refractory Concrete (8124-Photo) 3-26

Figure 3-36. Tank AY-102 Primary Tank Bottom Weld Map 3-29

Figure 3-37. Tank AY-101 Primary Tank Bottom Weld Map 3-30

Figure 3-38. Tank AY-102 Primary Tank Bottom Weld Map 3-31

Figure 3-39. Tank AY-102 Thermocouple Operating Status during Stress Relieving 3-32

Figure 3-40. Tank AY-102 Insulated Prior to Stress Relieving (50725-18-Photo) 3-34

Figure 3-41. Tank AY-101 Less Than 1/2-in. Surface Deterioration 3-36

Figure 3-42. Full Depth Crack in Tank AY-102 Refractory 3-36

Figure 3-43. As-Found Refractory Condition Near Tank AY-102 Riser 90 3-37

Figure 3-44. Tank AY-101 Refractory Repair 3-37

Figure 3-45. Example of Tank AY-101 Primary Tank Pull Up From Refractory (52788-8-Photo) 3-38

Figure 3-46. Tank Configuration with Three-Inch Secondary Liner Bottom Curvature During Hydrostatic Test 3-40

Figure 3-47. View of South Quadrant on Tank AY-102 After Hydrostatic Test Showing Small Amounts of Pooling (51660-16) 3-41

Figure 3-48. View of Northeast Quadrant on Tank AY-102 After Hydrostatic Test Showing Noticeable Amounts of Pooling in Close Proximity to Annulus Riser 90 Location (51660-15) 3-41

Figure 3-49. Refractory Removal and Rebar Placement for Concrete Pours (A) (52735-10), Refractory Section Prepared for Concrete Pour with Adjacent Section Already Completed (B) (52735-1) 3-43

Figure 3-50. Diagram Comparison of 8-In. Thick Concrete Section Thickness to Photo of Southeast Section of the Tank AY-102 Annulus (52720-7) 3-43

Figure 3-51. Diagram Comparison of 10-In. Thick Concrete Section Thickness to Photo of Unknown Section of the Tank AY-102 Annulus (52720-6) 3-44

Figure 3-52. Material in Refractory Slot Near Annulus Riser 90 Found in 2012 3-45

Figure 3-53. Damaged Refractory in AY Farm 3-48

Figure 3-54. Adsorption of ^{137}Cs on Freshly Prepared Metal Hydroxides (left) and on the Metal Hydroxides after Ten Days of Aging (right) as a Function of the pH of the Solution. 3-50

Figure 3-55. Tank AY-102 Dome Survey Benchmarks 3-56

Figure 3-56. Tank AY-102 Dome Elevation Survey Data 3-57

Figure 3-57. Tank AY-102 Refractory Thermocouple Operating Status as of August 2012 3-58

Figure 3-58. Tank AY-102 Foundation Thermocouple Operating Status as of August 2012 3-59

Figure 3-59. Tank AY-102 Dome Thermocouple Locations 3-60

Figure 3-60. Tank AY-102 Refractory Thermocouple History since 2006 – Outer Ring 3-62

Figure 3-61. Tank AY-102 Refractory Thermocouple History since 2006 – Middle Ring 3-63

Figure 3-62. Tank AY-102 Refractory Thermocouple History Since 2006 – Inner Ring 3-63

Figure 3-63. Tank AY-102 Concrete Foundation Thermocouple History Since 2006 3-64

Figure 3-64. Tank AY-102 Concrete Dome Thermocouple History Since 2006 3-64

Figure 3-65. Tank AY-102 Refractory Thermocouple Comparison to Tank AY-101 3-67

Figure 3-66. Tank AY-102 Concrete Foundation Thermocouple Comparison to Tank AY-101 3-68
Figure 3-67. Tank AY-102 Annulus Ventilation Duct Upgrade 3-74
Figure 3-68. Existing Annulus Vent Lines 3-75
Figure 4-1. Tank AY-102 Liquid Level History (1971-2012) 4-4
Figure 4-2. Liquid Level Decrease for Tank AY-102 2007-2012 4-6
Figure 4-3. Location of Tank AY-102 In-Tank Temperature Monitors 4-8
Figure 4-4. In-Tank Temperatures for Tank AY-102 in Use as the Aging Waste Spare Tank from 1971-1976 4-9
Figure 4-5. Tank AY-102 4 in. Thermocouple Readings in Risers 70 and 72 (Center-Solids) from 1994 – Present 4-10
Figure 4-6. Tank AY-102 4-in. Thermocouple Readings in Risers 40, 41, 42, and 43 (Outer Radial Solids) from 1994 – Present 4-11
Figure 4-7. Tank AY-102 158-in. Thermocouple Readings in Risers 40, 41, 42, and 43 (Bulk Supernatant) from 1994 – Present 4-11
Figure 4-8. Pitting Data for Nitrate Ion Concentrations in the Range of 0.004 M to 0.28 M at pH 10 and 40°C 4-17
Figure 4-9. Tank AY-102 Primary Tank Liquid Levels and Solids Levels Showing Five Chemistry Intervals 4-20
Figure 4-10. 702-AZ Primary Ventilation System 4-28
Figure 4-11. 702-AZ Primary Ventilation System Flow Diagram 4-29
Figure 4-12. 296-A-42 702-AZ Primary Exhauster Record Sample Results 4-31
Figure 4-13. Tank AY-102 Multi-Probe Corrosion Monitoring System Average Monthly Tank and Supernatant Tank Material Electrode Potentials 4-35
Figure 4-14. Tank AY-102 ER Sensor Average Monthly Corrosion Rates 4-36
Figure 4-15. Tank AY-Core Drill String (July 26, 2012) In-Tank Photo ID# AY-102-163 4-38
Figure 4-16. Tank Integrity Inspection Guide for Tank AY-102 4-38
Figure 4-17. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 1 and Scan 2 Tank AY-in Riser 89 for FY1999 4-40
Figure 4-18. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 1 and Scan 2 in Riser 89 for FY1999 4-43
Figure 4-19. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 2 in Riser 89 between FY1999 and FY2007 4-43
Figure 4-20. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 1 and Scan 2 in Riser 88 for FY2007 4-43

Figure 4-21. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 1 and Scan 2 in Riser 89 for FY2007 4-43
Figure 4-22. Double-Shell Tank Annulus Diagram 4-48
Figure 4-23. Thermocouple Conduit Orientation in Tank Annulus 4-49
Figure 4-24. Simplified Annulus Ventilation Flow Diagram 4-50
Figure 4-25. Annulus Ventilation Inlet Piping During Construction 4-51
Figure 4-26. Annulus Ventilation Supply Piping Penetrating Refractory 4-52
Figure 4-27. Annulus ENRAF Leak Detection Installation on Tank AY-102 August 2012 4-60
Figure 4-28. Tank AY-102 Riser 90 Annulus ENRAF 152 Liquid Levels October 2011 4-61
Figure 4-29. Tank AY-102 Annulus ENRAFs Liquid Levels 2012 4-63
Figure 4-30. Video of Tank AY-102 Annulus through Riser 87 Showing Broken ENRAF Displacer (August 30, 2012) 4-64
Figure 4-31. AY Farm Ventilation Tank Annulus System Flow Diagram 4-65
Figure 4-32. Sample Net Beta Counts for the Tank AY-102 Annulus Continuous Air Monitor- March 2005 to September 2012 4-69
Figure 4-33. 296-A-19 Tank AY-102 Annulus Exhauster Record Sample Results 4-70
Figure 4-34. Tank AY-102 Annulus Description 4-71
Figure 4-35. AY Farm Tank Annulus Description Showing Refractory Slot 4-71
Figure 4-36. 2012 Visual Inspection Riser Selection 4-73
Figure 4-37. 2012 Visual Inspection Coverage (A) 2006 Visual Inspection Coverage (B) - Areas Not Inspected Shown in Red 4-74
Figure 4-38. 2001 Visual Inspection Coverage (A) 1992 Visual Inspection Coverage (B) - Areas Not Inspected Shown in Red 4-75
Figure 4-39. Anomalies Noted from Riser 77 Inspection on August 5, 2012 (A) and September 7, 2012 (B) 4-76
Figure 4-40. Annulus Floor Comparisons Between Inspections on October 23, 2006 Riser 86 (A) and August 1, 2012 Riser 87 (B) 4-77
Figure 4-41. Composite View of Annulus Floor From Riser 87 Centerline Towards Riser 90 on August 30, 2012 4-78
Figure 4-42. Composite View of Annulus Floor From Riser 87 Centerline Towards Riser 86 on August 30, 2012 4-78
Figure 4-43. Highlighted Area Viewed During the Riser 87 Inspection on August 30, 2012 4-79
Figure 4-44. Riser 89 Primary Top Knuckle Comparison on December 4, 2006 (A) and August 1, 2012 (B) 4-80

Figure 4-45. Riser 89 Close Up of Crystal-Like Material on August 1, 2012 4-80
Figure 4-46. Riser 89 Crystal-Like Material Comparison on August 1, 2012 (A) and September 5, 2012 (B) 4-81
Figure 4-47. Riser 89 White Material Comparisons on December 4, 2006 (A) and September 5, 2012 (B) 4-81
Figure 4-48. Riser 89 Refractory Slot Debris on September 5, 2012 4-82
Figure 4-49. Riser 80 Annulus Floor on September 7, 2012 Looking Towards Riser 91 (A) and on August 5, 2012 Looking Towards Riser 88 (B) 4-82
Figure 4-50. Riser 90 Annulus Floor Mound on August 10, 2012 4-83
Figure 4-51. Riser 90 Cascade of White Material from Refractory Slot on August 10, 2012 4-83
Figure 4-52. Riser 90 Cascade of White Material From Refractory Slot on August 16, 2012 4-84
Figure 4-53. Riser 90 Composite/Panoramic View of Anomalies on August 16, 2012 4-84
Figure 4-54. Riser 86 Annulus Floor on September 7, 2012 Looking Towards Riser 87 (A) and Looking Towards Riser 89 (B) 4-85
Figure 4-55. Riser 86 Composite of White Material on Annulus Floor on September 7, 2012 4-86
Figure 4-56. Riser 83 Material On Annulus Floor on August 29, 2012 (A) and September 10, 2012 (B) 4-87
Figure 4-57. Annulus Condition Comparison From Riser 82 on December 28, 2006 (A) and From Riser 83 on August 29, 2012 (B) 4-88
Figure 4-58. Riser 83 Refractory Slot on September 10, 2012 (A) and September 17, 2012 (B) 4-89
Figure 4-59. Riser 83 View of Material on Annulus Floor After Sampling Activities on September 26, 2012 4-90
Figure 4-60. Riser 83 View of Material on Annulus Floor on October 1, 2012 4-90
Figure 4-61. Riser 83 View of Material on Annulus Floor on October 1, 2012 4-91
Figure 4-62. Riser 83 View of Material on Annulus Floor on October 21, 2012 4-92
Figure 4-63. Riser 83 View of Changes in Condition of Refractory Slot Material 4-93
Figure 4-64. Riser 83 View of Changes in Condition of Annulus Floor Material Directly Below Refractory Slot 4-93
Figure 4-65. Riser 83 View of Changes in Condition of Annulus Floor Material near Off-Riser Sampler Tire Depressions 4-94
Figure 4-66. Riser 91 Annulus Floor on September 6, 2012 Looking Towards Riser 83 (A) and Looking Towards Riser 80 (B) 4-95
Figure 4-67. Riser 91 Refractory Slot Debris on September 6, 2012 4-95

Figure 4-68. Riser 88 Annulus Floor on September 5, 2012 Looking Towards Riser 80 (A) and Looking Towards Riser 79 (B) 4-96
Figure 4-69. Riser 88 Refractory Slot Debris on September 5, 2012 4-96
Figure 4-70. Riser 79 Annulus Floor on September 7, 2012 Looking Towards Riser 88 (A) and Looking Towards Riser 77 (B) 4-97
Figure 4-71. Tank AY-102 Visual Inspection Results 4-98
Figure 4-72. Tank AY-102 Riser 90 Duct Tape Survey of Residual Sample Material 4-99
Figure 4-73. Tank AY-102 Annulus Duct Tape Survey Particulates of Light Gray and Amber-Colored Aggregates of Fine Grained Crystalline Material 4-100
Figure 4-74. Tank AY-102 Sampling Region and Riser Location Diagram 4-101
Figure 4-75. Off-Riser Sampler Traversing Over Thermocouple Conduit 4-101
Figure 4-76. Composite Image of Material on Annulus Floor Prior to Sampling Attempts 4-102
Figure 4-77. Crystal Nodules During Sampling Effort 4-102
Figure 4-78. View of Material and Liquid Indications During Sampling Activities 4-103
Figure 4-79. Composite Image of Material on Annulus Floor After Sampling Attempts 4-103
Figure 4-80. Tank AY-102 Annulus Sample (12.8 g) Taken Underneath Riser 83 Deposit on September 26, 2012 4-104
Figure 4-81. Mill Scale Removed from Tank AY-102 Annulus Sample (7.6 g) 4-104
Figure 4-82. Scanning Electron Microscope Photo (left) from Sample and Energy-Dispersive X-ray Spectroscope Spectrum (right) from Spot Marked with a Cross Indicating a Potassium-Rich Phase 4-105
Figure 4-83. Remote Underground Sampler (RUS) for Riser 90 4-108
Figure 4-84. Auger Sampling Mound on October 15, 2012, Showing the Break-up of the Crust and Underlying Material 4-109
Figure 4-85. Condition of the Mound after the Sampling Events 4-109
Figure 4-86. Auger Collecting Sample of the Refractory Slot Crystalline Material near Riser 90 October 15, 2012 4-110
Figure 4-87. Condition of the Crystalline Material after the Sampling Event 4-110
Figure 4-88. Riser 90 Mound Material Sample October 15, 2012 4-110
Figure 4-89. Riser 90 Refractory Slot Crystalline Material Sample October 15, 2012 4-110
Figure 4-90. Riser 90 Mound Material Sample October 17, 2012 (0.12 grams) 4-111
Figure 4-91. Scanning Electron Microscope Photo (left) from Sample and Energy-Dispersive X-ray Spectroscope Spectrum (right) from Spot Marked with a Cross Indicating Potassium Feldspar 4-111

Figure 4-92. Riser 90 Refractory Slot Crystalline Material Sample October 17, 2012 (0.20 g) 4-112
Figure 4-93. General Leak Detection Pit Layout 4-120
Figure 4-94. Concrete Base Slabs for AY Farm Showing Drain Slots (8041-1) 4-121
Figure 4-95. Leak Detection Pits Riser for the AY Farm Tanks (8160-1) 4-121
Figure 4-96. Tank AY-102 Leak Detection Pit Level Since 1995 Versus Level in Primary Tank 4-123
Figure 4-97. Tank AY-102 Leak Detection Pit Level 2006-2009 4-124
Figure 4-98. Tank AY-102 Leak Detection Pit Level 2010 to Present 4-124
Figure 4-99. Results of Field Test Tank AY-102 Leak Detection Pit in 2008 4-126
Figure 4-100. Primary-Annulus-Leak Detection Pit Vapor Path Connectivity in Aging Waste Tanks 4-127
Figure 4-101. Depiction of "Historic Level" for Tank AY-102 Leak Detection Pit at 41 in. 4-127
Figure 4-102. Depiction of Tank AY-102 Leak Detection Pit Level Based on Zip Cord Measurement During Sampling 4-129
Figure 4-103. September 18, 2012 Video of Tank AY-102 Leak Detection Pit After Sampling and Just Prior to Pumpout Showing Drain Line Just Underwater ... 4-130
Figure 4-104. Tank AY-102 Leak Detection Pit Level Increase Compared to Ideal Fill Curve-2008 4-131
Figure 4-105. AY Farm Leak Detection Pit Sump Tanks and Dip Tube Details Showing 2-in. Offset 4-132
Figure 4-106. Tank AY-102 Leak Detection Pit Level Increase Compared to Ideal Fill Curve-2007-2008 4-133
Figure 4-107. Tank AY-102 Leak Detection Pit 2-in. Vent Line (2-in. V-0507-M5) Inspection 4-134
Figure 4-108. Tank AY-102 Leak Detection Pit 6-in. Drain Line Inspection 4-135
Figure 4-109. Tank AY-102 Leak Detection Pit 48-in. Sump Tank Inspection 4-136
Figure 4-110. Comparison of Tank AY-102 Leak Detection Pit Drain Line Condition in 2008 (A) and 2012 (B) 4-137
Figure 4-111. Tank AY-102 Leak Detection Pit Drain Line Interior Condition 4-137
Figure 4-112. Tank AY-102 Leak Detection Pit Drain Line Elbow Condition 4-138
Figure 4-113. Debris along the Bottom of Leak Detection Pit Drain Line 4-138
Figure 4-114. White Debris along Leak Detection Pit 24-in. Diameter Pipe Wall 4-139
Figure 4-115. Leak Detection Pit 48-in. Diameter Steel Sump Condition 4-140

Figure 4-116. Moisture Line on Leak Detection Pit 24-in. Diameter Well Wall Found during Inspection 4-140

Figure 4-117. Tank AY-102 Leak Detection Pit Drain Line Airflow Test 4-141

TABLES

Table 1-1. Sample Results 1-5
Table 3-1. Tank AY-102 Nondestructive Examinations Used During Construction 3-11
Table 3-2. AY Farm Primary Tank Bottom Weld Comparison 3-28
Table 3-3. Kaolite Laboratory Test Results After Freezing Samples at 10°F 3-42
Table 3-4. Comparison of Properties for Kaolite 2000 and Kaolite 2200-LI 3-46
Table 3-5. Synthetic Waste Solution Tested on Kaolite 20 and Kaolite 2200-LI 3-47
Table 3-6. Analysis of Damaged Refractory from Tanks AY-102 and AY-101 3-49
Table 3-7. Tank AY-102 Thermocouple Operation Status Since 1995 3-61
Table 3-8. Double-Shell Tank Operating Specification Document Concrete Temperature Requirements 3-62
Table 3-9. Thermocouple TE-102-01 Refractory Temperature Data – January 2008 (2 pages) 3-65
Table 3-10. Tank AY-101 and AY-102 Thermocouples Operable as of August 2012 3-66
Table 3-11. Upgrade Projects in the AY Farm and for Tank AY-102 (2 pages) 3-70
Table 4-1. Time Intervals Based on the Waste Types Stored 4-13
Table 4-2. Proposed Specifications for the Control of Stress Corrosion Cracking in Nitrate Ion Wastes in Double-Shell Tanks with Temperatures Less Than 50°C 4-14
Table 4-3. Current Waste Chemistry Limits for Tanks AN-102, AN-106, AN-107, AY-101, and AY-102 Interstitial Liquid 4-18
Table 4-4. Current Waste Chemistry Limits for All Double-Shell Tank Wastes Except Tank AN-102, AN-106, AN-107, AY-101, and AY-102 Interstitial Liquid 4-19
Table 4-5. 702-AZ Primary Ventilation Outages (2003 to Present) 4-30
Table 4-6. Tank AY-102 Multi-Probe Corrosion Monitoring System Sensing Elements 4-32
Table 4-7. Tank AY-102 Multi-Probe Corrosion Monitoring System Electrode and Electrical Resistance Sensor Status as of June 2012 4-33
Table 4-8. Average Tank AY-102 Tank Potential (March 2009 through August 2012) 4-33
Table 4-9. Average Tank AY-102 MPCMS Tank Material Electrode Potentials (March 2009 through August 2012) 4-34
Table 4-10. Average Corrosion Rates from the Tank AY-102 Multi-Probe Corrosion Monitoring System Electrical Resistance Sensors (March 2009 through August 2012) 4-36
Table 4-11. Ultrasonic Testing Evaluation Guidelines and Reportable Values 4-39

Table 4-12. Ultrasonic Testing Wall Thickness Measurements FY1999 4-40
Table 4-13. Comparison of Tank Ultrasonic Testing Wall Thickness Measurements FY1999-FY2007 4-42
Table 4-14. Tank AY-102 Primary Tank Occurrence Reports and Problem Evaluation Requests (3 pages) 4-45
Table 4-15. Tank AY-102 Annulus Ventilation Outages 1980-2000 4-53
Table 4-16. Tank AY-102 Annulus Ventilation Outages 2003-Present 4-54
Table 4-17. Summary of Events in Response to the Tank AY-102 Water Intrusion (2 pages) 4-57
Table 4-18. Tank AY-102 Annulus ENRAF 152 (Riser 90) October 2011 Events 4-62
Table 4-19. Tank AY-102 Annulus Continuous Air Monitor Sample Results (October 26, 2011) 4-68
Table 4-20. Elevated Tank AY-102 Annulus Continuous Air Monitor Sample Results for Period October 2011- September 2012 4-68
Table 4-21. Tank AY-102 Risers Used for Visual Inspection 4-72
Table 4-22. Detectable Radionuclide Results in Swab from Riser 90 4-100
Table 4-23. Riser 83 Material Ion Chromatography Results 4-107
Table 4-24. Riser 83 Material Radionuclide Results 4-107
Table 4-25. Riser 90 Refractory Slot Crystalline Material Sample Chemical Results Compared to Best Basis Inventory 4-113
Table 4-26. Riser 90 Refractory Slot Crystalline Material Sample Radionuclide Results Compared to Best Basis Inventory 4-113
Table 4-27. Tank AY-102 Tank Annulus Occurrence Reports (2 pages) 4-115
Table 4-28. Volume of Liquid 4-118
Table 4-29. Total Estimates of Waste Leaked, High and Low Range, ... 4-119
Table 4-30. AY Farm Limits for Leak Detection Pit Liquid Level 4-122
Table 4-31. Sample Results from Tank AY-102 Leak Detection Pit Sampling 4-128
Table 4-32. Tank AY-102 Leak Detection Pit Liquid Sample Results- 2007-2012 4-128
Table 4-33. Tank AY-102 Leak Detection Pit Problem Evaluation Request 4-142
Table 4-34. Environmental Notifications for Tank AY-102 (4 pages) 4-144

TERMS

Acronyms and Abbreviations

ABCASH	Automated Bar Coding of All Samples at Hanford
AC	administrative control
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BBI	Best-Basis Inventory
BNW	Battelle Northwest Laboratory
CAM	continuous air monitor
CFC	chlorofluorocarbons
CML-SSP	Centre of Environmental Science-Section Substances and Products
DLRSS	dome load record summary sheets
DOE	U.S. Department of Energy
DSSF	double-shell slurry feed
DST	double-shell tank
ECN	engineering change notice
Ecology	Washington State Department of Ecology
EDS	energy dispersive spectroscopy
EPOC	Expert Panel Oversight Committee
ER	electrical resistance
GEA	gamma energy analysis
HEPA	high-efficiency particulate air
HLW	high-level waste
IC	ion chromatography
ICP	inductively coupled plasma
IDMS	integrated document management system
ISA	International Society of Automation
IL	interstitial liquid
LAW	low-activity waste
LDP	leak detection pit
MPCMS	multi-probe corrosion monitoring system
NDE	nondestructive examination
OR	occurrence report
ORP	U.S. Department of Energy, Office of River Protection
ORS	off riser sampler
OSD	Operating Specification Document
PCSACS	personal computer surveillance analysis computer system
PDM	Pittsburgh-Des Moines Steel Company
PER	problem evaluation request
PLM	polarized light microscopy
PNNL	Pacific Northwest National Laboratory
PXSMC	plutonium uranium extraction miscellaneous waste
QA	quality assurance
RUTI	Remote Ultrasonic Test Inspection

SCC	stress corrosion cracking
SCE	saturated calomel electrode
SDDS	Surveillance Data Display System
SEM	scanning electron microscopy
SRP	Savannah River Plant
SRS	Savannah River Site
SST	single-shell tank
TIC/TOC	total inorganic carbon/total organic carbon
TIIG	Tank Integrity Inspection Guide
TMACS	tank monitoring and control system
TOC	Tank Operations Contract
TWINS	tank waste information network system
UT	ultrasonic testing
WAC	Washington Administrative Code
WFO	Waste Feed Operations
WRPS	Washington River Protection Solutions, LLC
WST	waste storage tank
WTP	Waste Treatment and Immobilization Plant
XRD	X-ray diffraction

Units and Symbols

α	alpha
β	beta
°C	Celsius
°F	Fahrenheit
µ	micron
%	percent
Ci	curie
cm	centimeter
cpm	counts per minute
dpm	disintegrations per minute
ft	feet
ft^3	cubic feet
g	gram
gal	gallon
gpm	gallons per minute
hr	hour
in.	inch
kg	kilogram
kgal	thousand gallons
kL	kiloliter
L	liter
lb	pound
M	molar
Mgal	million gallons
min	minutes
mL	milliliter
mR	milliroentgens
mrem	millirem
mV	millivolt
ncpm	net counts per minute
psi	pounds per square inch
psig	pounds per square inch gauge
sec	second
wg	water gauge
wt%	weight percent

TRADEMARK DISCLOSURE

ENRAF is a registered trademark of Enraf B.V., Delft, Netherlands.
Kaolite is a registered trademark of Babcock & Wilcox Company.
Linde is a registered trademark of Linde AG Corporation.
HEPA is a registered trademark of HEPA Corporation.

1.0 INTRODUCTION

This document provides the results of a formal leak assessment performed on Tank 241-AY-102 (Tank AY-102). The basis for the leak assessment process is documented in HNF-3747, *Tank Leak Assessment Process: Technical Background*. Engineering procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*, was used for this leak assessment.

1.1 TANK DESCRIPTION

Tank AY-102 is one of two 1 million gallon (Mgal) tanks in the 241-AY Tank Farm (AY Farm) located in the southeast portion of the 200 East Area. The Tank AY-102 system consists of a primary tank and secondary liner structure; concrete shell, insulating pad (refractory), and foundation; central pump pit; sluice pits; annulus pump pit; leak detection pit (and well); air lift circulators; and monitoring and alarm systems; and the capability for a mixer pump (see Figure 1-1). The primary steel tank rests inside the secondary steel liner and is supported by the refractory on the floor of the secondary liner. An annular space of 2.5 ft is formed between the primary tank and secondary liner. The primary tank and annulus have separate ventilation systems, both of which are kept at pressures negative to the environment with the use of exhaust fans.

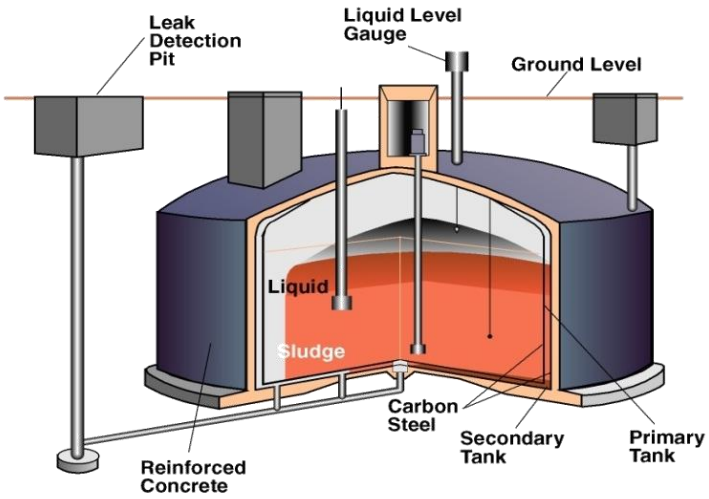


Figure 1-1. Double-Shell Tank

The primary tank is a fully enclosed structure with the only penetrations being side fill lines and dome risers. The secondary steel tank provides containment up to a height of 39 ft-8 in. from the bottom to where the secondary liner meets the top knuckle of the primary tank. The annulus has 22 risers that allow for the insertion of inspection equipment and placement of instruments in the annulus. Six additional risers act as annulus ventilation outlets.

The liquid level in the tank is limited to 362 in. because of the side fill lines, which are positioned at about 372 in. The height difference between the waste level and height of the containment allows more than 8 ft of freeboard above the maximum liquid level in the primary tank, is the annulus ever fills and equalizes with the level in the primary tank. The secondary liner meets at a working point where both radii of the curvatures of the haunches are coincident. This joint is not welded or fastened, but is offset ½ in. by the use of backup copper bars and covered by an 18-gauge, 14-in. wide metal flashing that is tack-welded to the primary tank. This allows for movement from expansion or contraction between the two tanks after the concrete shell has been cast over the tanks.

1.2 DESCRIPTION OF EVENT

Routine periodic visual inspection of the Tank AY-102 annulus was conducted on August 1 and August 5, 2012. This inspection was conducted using Risers 77, 80, 87, and 89. The inspection video footage was reviewed by Engineering on August 7, 2012. Three of the four risers used for the inspection, Risers 77, 87 and 89, indicated the following areas required additional evaluation:

- An isolated build-up of brown material on the annulus floor near Riser 90, as viewed from Riser 77. (This is the first time that this region of the tank was inspected; limited lighting and equipment obstructions in this region of the tank inhibited the inspections in 2006).
- A small cascade of material on the refractory and the annulus floor near the isolated build-up of brown material, as viewed from Riser 77.
- Material on the annulus floor, as viewed from Riser 87. Comparison with the 2006 inspection suggested that change had occurred, but was indeterminate since an improved lighting source was used during the most recent inspection.
- An isolated patch of crystals adhered to the primary top knuckle (above the liquid level of the tank), as viewed from Riser 89. Comparison with the 2006 inspection indicated that change had occurred.

The annulus inspections were reviewed and discussed with management. It was determined that (1) the annulus air continuous air monitor (CAM) was still operating and was not in an alarm condition; (2) the annulus inspection camera recovered from the annulus inspection had no reported contamination; and (3) previous work evolutions in the annulus showed no signs of increased radiation levels above minimal contamination levels known to be present.

1.2.1 Event Response and Results

A project team was established to respond to the event and direct the immediate actions. This team completed a comprehensive inspection of the annulus and put into place the resources to inspect the annulus floor anomalies twice weekly to monitor for changes in appearance. The team also initiated efforts to sample the annulus material.

Near-term actions were listed in problem evaluation request (PER), WRPS-PER-2012-1363, “AY-102 Annulus Video Inspection – Potential Intrusion Identified,” including:

- Detailed inspection of the annulus floor material near Riser 90
- Annulus floor contamination survey near Riser 90
- Evaluate capabilities to obtain remote samples of areas requiring evaluation
- Determine additional actions.

The PER, WRPS-PER-2012-1363, was later closed, and the actions were transferred to PER, WRPS-PER-2012-1438, "Video Inspection of the Tank 241-AY-102 Identifies Dry Material on Annulus Floor," and Occurrence Report (OR), EM-RP-WRPS-TANKFARM-2012-0013, "Video Inspection of Tank 241-AY-102 Identifies Dry Material on Annulus Floor," as follows:

- Increased monitoring frequency of the liquid level in the primary tank and liquid detection in the annulus space
- Initiated a tank leak assessment process following a company- and regulator-approved process
- Initiated activities to obtain samples of the identified material
- Initiated camera installation in Riser 90 for twice-a-week visual monitoring
- Initiated planning to perform a comprehensive inspection of the tank annulus
- Initiated extent-of-condition evaluations.

As a result of the comprehensive inspection of the annulus, additional material was found on the annulus floor near Riser 83. The project team deployed the off-riser sampler to obtain material from this location.

All the information assembled by the project team activities was used by the Tank AY-102 Leak Assessment Team as part of this leak assessment process.

Inspection Background

The Tank AY-102 annulus was last inspected in 2006 using multiple tank risers. The inspection showed evidence of water intrusion and the tank was included in a 2007 Annulus Corrosion Recovery Plan intended to investigate and stop the intrusion (Ferrera 2007). The actions were completed with the cutting and capping of the pressurized water line in the tank farm, and the determination that the nearby water line was sound. The recovery plan was closed out per WRPS-0901335, "Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Closure of Technical Safety Requirement Recovery Plan for Water Intrusion into the Annuli of Tanks 241-AY-101 and 241-AY-102" (Johnson 2009).

1.2.2 Prior Annulus Conditions 2011 and 2012

A review of annulus conditions prior to the August 2012 inspection indicated there may have been two alarm conditions in 2011 that could be related to annulus inspection anomalies and one equipment failure in 2012.

Tank AY-102 ENRAF Annulus Leak Detector Alarm October 2011

On October 9, 2011, a high-level alarm of the tank monitoring and control system (TMACS) from the ENRAF[1] AY102-WSTA-LDT-152 (ENRAF 152) leak detector (Riser 90) indicated a level increase in the annulus (Figure 1-2). The other two annulus ENRAFs were both within the expected operating range.

[1] ENRAF is a registered trademark of Enraf B.V., Delft, Netherlands.

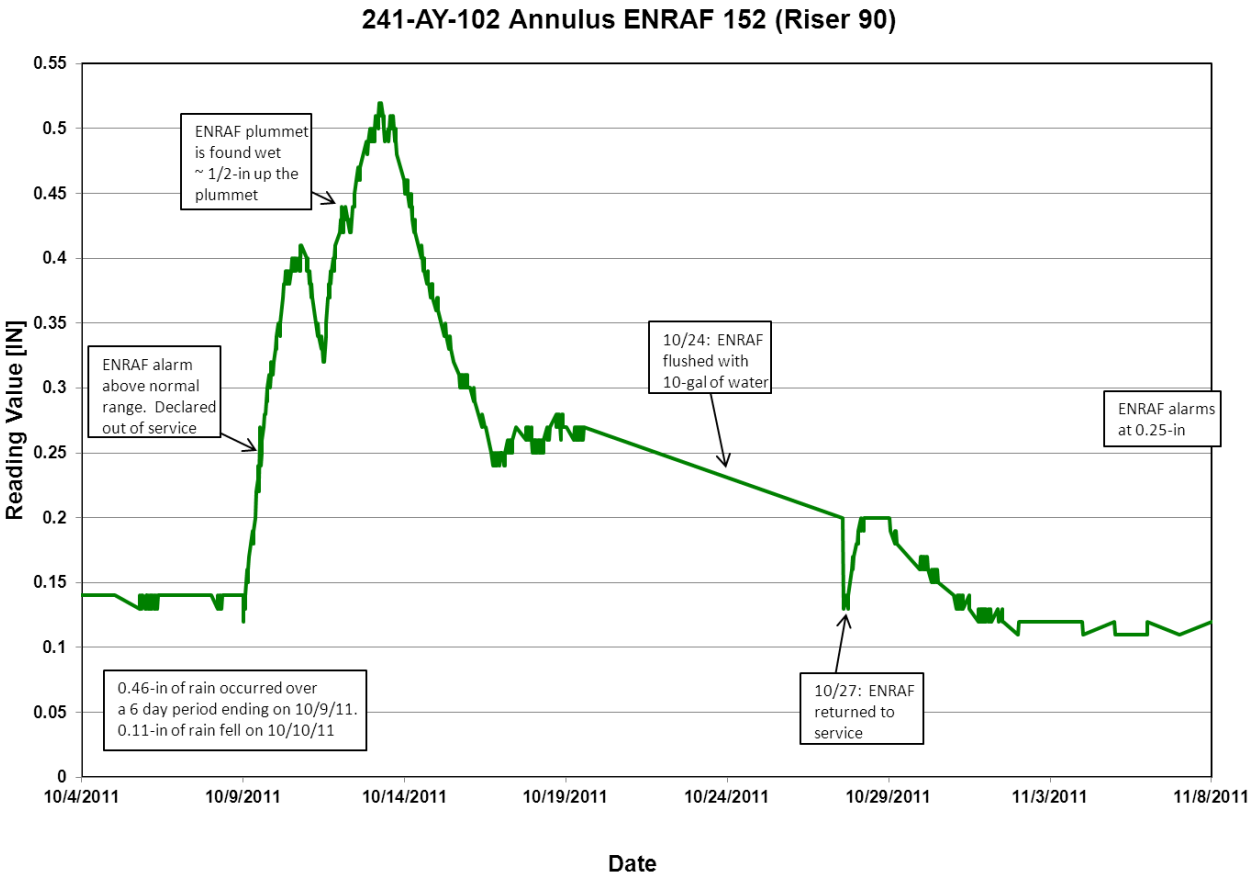


Figure 1-2. Tank AY-102 Annulus ENRAF 152 Liquid Level 2011

During calibration on October 12, 2011, "Water was observed approximately ½ in. up on the displacer" (WRPS-PER-2011-2120, "Create Pre-Planned Work Package to Investigate Annulus Water Intrusion"), with dose readings of 2 to 4 mrem. Verbal feedback indicated some deposits were noted on the displacer. Environmental notification, TOC-ENV-NOT-2011-0012, "AY-102 Annulus ENRAF," was issued October 13, 2011. The displacer was flushed with approximately 10 gal of water on October 24, 2012 and dried.

The indication of moisture in the annulus was thought to have been water intrusion possibly caused by 0.46 in. of rain in the 6 days preceding the alarm and 0.11 in. the day after. The negative pressure on the annulus ventilation system had the potential to draw rainwater through compromised riser gaskets or other sealing points. There were a number of potential penetrations reported to have been sealed on October 13, 2011 (responses to Washington State Department of Ecology [Ecology] questions during October 13, 2011 meeting).

Tank AY-102 Annulus Continuous Air Monitor Alarm October 2011

On October 26, 2011, the Tank AY-102 annulus leak detector CAM alarmed above the 2,000 cpm set point, with a field instrument reading of 4,200 cpm, and the annulus exhauster was shutdown for approximately 4 hours. This occurred two days after a 10-gal flush of ENRAF 152 (see Figure 1-2).

The WRPS radiological control count room performed a gamma energy analysis (GEA) of the annulus CAM filter paper. Preliminary results appeared to be radon progeny and ^{137}Cs. The sample was sent to the 222-S Laboratory, which reported the results shown in Table 1-1. After the annulus exhauster was restarted, the CAM readings returned to normal.

Table 1-1. Sample Results

	α µCi/mL	β µCi/mL	β ncpm
Initial	6.40E-13	4.32E-11	18,840
1-day decay	2.16E-13	4.22E-11	18,400
7-day decay	3.06E-14	4.14E-11	18,270

The primary tank headspace and the annulus ventilation system are cross-connected via floor drains in the annulus pump pit and the leak detection pump pit. The cross-connections provide a pathway for contamination to enter the annulus. The floor drains are kept sealed by maintaining the primary tank liquid level above 60 in. On several occasions in the mid-1980s, the Tank AY-102 liquid level dropped below the level needed to maintain the seals. These events are believed to be the source of low levels of legacy contamination sometimes found in the annulus pump pit and elsewhere. The source of the CAM alarm was believed to result from this legacy contamination.

ENRAF Leak Detector Failure

On March 10, 2012, the Riser 90 ENRAF 152 was declared out of service. During planned repairs on May 24, 2012, the ENRAF displacer wire broke while trying to retrieve the stuck displacer on the annulus floor. On June 4, 2012, a bullet-style video camera identified that the displacer was in a location that would interfere with the performance of a replacement ENRAF displacer. The majority of fallen wire was removed but attempts to retrieve or move the displacer from the bottom of the annulus were unsuccessful. Subsequent annulus inspections indicated white material on the annulus floor at the Riser 90 location and that the displacer was apparently embedded in it (see Section 4.2.4.1). On July 24, 2012, the upper flange of the riser was rotated to avoid the displacer and debris on the annulus floor. A replacement ENRAF 152 drum and displacer were installed on Riser 90; the ENRAF was functionally tested and returned to service (TFC-WO-12-2156, “241-AY Annulus ENRAF Cals and Functional Tests”).

1.2.3 2012 Inspections and Sample Results

Continuing Annulus Inspections

The results of the comprehensive annulus inspections in August, September, and October 2012 identified unexpected changes near Risers 77, 83, 87, 89, and 90. All of the areas are located on the annulus floor or on the refractory except for Riser 89 where crystal-like growth was found on the primary top knuckle where the primary tank and the secondary liner converge.

Sample Results – Annulus and Leak Detection Pit

August 10, 2012 Riser 90: A double-sided tape wrapped weight was used to obtain a sample of material on the annulus floor. Most of the material appeared to be rust, with a few blue-colored flakes. Qualitative analysis indicated the bulk of the sample was dominated by rust (iron and oxygen), the blue particulate indicated kaolinite, with the remainder of the particulate, light gray to amber, being fairly uniform with sodium, potassium, carbon, oxygen, phosphorous, and

chlorine. The sodium salt crystals were water soluble phases that have been previously identified in Hanford tank waste.

September 5, 2012 Leak Detection Pit: The leak detection pit (LDP) sample indicated very low levels of ^{137}Cs and ^{90}Sr with a pH between 6.6 and 6.9, all of which indicated the LDP liquid was not tank waste.

September 26, 2012 Riser 89: The off-riser sampler was used to collect nodule material for analysis. Sampler movement demonstrated liquid was present underneath a salt surface. Principal constituents in the sample included $NaNO_3$, Na_2CO_3, $NaNO_2$, KNO_3, ^{137}Cs (90.9 µCi/g), and ^{90}Sr (0.120 µCi/g).

October 15 and 17, 2012 Riser 90:

Sampling of the mound and the refractory slot crystalline material near Riser 90 occurred on October 15, and October 17, 2012. Difficulties retrieving the samples and then keeping the samples intact were experienced during both sampling events. Minimal sample material was obtained during both events. The sampling observations resulted in the conclusion that the mound material near Riser 90 was soil rather than tank waste. The sample chemical and radionuclide analyses supported the conclusion that origin of the white crystalline material near Riser 90 was tank waste.

1.3 REPORT CONTENT

The information used during the team's deliberations along with the results, and conclusions are contained in the following sections of the report:

- Section 3.0, Tank AY-102 Construction
- Section 4.0, Tank AY-102 Operational History
  - Section 4.1, Primary Tank
  - Section 4.2, Annulus History
  - Section 4.3, Leak Detection Pit History and Evaluation
  - Section 4.4, Regulatory Notifications
- Section 5.0, Leak Evaluation
- Section 6.0, Hypotheses
- Section 7.0, Conclusions.

RPP-ASMT-53794, *Tank 241-AY-102 Supporting Documentation Miscellaneous Reports, Letters, Memoranda, and Data*, is a supporting supplemental document that contains information and documents not available in the Hanford Integrated Document Management System (IDMS) (To be issued by the end of the first quarter 2013).

2.0 METHOD OF ANALYSIS

The method of analysis used was engineering procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*. The formal leak assessment process is based on probabilistic analysis to assess the mathematical likelihood (probability) that a specific tank is leaking or has leaked. For Tank AY-102, the primary tank was analyzed. The technical basis for the process and additional details and examples of the methodology for implementing the process can be found in HNF-3747. For each step, a description of the process, products, and responsibilities is provided. The elements of a leak probability calculation methodology are discussed in Appendix A.

The leak assessment used a panel of experienced engineers and managers along with support personnel to review the Tank AY-102 historical data and evaluate the possibility that the material found in the tank annulus came from a primary tank leak. The panel consisted of:
D. J. Washenfelder (Assessment Coordinator, Technical Integration Program Manager),
J. K. Engeman (Mechanical Engineer, Technical Integration, C. L. Girardot (Process Engineer, Technical Integration), D. G. Harlow (Consultant, Technical Integration), A. C. Prince (Structural Engineer, Base Operations), R. P. Tucker (AN Team Area Manager), and
J. A. Voogd (Environmental Compliance Manager, Base Operations). The team met between August 28, 2012 and October 10, 2012 to gather and analyze information, develop the leak and non-leak hypotheses, and reach a consensus recommendation for Tank AY-102.

3.0 TANK AY-102 CONSTRUCTION

3.1 CONSTRUCTION SUMMARY

Tank AY-102 was the first of the 28 double-shell tanks (DST) to be constructed at the Hanford Site.

This section provides an overview of the general construction sequence of Tank AY-102. The information was compiled using tank construction records, construction photos, quality assurance (QA) daily logbooks, inspection sheets, memos, drawings, and other documentation.

3.1.1 Construction Sequence

Construction of the two AY Farm tanks was awarded to Pittsburgh-Des Moines Steel Company (PDM), with excavation beginning in 1968 and completing in 1970. The project was supervised by Vitro Engineering under Project IAP-614. Beginning after completion of the excavation of the worksite, the sequence for the construction of Tank AY-102 was as follows:

1. Install concrete foundation on which the secondary liner bottom rests
2. Fabricate and inspect the secondary liner bottom up to the top of the bottom knuckle plates
3. Place the secondary liner bottom onto the concrete foundation
4. Install the air supply piping, thermocouple conduits, and insulating retainer ring to be embedded in tank bottom refractory
5. Install the refractory
6. Fabricate and inspect the secondary liner wall up to elevation 654.83 ft (up to the placement of the secondary top knuckle)
7. Fabricate and inspect the primary tank bottom up to the top of the bottom knuckle plates
8. Place the primary tank bottom onto the refractory
9. Place the concrete shell to elevation 651.36 ft
10. Backfill the tank farm area to 654.83 ft
11. Fabricate and inspect the primary tank walls and wall penetrations
12. Install shoring for tank dome placement and concrete supports
13. Fabricate and inspect the primary tank dome and dome penetrations
14. Provide stress relief of the primary tank
15. Conduct hydrostatic test of the primary tank
16. Complete fabrication of the secondary shell and penetrations
17. Place concrete over the tank dome
18. Remove the temporary shoring
19. Install appurtenances (thermocouple trees, airlift circulators, etc.).

3.1.2 Concrete Foundation

The structural reinforced concrete foundation is 88 ft-6 in. in diameter and is designed to distribute all weight loads uniformly to the ground below. The circular center portion of the foundation is 6 ft in diameter and 2 ft thick. From the circular center portion, the foundation thickness tapers to a 1-ft thickness, and then expands to a thickness of 2 ft at the outer edge. The structural foundation contains slots, drain lines, and leak detection wells to collect any leakage from the secondary liner. Any leakage that reaches the foundation drains though the slots to an LDP. The foundation is composed of reinforced steel and concrete requiring a 3,000 psi, 28-day compressive strength (see drawing H-2-64310, "Concrete Tank Section and Details," for details). Figure 3-1 is a cross-sectional view of the concrete foundation, including the slots that direct any accumulation of liquid to the drain lines. Figure 3-2 provides a view of the overall construction progress of the two AY Farm tanks. In Figure 3-2, the foundation for both tanks has been completed and the secondary liner bottom plates are being staged to begin fabrication.

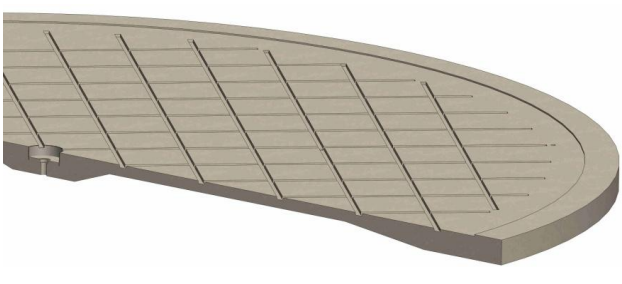


Figure 3-1. Concrete Foundation Cross Section

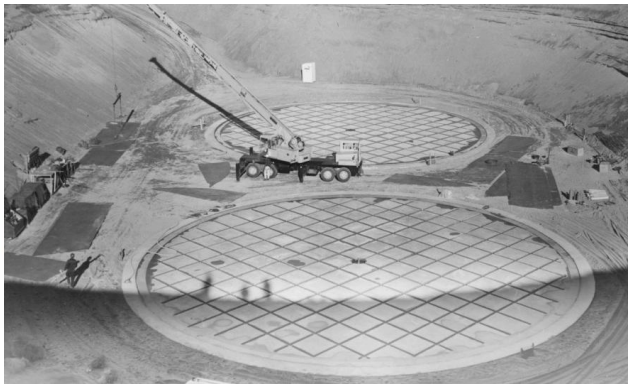


Figure 3-2. Concrete Foundation Complete and Preparing the Placement of Secondary Liner Bottom Plates (8041-1-Photo)

3.1.3 Secondary Liner Bottom

The secondary liner bottom was constructed onsite on top of the concrete foundation, with a protective cover installed to minimize damage to the concrete. Only the secondary liner bottom knuckles were fabricated offsite at a PDM fabrication facility in Provo, Utah, prior to being shipped to the worksite for welding to join the knuckles with the adjacent plates. The secondary liner bottom plates and bottom knuckle are made of ¼-in. thick carbon steel. The secondary liner bottom is sized to make the bottom section an 80-ft diameter secondary liner around the 75-ft diameter primary tank. This results in a 2½-ft wide annular space between the primary tank and secondary liner. Individual plates would be placed on the concrete foundation, and fabricators would use fit-up tools to secure the plates within the allowable tolerance to allow for proper welding. Figure 3-3 shows the secondary liner bottom where fit-up attachments are visible to join the secondary bottom knuckles to the adjacent bottom plates.

After the completion of fabrication on the top side of the secondary plates, successful welding required the fabricator to raise the secondary liner bottom to gain access to the bottom side of the plates. This required the secondary liner bottom to be raised with a crane and cribbing installed under the tank to allow workers to gain access. Figure 3-4 shows crews working under the secondary liner bottom to complete welding of the bottom plates.

The secondary liner bottom was raised and lowered by crane, with beam supports spanning the length of the tank at specified locations to limit deformation that would occur due to the thin plate size and the total weight being subjected to these locations. Prior to lowering the secondary liner bottom down onto the concrete foundation, the slots and center sump region of the foundation were cleaned with the knowledge that further access into these locations could not be provided again. Figure 3-5 shows the secondary liner bottom lifting beam assemblies in place.

3.1.4 Refractory

The refractory design used for the two AY Farm tanks specified a nominal 8-in. layer of Kaolite 2200-LI (Kaolite) to be located between the primary tank and secondary liner bottom (see Section 3.3 for details). The primary purpose of the refractory was to act as an insulating barrier between the primary tank and the concrete foundation during the stress relieving process where temperatures could damage the concrete if not properly protected. The refractory pad also housed air ventilation piping, thermocouple conduit, and air distribution slots. The air distribution slots allowed airflow to cool the primary tank bottom and to direct potential leaks to the tank annulus where leak-detection instrumentation is installed (see H-2-64449, “Tank Elevation and Details”).

Figure 3-3. Secondary Liner Bottom Assembly Resting on Concrete Foundation (8056-1-Photo)

Figure 3-4. Secondary Liner Bottom Assembly on Cribbing to Support Welding Efforts (8067-1-Photo)

Figure 3-5. Secondary Liner Bottom Assembly With Lifting Beams to Support Lifting (8069-Photo)

Prior to installing the refractory, thermocouple conduit was installed and located as necessary to allow temperature monitoring of the primary tank bottom once placed into service. Four ventilation pipes were installed in the refractory, terminating at the center of the tank with an air distribution ring. Air is drawn through this ventilation piping and out along the air distribution slots cast into the refractory. For the purpose of the ventilation system, this rings acts as a transition point between the ventilation piping and the air distribution slots in the refractory. The ring was also used for construction purposes discussed in the subsequent sections. Figure 3-6 shows crews installing the tank bottom ventilation piping to the center air distribution ring. Figure 3-7 is a diagram of the flow path in which the air would travel to cool the bottom of the primary tank.

Figure 3-6. Crews Installing Ventilation Piping to Center Air Distribution Ring (8098-1-Photo)

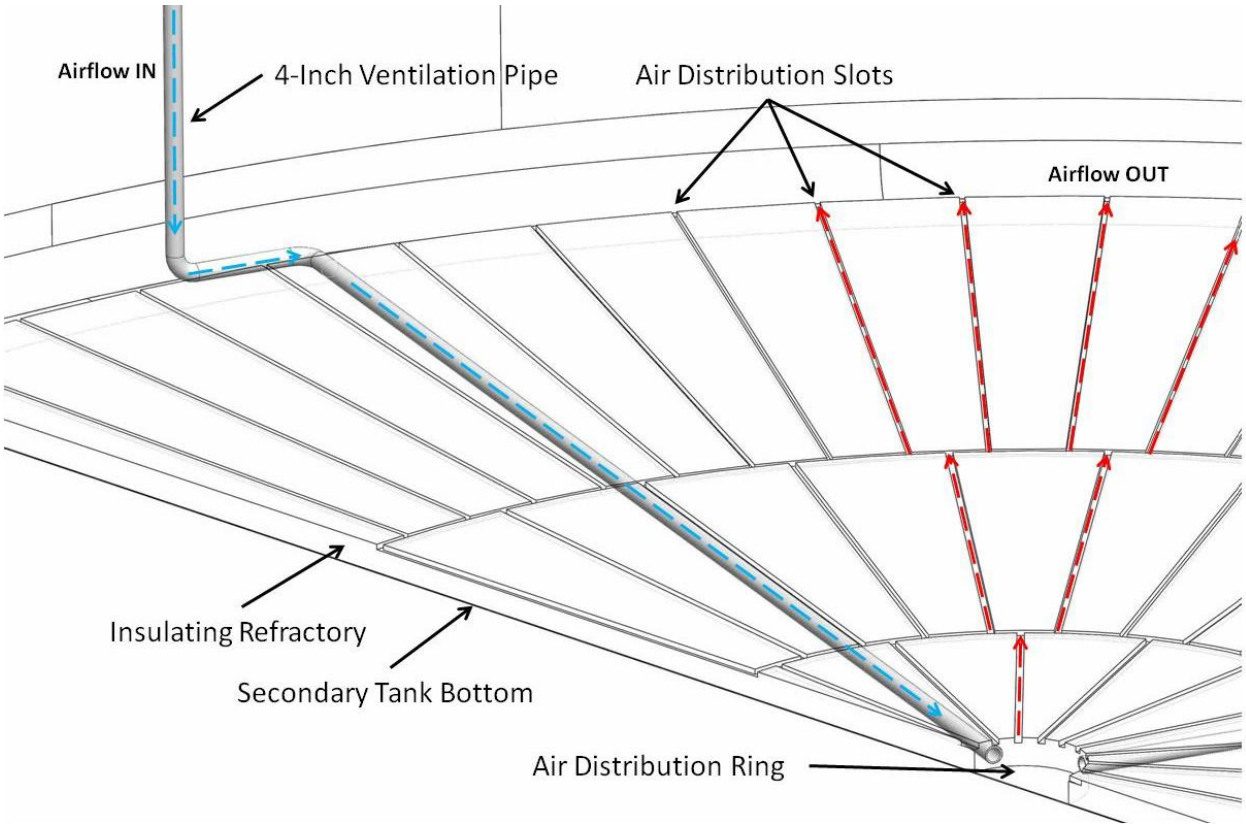


Figure 3-7. Diagram of Ventilation Flow Path Into and Out of the Refractory

Following installation of the ventilation piping, center air distribution ring, and thermocouple conduit, a 6½-in. x 2 in. x 3/16-in. bent plate (referred to as the stiffener ring) was installed along the perimeter of the yet to be installed refractory. The stiffener ring was to act as a form and to contain any spalling material. The ventilation piping and the thermocouple conduit penetrate through the stiffener ring.

Prior to pouring of the refractory, a weather enclosure was set up to prevent temperatures inside the tank from reaching levels that would damage the refractory or delay the curing time, causing schedule delays in the project. Figure 3-8 shows the weather enclosure installed on Tank AY-102 during the refractory installation.

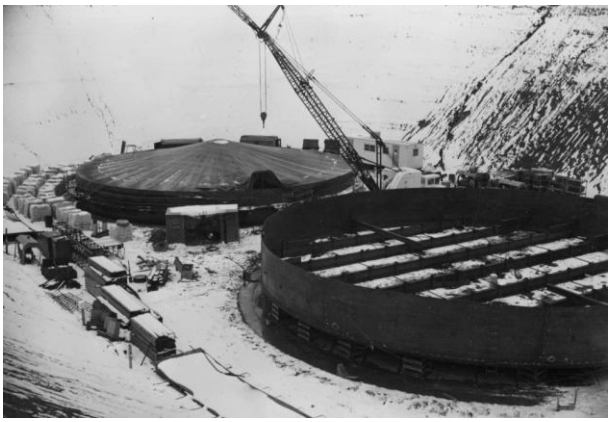


Figure 3-8. Weather Enclosure Installed on Tank AY-102 for Refractory Installation in Photo Background (8100-1-Photo)

Pouring the refractory occurred in 36 sections. Each section was pie-shaped covering 10 degrees of the primary tank bottom, requiring about 80 ft^3 of mixture per pour. Typically, two refractory pours could be accomplished per day, allowing the next day's pour to use the adjacent sections as side forms. A screed, which spanned the radius of the refractory, could rotate in a circular motion originating at the center of the tank. Figure 3-9 shows the first completed section for Tank AY-102 and the configuration of the screed. Figure 3-10 shows the refractory nearing completion for Tank AY-101.

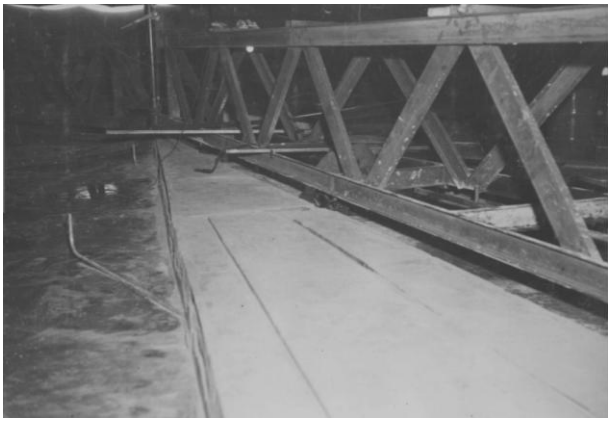


Figure 3-9. First Completed Refractory Section on Tank AY-102 With Screed Located Adjacent (8118-Photo)

3.1.5 Secondary Liner Wall Fabrication – Vertical Concrete Shell – Partial Backfill

After completion of the refractory and curing, the weather enclosure was removed and the secondary liner wall was erected. This allowed the vertical portion of the concrete shell to be poured and a partial backfill to take place.

Figure 3-10. Nearly Completed Refractory on Tank AY-101 With Screed in Background (8124-Photo)

The ¼-in. thick secondary liner wall was welded up to the elevation just below the secondary top knuckle. Due to the curvature of the top knuckle and the requirement for access into the annulus during the primary tank construction, the top knuckle was installed after completion of all welding, inspection, stress relieving, and hydrostatic testing of the primary tank. The secondary liner wall is made up of a four-plate course, including a bottom and top knuckle. Figure 3-11 is a diagram of the fabrication sequence of the secondary liner wall.

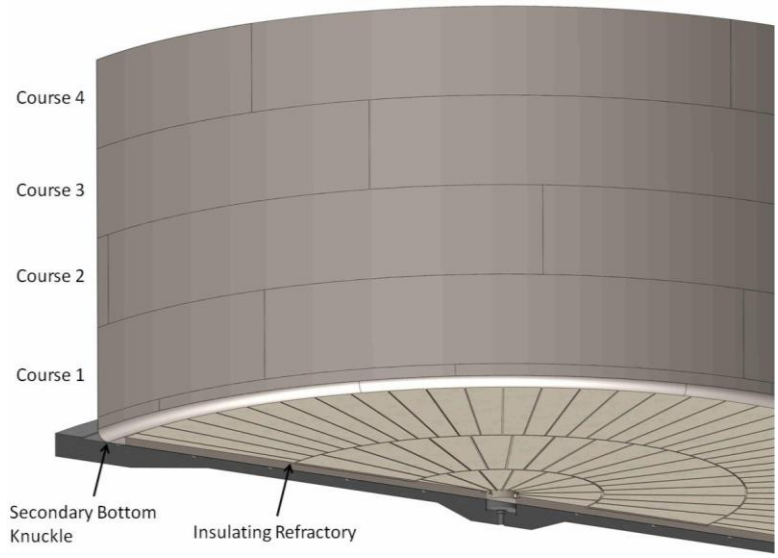


Figure 3-11. Secondary Liner Wall Installation Up to Course 4 to Support Concrete Shell Pours and Backfill

The concrete shell is 83 ft outside diameter at 1½-ft thick, and rests on steel slide plates supported by the tank foundation. The concrete shell was poured directly against the secondary liner (i.e., the secondary liner was used as a casting form for the concrete shell). The vertical portion of the reinforced concrete shell was poured in three courses. Each course was composed of concrete requiring a 28-day compressive strength of 3,000 psi. All three courses were completed prior to allowing backfill to begin. Figure 3-12 shows the third course being installed on Tank AY-102. Figure 3-13 shows the backfilling effort in the AY Farm excavation area.

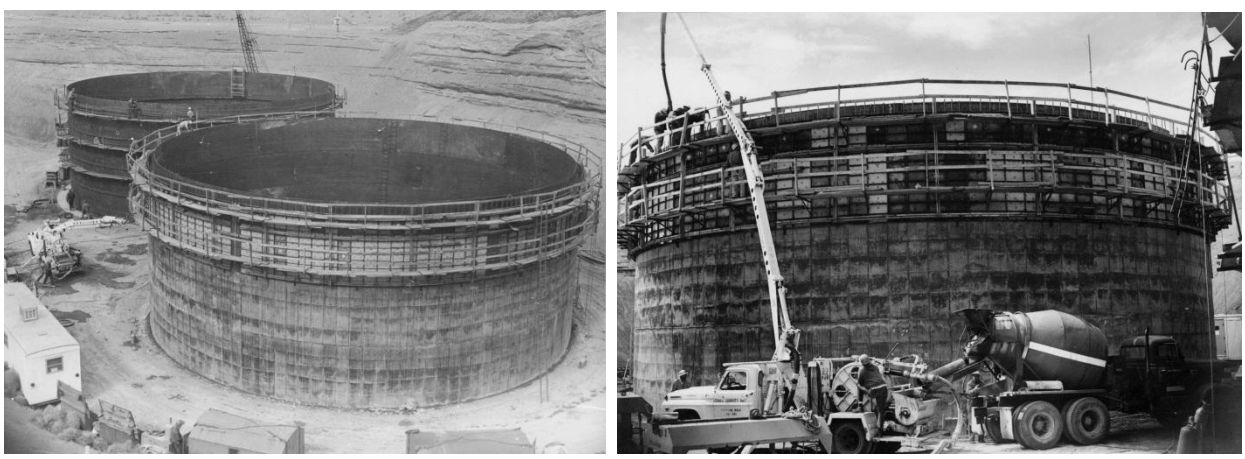


Figure 3-12. Vertical Concrete Shell Pour In Progress on Tank AY-102 (8113-Photo and 8135-Photo)

Figure 3-13. AY Farm Backfill (8159-Photo and 8173-Photo)

3.1.6 Primary Tank Bottom

During the work activities to place the vertical concrete shell sections and backfilling, the placement of the primary tank bottom commenced. Similar to the construction sequence for the secondary liner bottom, a protective cover was placed on the refractory to guard it against damage during fabrication of the primary tank bottom. The tank bottom is composed of primarily ⅜-in. plate, with the exception being a 4-ft diameter, 1-in. thick steel plate located at the center and ⅞-in. thick plate located along the outside of the tank bottom joined to the tank bottom knuckle. A small vertical section of ⅞-in. thick steel plate, referred to as the bottom transition plate, is also joined to the bottom knuckle. Figure 3-14 is a diagram showing the location of the primary tank bottom steel and relative thickness.

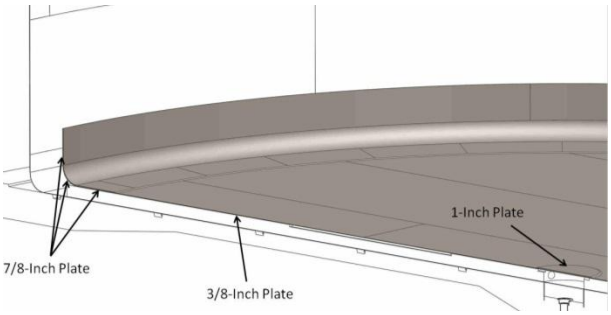


Figure 3-14. Primary Tank Bottom and Knuckle Assembly Thickness and Location

After completing the welds on the top of the primary tank bottom, as done on the secondary liner bottom, the assembly was lifted up and placed on cribbing to allow workers to access the bottom of the plates. Similar lifting techniques were used to limit distortion of the steel plates. Figure 3-15 shows the primary tank bottom being fabricated and the lifting beams in place for raising or lowering the primary tank onto the refractory.

Figure 3-15. Primary Tank Bottom Welding Progress and Lifting Beam Arrangement for Raising/Lowering onto Refractory (8123-Photo and 8172-Photo)

3.1.7 Primary Tank Wall Fabrication - Tank Dome Shoring - Tank Dome Fabrication

The primary tanks, although never certified to the *ASME Boiler and Pressure Vessel Code* (ASME Code), were designed using the general criteria of the ASME Code, Section VIII, Division 2 (1965), and fabricated and constructed using American Society for Testing and Materials (ASTM) A515, Grade 60 carbon steel. The primary tank measures 75 ft in diameter to the inside of the vertical plate.

While the vertical wall of the secondary liner is all ¼-in. thick steel, the primary tank plate thickness begins at a thickness of ⅞-in. and decreases as the elevation increases. Above the bottom knuckle and bottom transition plate, there are three courses of plates that make up the majority of the primary tank wall. The first of these courses is ¾-in. thick. The next two courses are ½-in. thick. Above the third course plate is a ⅜-in. thick plate referred to as the top transition plate. This top transition plate is butt welded to a ⅜-in. thick primary top knuckle, which begins the elliptical shape of the steel tank dome. Figure 3-16 shows the installation of the first course of the primary tank in one of the AY Farm tanks. The diagram in Figure 3-17 shows the plate location and relative thickness.

Figure 3-16. Welding of Primary Tank Wall Course 1 to Bottom Transition Plate (8179-Photo)

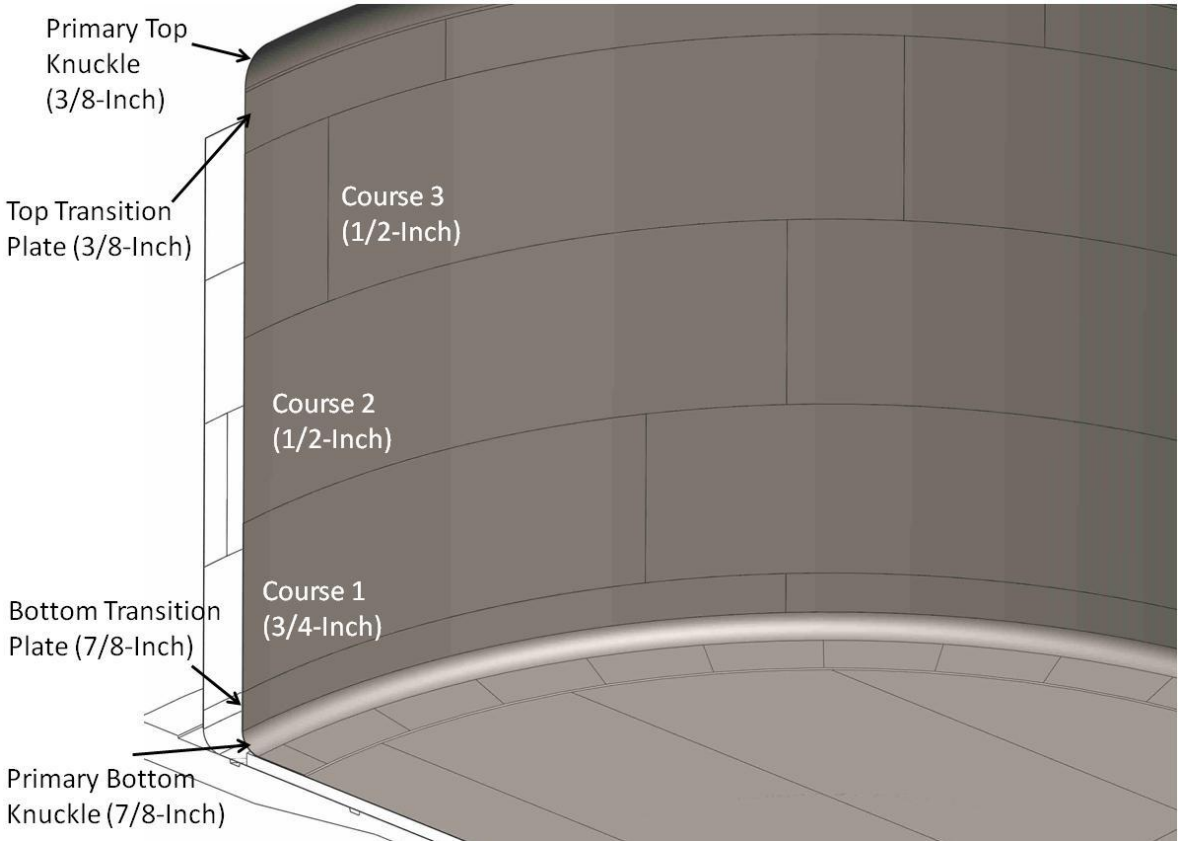


Figure 3-17. Primary Tank Wall Plate Configuration and Thickness

To facilitate the installation of the tank dome plates, temporary shoring and beams of specific curvature were installed into primary tanks. These beams provided a resting place for the tank dome plates for proper fit-up and welding. An elaborate column structure composed of interconnected struts resting on metal grating supported these beams. The metal grating was spaced in accordance with the construction drawings and allowed stress relieving of the primary tank without removal. Figure 3-18 shows the placement of the metal grating footings in the bottom of the primary tank.

Figure 3-18. Installation of Column Footings on Metal Grating Along Primary Tank Bottom to Facilitate Tank Dome Installation (50281-5-Photo and 50281-17-Photo)

After the footings were placed on the primary tank bottom, the support column structures were lifted and set in place. Figure 3-19 provides a photographic timeline of the column support installation and dome plate installation. Figure 3-19A shows the primary tank wall plates erected up to the primary tank knuckle, as shown in Figure 3-17. The column support structures are present in the foreground of the image prior to placement into the primary tank. Figure 3-19B shows the column supports installed into the primary tank and the curved beams used to support the dome plates in the image foreground. Figure 3-19C highlights the dome plate installation around the circumference of the primary tank. Figure 3-19D provides a view of the support structure as seen from the inside of the tank standing on the primary tank bottom looking up towards the dome. Note the extensive amount of lumber used to allow workers to access the dome plates. The column supports were not used in subsequent DST construction projects.

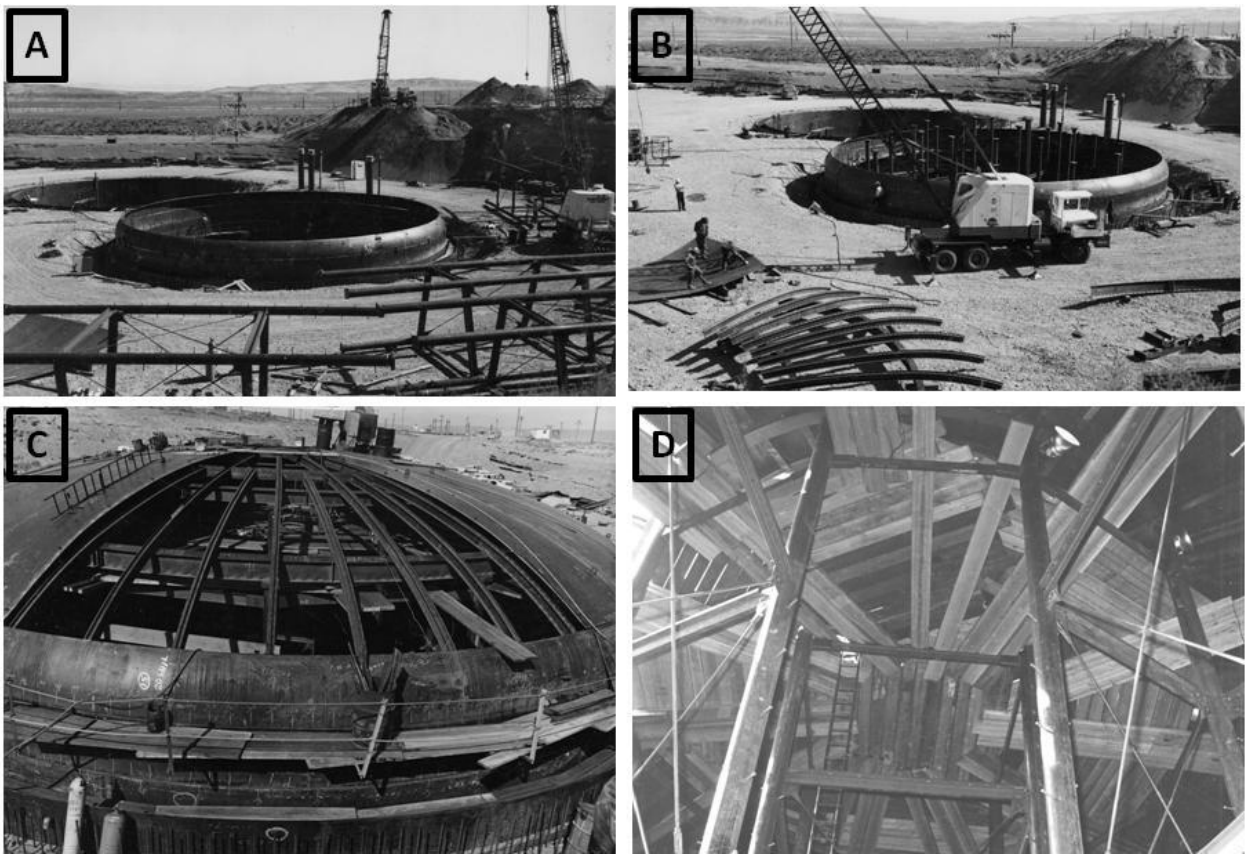


Figure 3-19. Tank Prior to Installation of Tank Dome Fabrication Support Structure (A) (50281-18-Photo), Dome Fabrication Support Columns Installed (B) (50350-1-Photo), Dome Plate Assembly (C) (50725-19-Photo), and Column Support Structure During Dome Assembly (D) (50725-24-Photo)

At the center of the tank dome is a ½-in. thick steel plate referred to as the roof saucer. The roof saucer is 12 ft in diameter and is curved to match the dome plates. The remaining dome plates are ⅜-in. thick steel spanning the distance from the primary top knuckle to the roof saucer. In most cases, the dome plates were welded into subassemblies prior to installation on the tank dome. These subassemblies included two or three dome plates.

Figure 3-20A shows the welding of the dome plate subassemblies during the AY Farm construction. Figure 3-20B shows the welding of dome plate subassemblies during SY Farm construction.

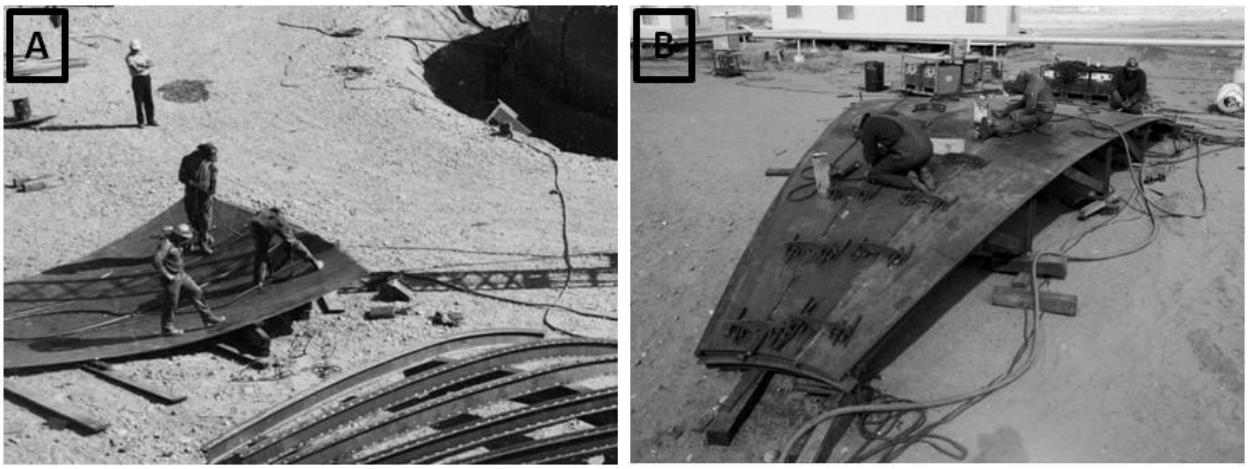


Figure 3-20. Tank Dome Plate Subassembly Fabrication for AY Farm (A) and SY Farm (B)

After installation of the dome plates, the necessary riser penetration holes were cut and pipe was welded to the tank dome plates, serving as the access points into the tank for the remainder of construction and during tank operation. Each AY Farm tank contains a total of 126 penetrations to support the installation of permanent equipment (e.g., airlift circulators, thermocouples, dry wells, ventilation inlet/outlet) and temporary equipment (e.g., pumps, liquid level measurement devices, etc.).

3.1.8 Nondestructive Examination

Throughout the construction of the primary tank and the secondary liner, nondestructive examination (NDE) was required. The level of NDE varied between the primary tank and secondary liner, and the elevation of the tank. The change in NDE based on elevation was based on the planned use of the tank to contain waste up to a specific elevation. Table 3-1 provides a summary of the NDE used to ensure the pedigree of the primary tank and secondary liner. Further information on the NDE used can be found in the construction specification for the tank, HWS-7789, *Specification for Primary and Secondary Steel Tanks PUREX Tank Farm Expansion Project IAP-614*.

Table 3-1. Tank AY-102 Nondestructive Examinations Used During Construction

	Primary Tank Inspections	Secondary Liner Inspections
Tank bottom	• 100% radiography • Magnetic particle • 100% visual • Vacuum leak test • Hydrostatic leak test	• 100% radiography • Magnetic particle • 100% visual • Vacuum leak test
Bottom knuckle	• 100% radiography • Magnetic particle • 100% visual • Vacuum leak test • Hydrostatic leak test	• 100% radiography • Magnetic particle • 100% visual • Vacuum leak test
Vertical wall	• 100% radiography • Magnetic particle • 100% visual • Hydrostatic leak test	• Random spot radiography • Magnetic particle • 100% visual

3.1.9 Primary Tank Stress Relieving

After completing the tank dome fabrication, the tanks were ready for post-weld stress relieving. The lumber used by workers on the dome support structure (see Figure 3-19D) was removed; however, the steel portions of the dome support structure remained during stress relieving. To protect the surrounding concrete shell, temporary insulation was installed into the annulus (Figure 3-21). The refractory underneath the primary tank protected the concrete foundation. In addition to the tank annulus, the tank dome and riser penetrations were insulated to prevent heat loss during the stress relieving process. The applicable requirements for stress relieving the primary tank are from the ASME Code, Section VIII (1965 edition). This code specified a temperature hold time of 1,000°F for 3 hr/in. of thickness. In the case of the AY Farm tanks, the center section of the primary tank bottom contains a 1-in. plate requiring a 3-hr hold time. Propane burners were installed on the tank dome to force heat into the tanks. Installed thermocouples and strain gauges were used to track the progress of the tank stress relieving.

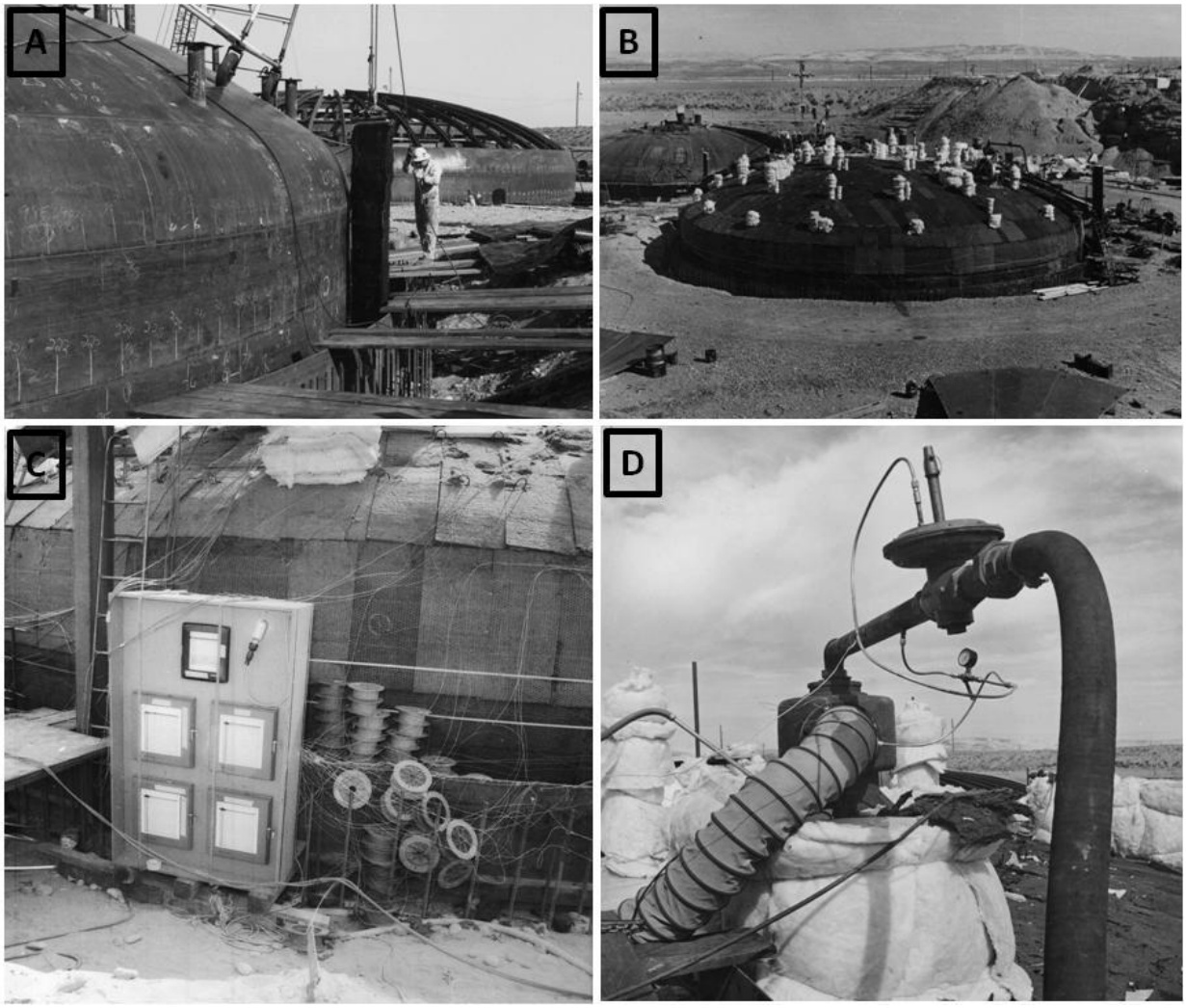


Figure 3-21. Insulation Being Installed Into Annulus for Stress Relieving (A) (50618-3-Photo), Tank AY-102 Completely Insulated (B) (50725-18-Photo), Thermocouple Strip Charts and Thermcouple Wiring (C) (50725-22), Propane Burner Installed in AY-102 Riser Penetration (D) (50725-20-Photo)

Figure 3-21A and Figure 3-21B show the tank fabricator installing the temporary insulation in the tank annulus and Tank AY-102 completely insulated awaiting stress relieving, respectively. Figure 3-21C shows the thermocouple data strip charts used during the stress relieving of the tank, and Figure 3-21D shows the propane burner installed on Tank AY-102.

3.1.10 Primary Tank Hydrostatic Test

After completion of the tank stress relieving, all of the equipment supporting that evolution including the temporary insulation was removed. The tank was then filled with approximately 1.3 Mgal of water equating to a liquid level of 39 ft from the primary tank bottom. This required the side fill lines in the primary tank to be temporarily blanked to allow for the increased liquid level. All of the visible welds were chalked and verified to be leak-tight. Welds on the primary tank bottom, which could not be visibly seen, were vacuum tested during fabrication to ensure the leak tightness.

3.1.11 Complete Secondary Liner Wall and Tank Penetrations

Once the hydrostatic test was completed, the need for access into all portions of the annulus was limited. The secondary top knuckle was installed and welded to the secondary liner vertical wall section. The secondary top knuckle is not welded to the primary tank. By design, a ½-in. gap exists between the primary tank dome and termination of the secondary liner. This gap was maintained by the use of temporary ½-in. thick copper back-up bars, which were wedged between primary and secondary top knuckles during welding. To prevent the collection of debris or concrete during the remaining construction, flashing was installed over the outside of the secondary top knuckle by tack welding to the outside of the primary tank. Figure 3-22A shows the installation of the secondary top knuckle, completing the secondary liner wall, during SY Farm construction, which was similar to AY Farm construction. Figure 3-22B is the fabrication detail used for the AY Farm construction (additional information is provided in H-2-64449, Detail 9).

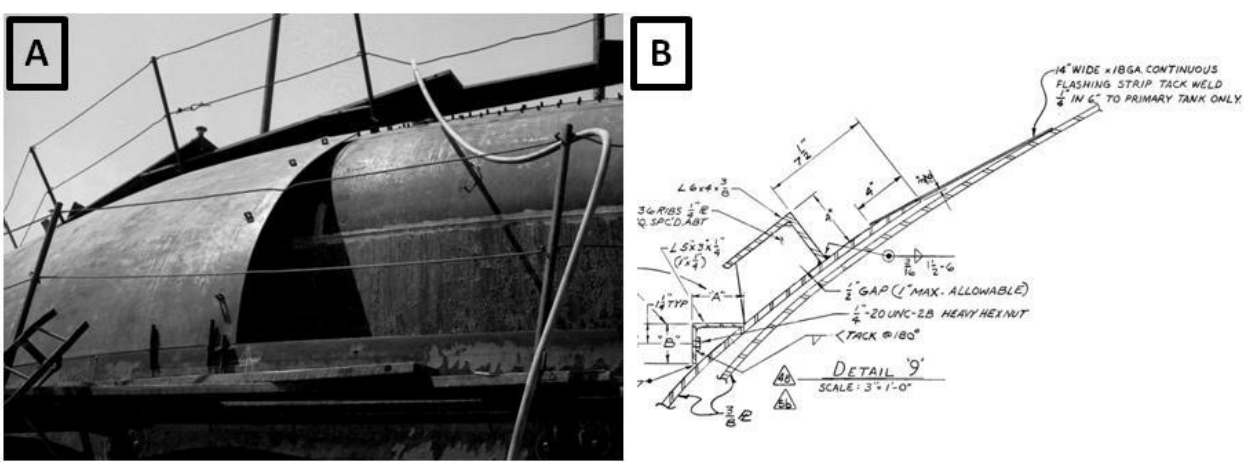


Figure 3-22. Installation of Secondary Top Knuckle During SY Farm Construction (A), Fabrication Detail Used for AY Farm Construction

3.1.12 Place Concrete over Tank Dome – Remove Tank Dome Shoring

An extensive reinforcing steel (rebar) system was installed around the tank, with a significant amount of rebar placed in the tank haunch. The tank haunch is the transition between the vertical concrete shell and the tank dome. The rebar placement can be seen on drawing H-2-64310. Each of the riser penetrations had concrete anchors installed in addition to the anchors (J-bolts) placed on the tank dome to engage with the surrounding concrete shell. Figure 3-23 shows the tank fabricator installing rebar. The J-bolts can also be seen along the tank dome.

Figure 3-23. Tank Fabricator Installing Reinforcing Steel (51084-1-Photo)

Prior to the installation of the concrete over the tank dome, additional measures were taken to ensure proper weight distribution occurred on the primary tank bottom. The existing metal grating used during the dome fabrication and stress relieving, which acted as the base of the some support columns, was replaced with wood using a larger footing.

The concrete required a 3,000 psi, 28-day compressive strength. The concrete dome was poured in two sections, with the first section including the remainder of the vertical shell and the tank haunch. The second section started at a keyed construction joint, approximately 33 ft from the tank center, composed the remainder of the tank dome. During the concrete pours and curing, the tank fabricators pressurized the primary tank to approximately 0.6 psig to add to the dome support structure capacity used to withstand the bearing load of the concrete. This was done to address the concern of placing stresses onto the tank knuckle after tank stress relieving. Figure 3-24 shows Tank AY-102 after the completion of the tank dome concrete pours.

Figure 3-24. Tank AY-102 After Completion of Tank Dome Concrete Pours (51305-14-Photo)

3.1.13 Tank Appurtenances Installation

After completing the concrete pours, the tank dome support structures were disassembled and removed in pieces through the existing 42-in. diameter riser penetrations. The equipment to be placed on the interior of the tank was then installed, including the tank airlift circulators, thermocouples, steam coil, dry wells, and annulus pump pit and leak detection pump pit drains. These pieces of equipment were welded to the existing penetrations that had previously been installed on the tank dome prior to the tank stress relief. Figure 3-25 shows the in-tank equipment installation in Tank AY-102.

Figure 3-25. In-Tank Equipment Installation in Tank AY-102 (51660-15)

3.2 CONSTRUCTION ISSUES

This section provides a detailed view of the construction issues identified during the fabrication of Tank AY-102. This information has been compiled from a review of the QA daily logbooks, inspection sheets, memos, drawings, photos, construction records, and post-construction reports. The focus of this review was the secondary and primary tank bottom fabrication/testing, and the refractory. These fabrication elements were identified as potential failure points during the leak investigation.

3.2.1 Secondary Liner Bottom Construction

Assembly of the secondary liner bottom, including the lower knuckles, began after the completion of pouring the concrete foundation pad. Figure 3-26 shows the welding of the Tank AY-102 secondary liner bottom and knuckle assemblies.

Figure 3-26. Welding of Tank AY-102 Secondary Liner Bottom (8051-1-Photo)

The secondary bottom knuckle assemblies were fabricated offsite in Provo, Utah. Excessive distortion was experienced in the flat sections of the plates during the fabrication of the ¼-in. lower knuckle plates for secondary liners of both Tanks AY-101 and AY-102. Complete avoidance of thermally caused distortion is nearly impossible in butt-welded steel plate as thin as ¼ in. The degree of distortion was noted to be directly proportional to the number and magnitude of weld repairs.

In a few cases, attempts were made to flatten the distorted areas in a hydraulic press, but an “oil-can” effect was the only result and no measureable success was achieved. It was therefore decided to stress-relieve the repaired plates and then make another attempt to straighten them in the hydraulic press. However, there was no significant improvement, except that in some areas a little straightening was possible. It was decided to ship the plates to the worksite, complete all welding, and then employ carefully regulated flame-shrinking to aid in meeting flatness tolerances (Cardwell 1968). Figure 3-27 provides an example of a warped secondary liner bottom knuckle.

Figure 3-27. Example of Warped Secondary Liner Bottom Knuckle (8074-Photo)

In addition to the convex-concave irregularities, it was also noted that in some areas of repaired welds, the width of the weld had increased from the original nominal ½ in. to a dimension of 1¾ in. wide. For ¼-in. plate, this width was considered completely unnecessary by QA personnel; however, in spite of the undesirable width, the quality of the welds was within acceptable limits.

The joining of these plates at Hanford took place during the winter months. One welding issue occurred on December 30, 1968. With ambient temperatures of -20°F, crews began to preheat the ¼-in. thick knuckle plates and floor plates prior to attempting to weld. The preheating caused the material to start buckling and the foreman stopped the work (QA logbook December 30, 1968). Plate warpage and flatness issues continue to be an ongoing concern for Tank AY-102.

After welding was completed on the secondary bottom, crews were dedicated to working out the wrinkles on the floor. The primary method that appeared to have been used was “by shrinkage of metal with torch heating and fast quench with water” (QA logbook February 11, 1969). This practice had been previously discussed, as documented in a 1967 trip report (Hatch 1967). In those discussions, the Savannah River Plant (SRP) also mentioned that in certain cases at SRP, tank bottoms were not able to meet their flatness requirements. When SRP crews would flatten out the bulged region, the bulge would move to another location.

To examine the tank liner flatness, a transit was set up in the center of Tank AY-102 on February 7, 1969, and 56 elevations were read at various high and low areas of the tank bottom. Of the 33 shots of the bottom plates, five were near the 2-in. maximum convexity. Of the 23 on the knuckles, 12 were between 2 in. and 3 in., with one slightly more than 3 in. At the time of measurement, the temperature was 20°F (QA logbook February 7, 1969).

Work to reduce tank bottom convexities via flame-shrinking showed some success (QA logbook February 11, 1969); however, it was later found that the bright sunshine would heat the entire tank bottom and cause more distortion (QA logbook February 13, 1969). Further discussion was documented in the February 14, 1969 QA logbook entry noting the effect of ambient temperatures on the secondary liner bottom:

> *Tank 102 – One man worked at flame shrinking most of the day with debatable success. It is my opinion that PDM does not have in their employ on site, anyone of sufficient experience and skill to achieve the desired results. However, a measure of success was achieved in spite of the movement of the bottom in response to ambient temperature changes. It seems that a temperature increase of 10 degrees results in either additional distortions, or an increase in the magnitude of existing distorting. A return to the original lower temperature does not eliminate the increase of distortion experienced by the temperature rise* (QA logbook February 14, 1969).

Observations of the same movement of the secondary liner bottom were noted on February 14, 1969, by a second QA inspector stating:

> *Temperature changes during day causes air piping to raise and lower with the varying distortions of the tank bottom. Configuration of the tank bottom appears to be constantly changing and can be noted from day to day. After one week of shrinking metal to dissipate distortions, unacceptable distortions still remain in bottom* (QA logbook February 14, 1969).

Solutions to continue with the project with tank flatness issues present in the tank bottom plates were documented in "AY Tanks IAP-614" (Schulze 1969a). The letter documented verbal agreements reached on February 13, 1969, and made multiple changes to what was originally allowed in the construction specification. These included:

1. The slope of "bubbles" or ripples in tank bottom may be 1 in. per foot rather than ⅜ in./ft per specification HWS-7789, Section 14.3.
2. It will be acceptable to install flat bar stiffeners on top of the secondary liner bottom, as necessary, to constrain "bubbles" and prevent cracking or depressions in Kaolite as may be caused by deflection of "bubbles" or ripples. The height of Kaolite over flat bar shall be 5 in. minimum.

Note that the change in slope from ⅜ in./ft to 1 in./ft was not incorporated into construction specifications of the DST farms built after AY Farm. For the secondary liner, the main issue with tank bottom bulges is that they compress under the weight of a filled primary tank. The refractory then cracks due to its lack of strength in shear. For the primary tank, the main issue with tank bottom bubbles is the presence of tensile or compressive stresses along the wetted surface, a condition thought to be a related cause of stress corrosion.

In 1976, a study was performed to address the necessary tolerances for the tank bottoms of DSTs and to provide a rationale for these acceptable limits. SAM-76-1, *Recommended Bottom Flatness Tolerances for Million Gallon Waste Storage Tanks*, identifies that values limiting deflection and slope are necessary, but that additional constraints on root and crown radii should be enforced (see Figure 3-28). These curvatures, if sufficiently tight, can cause excessive bending stresses as the bump is flattened by hydrostatic loading. The effect is amplified if the bump is located near the bottom knuckle. The generation of this report was due to the presence of a tank bulge in SY Farm construction, specifically in Tank SY-103 (see Figure 3-29). Construction specifications for all DSTs after SY Farm construction used the constraints identified in SAM-76-1.

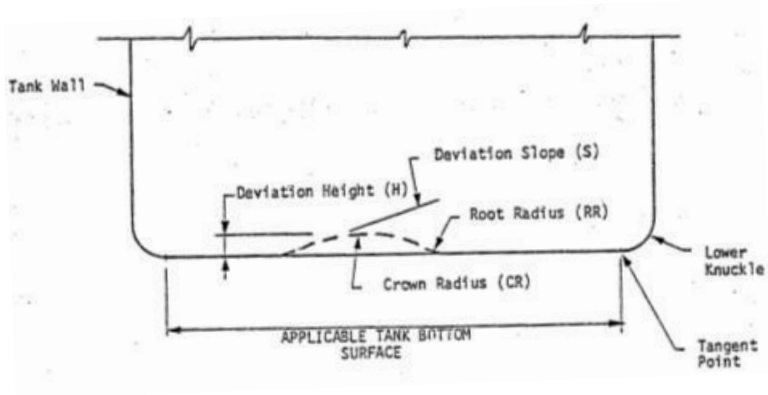


Figure 3-28. Tank Bottom Flatness Variables

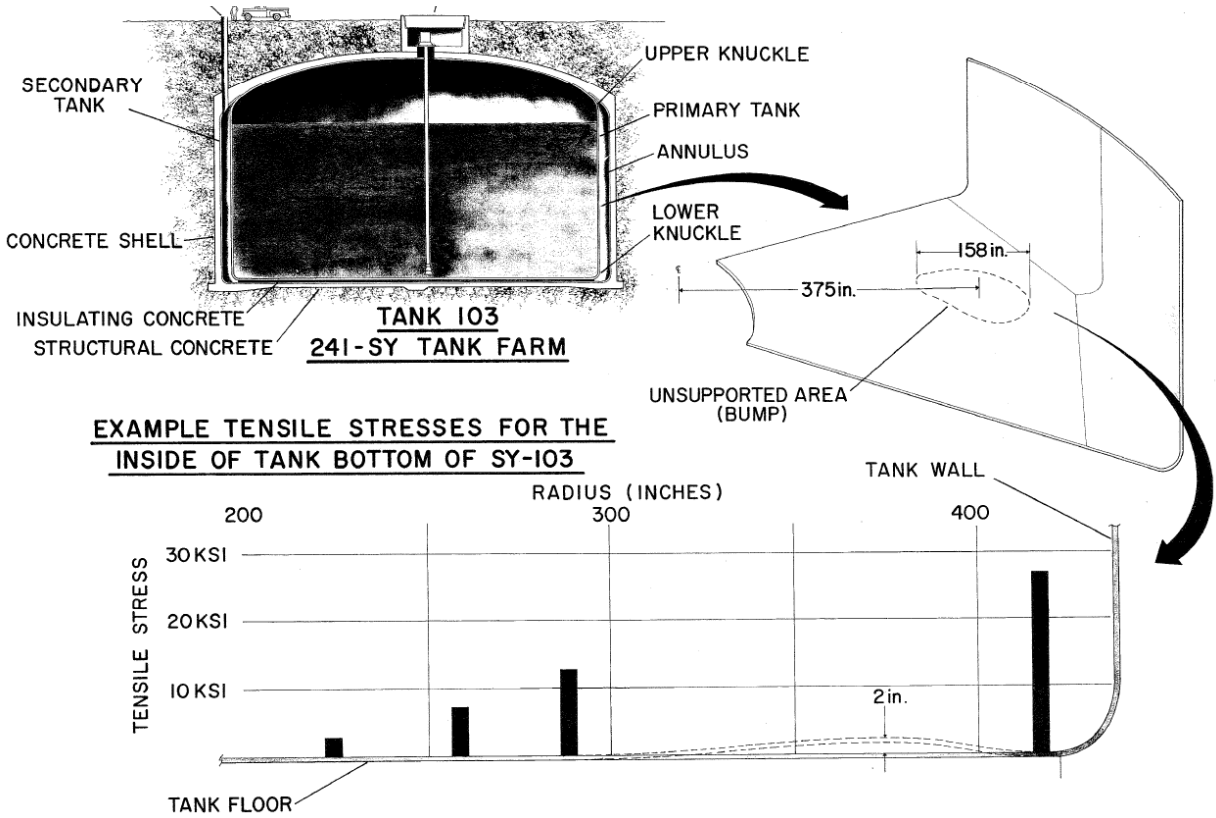


Figure 3-29. Tank SY-103 Primary Tank Flatness Stress Example

The existence of flatness issues with the secondary liner bottom would again be disclosed in "Subject IAP-614 PUREX Tank Farm Expansion – Insulating Concrete" (Schulze 1969b). This letter provides direction for the pouring sequence of the refractory to "minimize the possibility of raised portions of the steel bottoms being moved into unpoured sectors thus compounding the amount of distortion which might be present."

Field crews returned to Tank AY-102 on February 19, 1969, to resurvey the secondary liner bottom. The results identified 22 places that exceeded the 2-in. peak-to-valley tolerances, none that exceeded the 3-in. tolerance, and slopes approaching 1 in./ft in several locations. These conditions were accepted, completing work on the secondary liner bottom. In comparison, survey results of the Tank AY-101 secondary liner bottom found six places that exceeded the 2-in. peak-to-valley tolerances, one place that had a peak-to-valley tolerance of 3 in., and some slopes exceeding ⅜ in./ft. These conditions were accepted.

The movement of the plates affected performance of the pouring of the nominally 8-in. thick refractory (Kaolite) that separates the primary and secondary liner bottoms. On March 2, 1969, it was noted "that movement of peaks and valleys in ¼-in. plate is occurring" (QA logbook March 2, 1969). This movement was identified as the cause of premature cracking of the refractory after pours were complete. The log entry on March 5, 1969, notes that "the tank bottom moved downward causing approximately ⅛-in. crack to appear under portion of Section 21" (QA logbook March 5, 1969).

Differences in craftsmanship between Tanks AY-101 and AY-102 are indicated in the QA logbook (February 14, 1969), noting the condition of the welds on the secondary liner bottom of Tank AY-101:

> *Tank 101 - Scarfing of all the weld joints on the lower side of the bottom continued throughout the forenoon, and was completed in the early afternoon. I crawled under the tank in the afternoon and inspected the arc-gauged joints, both before and after grinding, and found them to be in excellent condition. The completed welding had not been brushed yet, but it appears to be of superior quality to the welding on Tank 102.*

3.2.2 Refractory Construction

The purpose of the refractory is to protect the concrete foundation from high temperatures during post-weld heat treatment. Prior to pouring of the refractory, the issues associated with the installation on the warped secondary liner bottom had to be addressed. The tank liner bottom was out of tolerance with respect to peak-to-valley and slope requirements, as discussed in Section 3.2.1, and posed issues with meeting the 8-in. thickness requirement listed in the design (Section 3.3 describes refractory material characteristics).

The path forward was based on the known high points (approximately 3 in.) on the secondary liner bottom, and the minimum thickness that could be tolerated to perform the tank stress relieving. This path forward was documented in "PUREX Tank Farm Expansion IAP-614 Minimum Thickness Insulating Concrete" (Graves 1969a).

> *Confirming discussions with A. Short and E.S. Davis, five inches of Kaolite insulating concrete is sufficient to protect the base concrete during stress-relieving of the primary tank. This judgment is based upon the Battelle report BNWL-797, detail requirements on the similar project at Savannah River, tests run by Nooter in Saint Louis for the Savannah River project, and Vitro calculations.*
>
> *It was with this information in mind that a "humped" bottom 3-in. in height could be accepted since this still left 5 in. of insulating available. The condition at the air inlet pipes requires a minimum thickness as shown, but in this limited area the steel plate of the secondary tank will spread the heat flow and thus lessen the intensity to a satisfactory level.*

As previously noted, decisions to continue with the project with tank flatness issues present in the tank bottom plates were documented in Schulze (1969a). The letter documented verbal agreements reached on February 13, 1969, and made multiple changes to what was originally allowed in the construction specification, which included:

1. *The Kaolite thickness will be governed by the cross-section, as shown on drawing H-2-64307, "Structural Insulating Concrete Plan and Details." Thus, the minimum thickness of Kaolite over any area in the tank bottom will be 5 in.*

The installation of the refractory was discussed with the contractor. Highlights of the meeting are documented in Cardwell (1969a), stating that:

1. *The shell bottom is out-of-tolerance with respect to peak-to-valley and slope requirements in several places. The out-of-tolerance conditions are acceptable provided the contractor assumes responsibility for the changes in elevation of the primary tank caused by these conditions.*
2. *Placing of Kaolite is to begin at the greatest out-of-tolerance location of the secondary shell.*
3. *Any visual cracks, fractures in or damages to the Kaolite will be repaired as recommended by the Kaolite manufacturer.*

Prior to the refractory pours, the refractory stiffener ring was installed, which was to act as a form for the subsequent refractory pours. This stiffener ring was modified later in construction due to weld breaks that occurred during stress relief, which is discussed in ensuing sections. The stiffener ring was installed to fit the secondary liner bottom "high spots" (HES QA Report 1969).

The stiffener ring was 6½ in. in height. If it was installed at the high spots (bumps) of the outer portions of the secondary liner bottom, the ring would have indicated where the refractory thickness exceeds 8 in. in regions without secondary liner bottom bulges. Figure 3-30 is a section view of the original construction configuration of the refractory and stiffener ring. The stiffener ring is also shown in Figure 3-31.

The installation of the refractory began on February 25, 1969, per the Tank AY-102 Kaolite insulation pour schedule (HES QA Report 1969).

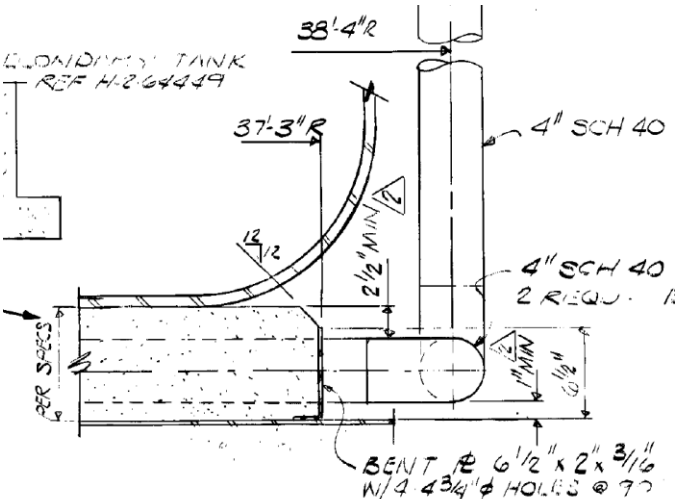


Figure 3-30. Construction Section View of Refractory and Stiffener Ring Position

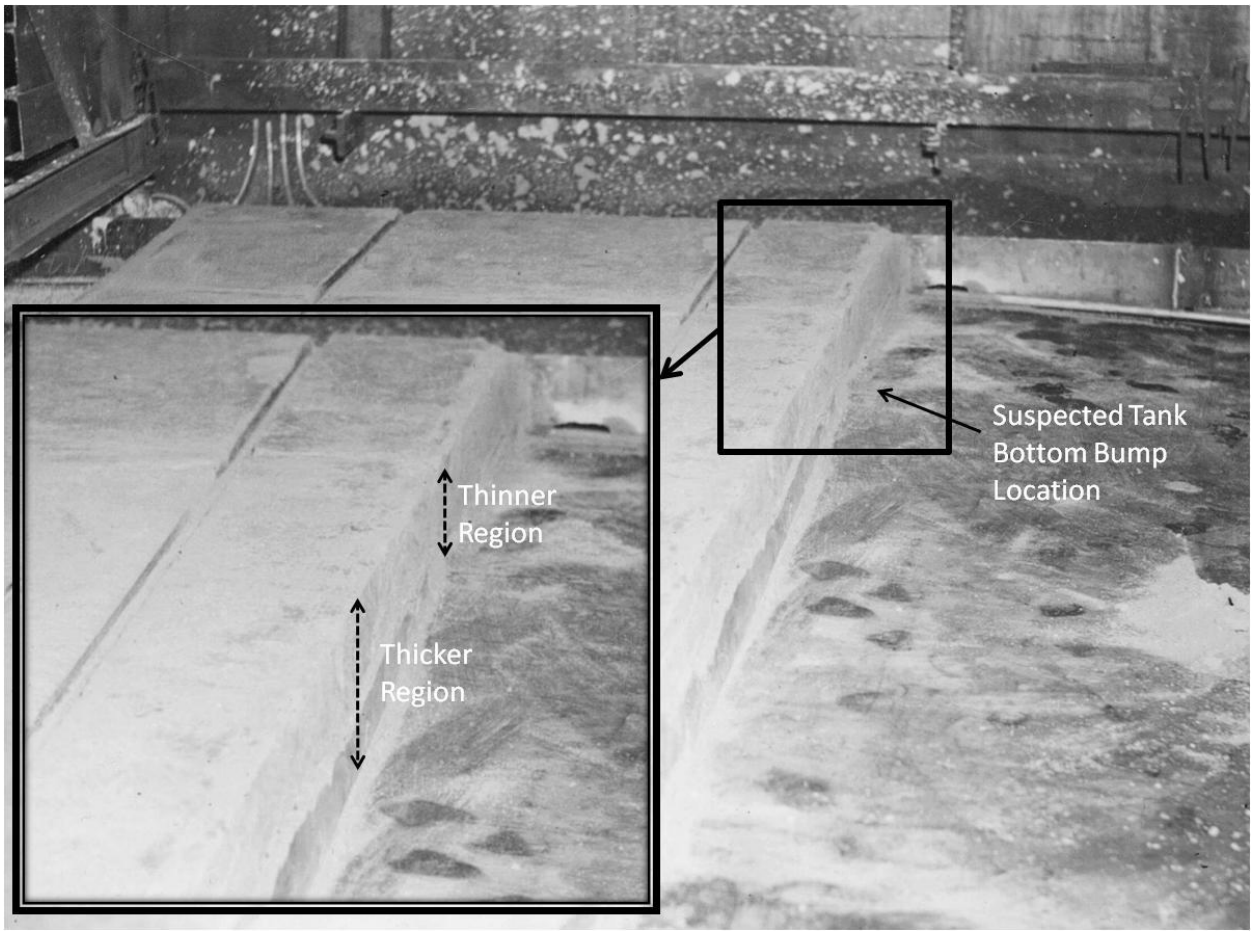


Figure 3-31. Refractory Pour in Tank AY-102 Showing Evidence of Tank Bottom Bulge (8119-Photo)

Placement of the Kaolite was required to begin at the greatest out-of-tolerance location of the secondary liner. This starting location coincided with a pour in the southeast quadrant of the tank. A photograph taken on February 25, 1969, inside of the weather enclosure of Tank AY-102 after the pour of the first refractory section in the southeast quadrant of the tank, indicates a decrease in thickness towards the section of the refractory closest to the secondary knuckle. This reduction in thickness is consistent with the substantial warpage issues in the flat sections of the knuckle assemblies, as discussed in Section 3.2.1. Figure 3-31 shows the first refractory pour performed on Tank AY-102 and the variation in thickness.

The refractory in Tank AY-102 was completed in late March 1969, with QA checks performed to ensure that a minimum thickness of 5 in. was achieved. The HES QA Report (1969) documents that a minimum of 7 in. was achieved. It was known that Tank AY-102 had at least one 3-in. bulge, as discussed in Section 3.2.1. If a minimum thickness of 7 in. was used to ensure that the minimum requirements were met and prevent rework of the refractory, then this combination equated to a thickness of 10 in. in regions where no secondary liner bottom plate bulges existed.

This height was confirmed by a design change to the primary tank bottom to account for this increased height. Design Change 2124-17, dated April 7, 1969, revised the cleat detail on drawing H-2-64449, Section A-A (Cardwell 1969b). The reason for the change was documented as:

> *The difference in elevation between the secondary and primary tank bottoms is increased approximately two inches because of variations in the level of the secondary tank bottoms. This, in turn, raises the cleats within the container ring (see Dwg. H-2-64449, Detail 6), causing the 3 in.-high cleats to become ineffective.*

The basis for this design change came from Graves (1969b):

> *As discussed previously, the 18 cleats shown in zone C-9 of drawing H-2-64449 should be increased in length to 5 in. to allow for the 2 in. extra thickness of Kaolite as placed, in Tank 102. Maintain present slope and cut at lower side. Please issue field change notice to PDM to cover change resulting from level deviations of secondary tank floor as erected by PDM.*

The tank cleats are designed to help center the primary tank bottom onto the refractory after welding was completed. The underside of the primary tank has 18 cleats welded in a circular pattern positioned to clear the container ring (i.e., air distribution ring), which is welded in the center of the secondary liner. Figure 3-32 shows the orientation represented on drawing H-2-64449 to illustrate the configuration and purpose of the cleats.

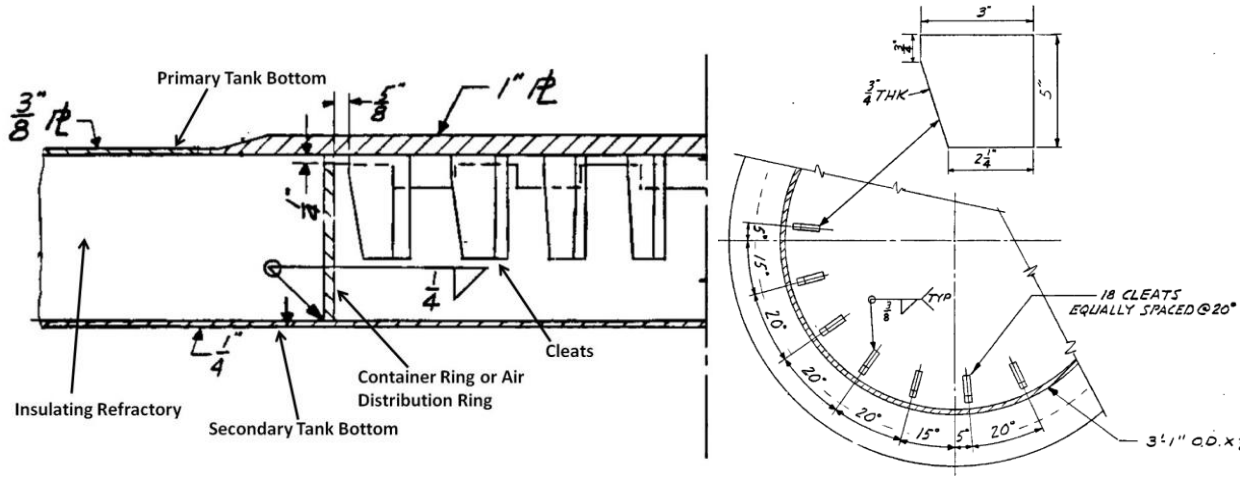


Figure 3-32. Primary Tank Bottom Cleats Engaged in Container Ring

The configuration in Figure 3-32 does not depict the actual condition faced by the tank fabricator due to the increased thickness in the refractory. Insufficient engagement between the cleats and the 7¾-in. tall container ring would have inhibited the fabricator's ability to center the primary tank bottom and prevent any shift during construction. With a refractory thickness of approximately 10 in., the original cleats with a height of 3 in. would have provided an engagement of no more than ¾ in. Figure 3-33A is a diagram of the original design condition. Figure 3-33B illustrates the field condition without revision to the cleats caused by the increased refractory in Tank AY-102. Figure 3-33C shows the actual conditions after the design change to the cleats based on construction records review.

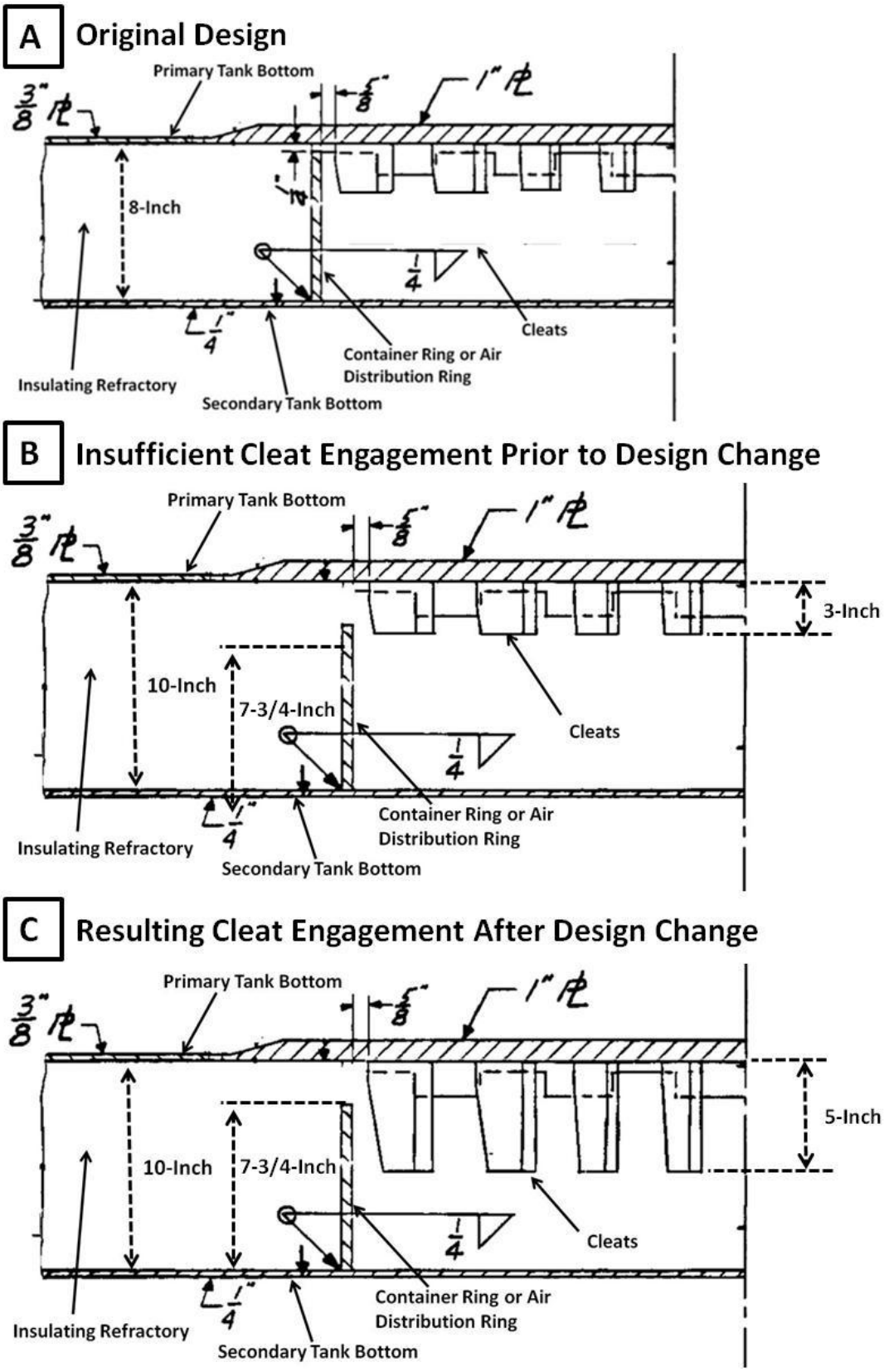


Figure 3-33. Primary Tank Bottom Cleat Design Change Summary

Inspection results of the Tank AY-102 Kaolite after pouring and cure identified surface cracks 1 to 2 in. deep across two sections, totaling approximately 7 ft long. The cracks were dug out and new material was installed. Cracks were thought to have occurred as a result of flexing of the secondary bottom plate beneath the refractory (HES QA Report 1969). A section of completed refractory in Tank AY-102 is shown in Figure 3-34. The refractory of Tank AY-101 nearing completion is shown in Figure 3-35.

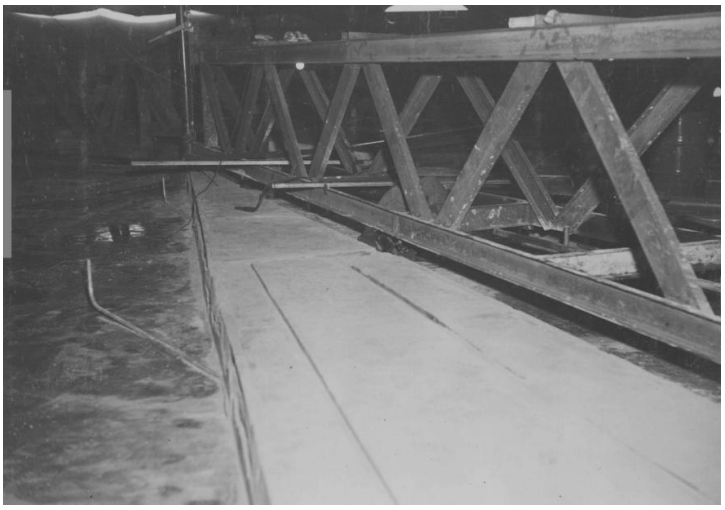


Figure 3-34. Completion of Refractory Section Pour in Tank AY-102 (8118-Photo)

Other issues noted by inspectors after completion of the Tank AY-102 refractory focused on uneven surfaces. It was noted that a 25-ft segment in the southeast corner of the refractory was ¼ to ⅜ in. too high (HES QA Report 1969). A logbook entry on March 10, 1969 documented the finding of 25 points, with variation of 1¼ in. from low to high. The contractor was advised to bring the elevation to within allowable tolerances (±¼ in). By the following day, the contractor had scraped down the high points to bring the surface level to within tolerance (QA logbook March 10, 1969).

Figure 3-35. Placement of Tank AY-101 Refractory Concrete (8124-Photo)

3.2.3 Primary Tank Bottom Construction

The welding performance on the primary tanks for both Tanks AY-101 and AY-102 was a topic of increased discussion throughout construction. In a letter from Davis (1969), the difference in performance between the two tanks is noted:

> *On several occasions we have met on an informal basis with representatives of Pittsburgh-Des Moines, Atomic Energy Commission and Atlantic-Richland, Hanford Company and, through discussion, have attempted to improve the quality of the fabricator's welding program-specifically, to reduce the amount of repairs to welds on the primary tanks. These meetings have not resolved what we feel is the primary problem – the lack of quality control by the fabricator.*

> *Recently, we have increased our inspection coverage of the welding of the 101 tank bottom. Whether or not this detail inspection coverage is the primary cause, the resulting number of weld repairs decreased from a ratio of 51% film repair incident on tank 102 to a ratio of less than 10% film repair incident for tank 101.*

The basis for the 51 percent is unknown based on the review of the documented rejected welds. This value should be approximately 36 percent, as discussed in the subsequent paragraphs of this section. On June 10, 1969, "AY Tank Farm Welding" was issued (Kligfield 1969). This letter reinforces the welding performance issues between the two tanks.

> *In the past few weeks I have met with our Title III People and the contractor (Hugo Stein) to discuss the incidents of repair on the welding of the primary tanks. We were left to believe that once we got into the heavier walls (the primary tank), we would not be experiencing as many rejectable welds as we had previously. The net results of the welding on the bottoms for Tanks 101 and 102 are generally good in terms of flatness but in Tank 102 there was a fit-up problem and one of the seams had to be repaired several times to meet our rigid specifications. The remaining part of the tank bottom was in pretty good condition. There were more weld repairs than I would have liked. In Tank 101 we feel that the welding has been decidedly improved; whether this is a case of more inspection or better welders is a matter of contention. There has been a continuous pro and con on the merits of the automatic, and really today I can't say which is giving us the better results.*

Review of the primary tank bottom weld maps indicate a difference in the success of welding between Tanks AY-102 and AY-101. The weld maps identify a drastically reduced number of required weld repairs needed for the Tank AY-101 primary tank bottom. In the Tank AY-102 tank primary bottom alone, 343 rejectable defects were found via weld radiographs and were repaired (HES QA Report 1969). The HES QA Report also documented some issues by the radiograph interpreter (Conam) identifying weld defects:

> *Of 343 rejectable defects found in this bottom, the Conam radiographer found only 294. The reason appears to be the fluorescent bulb type viewer he uses does not seem to provide sufficient illumination.*

The additional defects were found by the QA inspector during his review, as required by specification HWS-7789. Further detail on this topic was provided in Short (1969). This memorandum documented the visit of the tank fabricator (PDM) Quality Control Supervisor to go over various disputes between the fabricator and inspectors over the interpretation of previously taken radiographs.

> *The remaining radiographs that I reviewed while Nick was present of the eight vertical joints in the ½-inch SR-2 shell course of TK-102 primary, a total of eighty feet of film. In my review I found five areas of unacceptable weld that had been accepted by the Conam radiograph interpreter. Each time I called Nick's attention to the defect and solicited comments from him. He was completely surprised that the Conam interpreter was missing the defects. When he asked what type of radiograph viewer Conam had at the site, I told him that is was a "Campco," using fluorescent bulbs for illumination. He was surprised that a*

> *radiography company would utilize that type of viewer on a job of this kind. Nick promised to contact the Portland supervisor of Conam and insist that he provide a high intensity viewer for this job as expeditiously as possible.*

Based on a review of the primary tank bottom weld maps, a quantitative comparison between the welding success on Tanks AY-101 and AY-102 is shown in Table 3-2. It can be seen that the rejection rate of the Tank AY-102 welds were substantially higher even on repeat attempts to repair the welds. Prior to construction of the two AY Farm tanks, SRP provided insight on welding issues associated with their tank construction (Hatch 1967):

> *Discussion was held on the construction of the current tank and specifically SRP Specification 5098 for both primary and secondary steel liners on Project 981232. Craftsmanship remains the major problem with a reject weld-rate ranging between 10 to 20 percent.*

Weld rejection rates in Tank AY-102 primary tank bottom were in excess of 35 percent compared to the 10 percent on the Tank AY-101 primary tank bottom. If adequate, stress relief takes place to eliminate the residual stresses caused by the original weld and subsequent repairs, this difference does not equate to an inferior product. Even with the additional weld repairs, QA reports and daily logs did not note significant tank bottom warpage of the primary tank bottom in either Tanks AY-101 or AY-102. This improvement may be attributed to the warmer temperatures during welding versus temperatures during secondary liner bottom welding and the use of thicker steel plate in the primary tank.

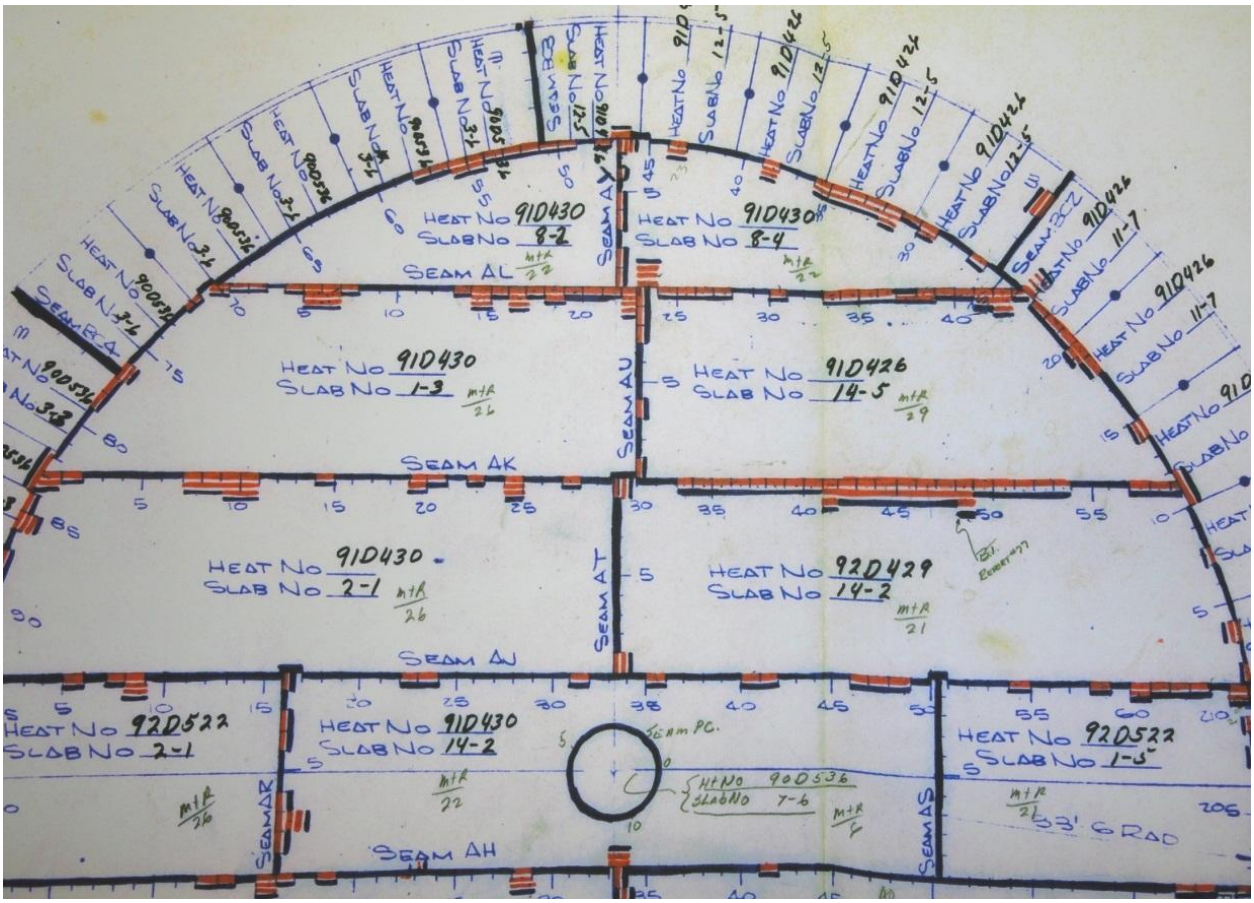
Table 3-2. AY Farm Primary Tank Bottom Weld Comparison

	Tank AY-101		Tank AY-102	
	Feet of Weld (ft)	Rejection Rate (%)	Feet of Weld (ft)	Rejection Rate (%)
Weld prior inspection	661	N/A	661	N/A
Weld rejected after original weld	66	10%	235	36%
Weld rejected after first repair	6	9%	80	34%
Weld rejected after second repair	1	17%	27	34%
Weld rejected after third repair	1	100%[a]	1	4%
Weld rejected after fourth repair	0	N/A	0	N/A
Total weld rejections	**74**		**343**	
Total weld	**735**		**1,004**	
Overall weld rejection rate	**10%**		**34%**	

[a] The weld requiring a third round of repair was the only weld on the Tank AY-101 tank bottom, thus equating to a 100% rejection rate.

N/A = not applicable.

As an illustration of the primary tank bottom welding issues, the weld map from the northern section of the AY-102 tank bottom is shown in Figure 3-36.



Red – Weld not passed due to defects, repair required. Multiple red lines indicate the number of times the repair was not accepted.
Blue – Weld passed.

Figure 3-36. Tank AY-102 Primary Tank Bottom Weld Map

Figure 3-37 and Figure 3-38 provide a qualitative comparison of the Tank AY-101 and AY-102 primary tank bottom and knuckle weld seams and the extent of required repairs.

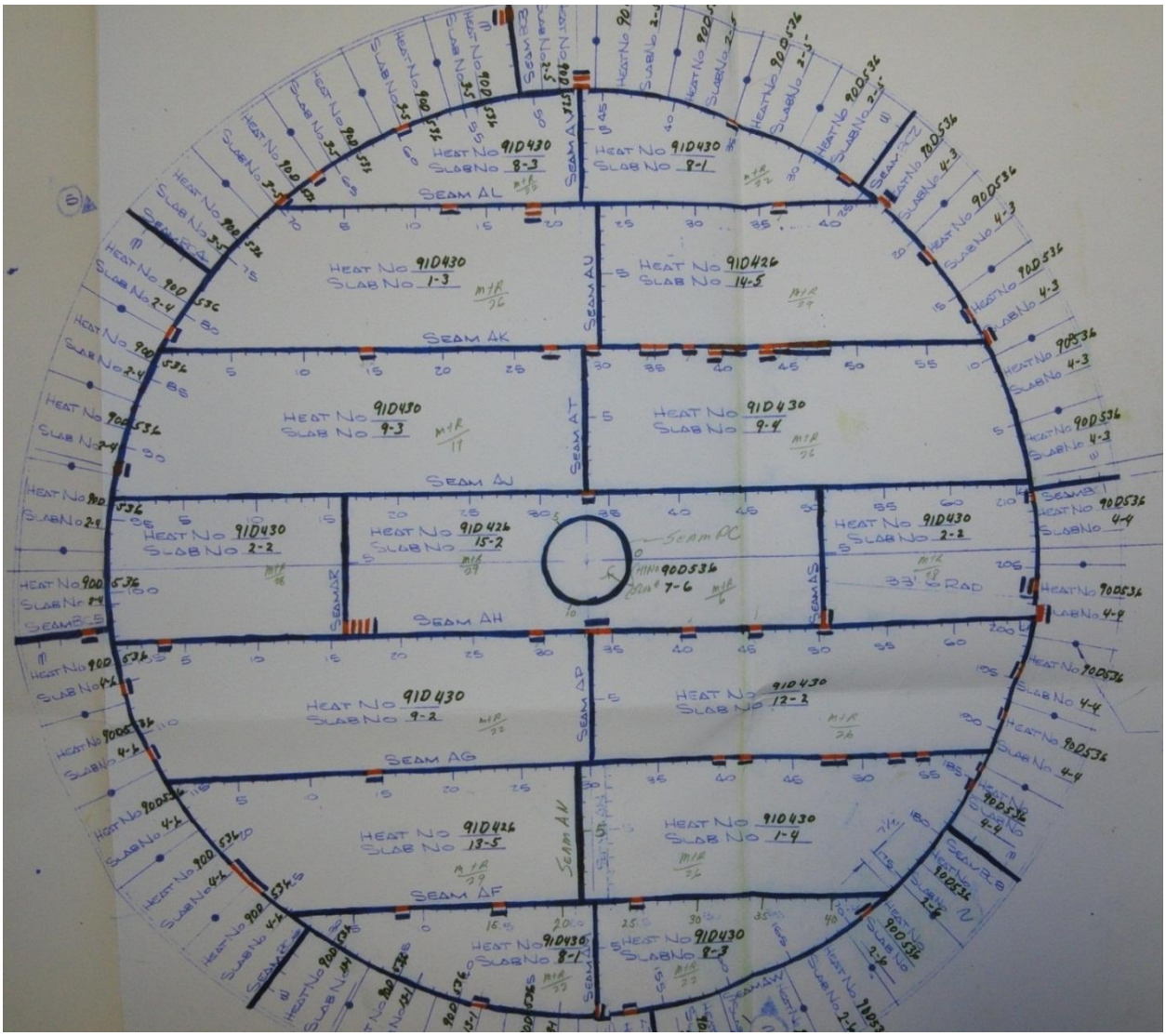


Figure 3-37. Tank AY-101 Primary Tank Bottom Weld Map

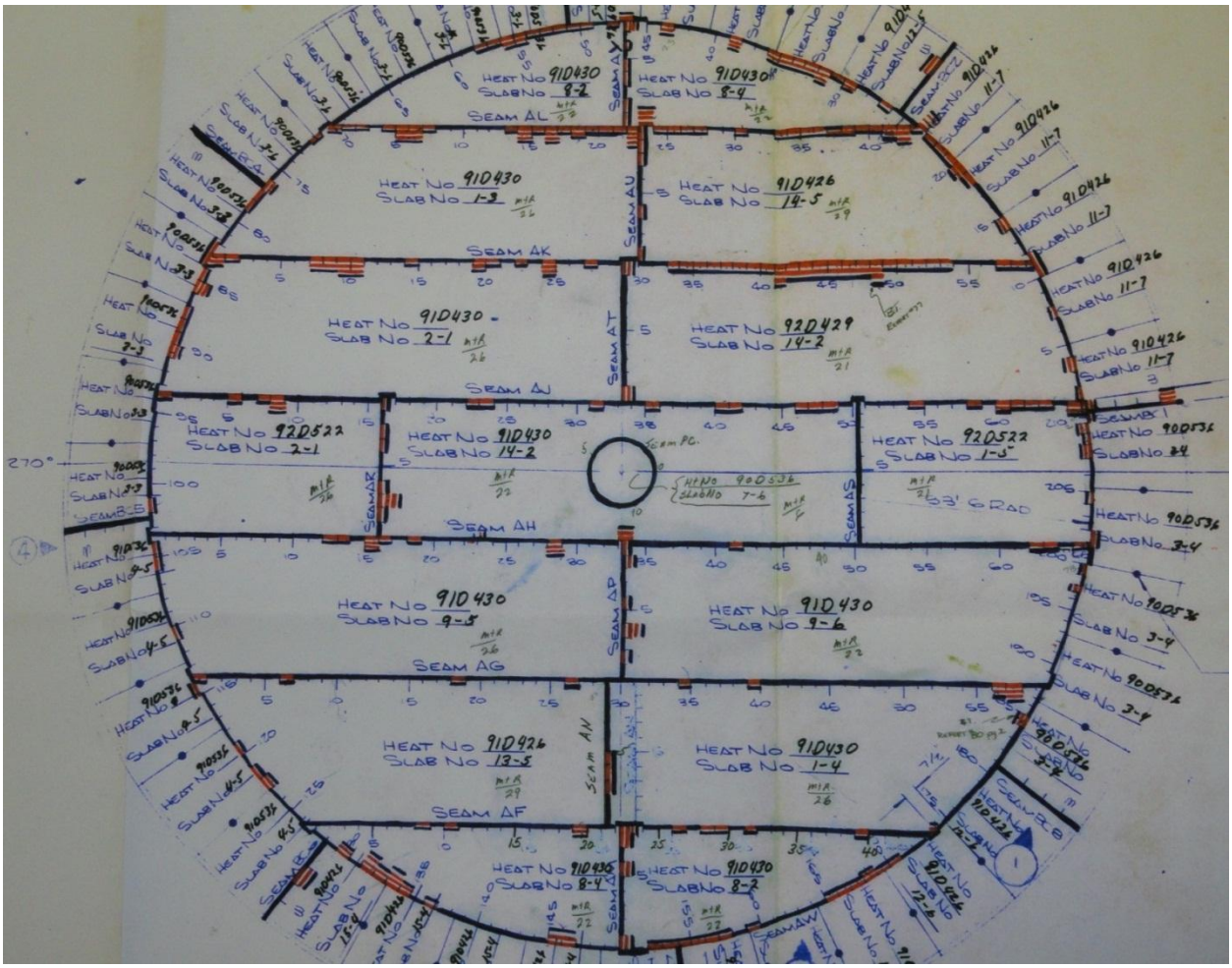


Figure 3-38. Tank AY-102 Primary Tank Bottom Weld Map

3.2.4 Stress Relieving of the Primary Tank

Stress relieving of the Tank AY-102 primary tank began on September 26, 1969, with firing system trouble ensuing almost immediately. These issues occurred for the first three days and sporadically during the whole stress relief period (Armstrong 1970).

Besides equipment issues, other items were noted during heatup to meet specification temperatures. As documented in Armstrong (1970), following the startup of the burners:

> *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.*

Various crew members expressed their opinion that the original long delay at heatup of the tank bottom was caused by the thermocouples laying in water in the Kaolite and not recording tank bottom temperatures (Schulze 1969c).

At approximately 12:00 a.m. on September 30, 1969, it is was conceded that due to limits of heat transfer, it would be impossible to reach 1,100°F (the specification minimum) in all sections of the tank in any reasonable time, if ever. 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. At approximately 4:00 a.m. on October 1, 1969, the tank bottom readings for the four previously listed thermocouples read 915, 935, 960, and 1030°F, respectively. The tank knuckle thermocouples were reading 970 and 980°F. At approximately 4:30 a.m. on October 1, 1969, it was decided that the tank bottom temperature would be accepted as being 1,000°F and the three-hour count was started at that time (Schulze 1969c). Figure 3-39 shows the locations of the primary tank bottom thermocouples relied on for the stress relieving evolution in Tank AY-102. Thermocouples 15, 16, 21, and 23 are in contact with the ⅞-in. thick steel plate making up part of the primary tank bottom.

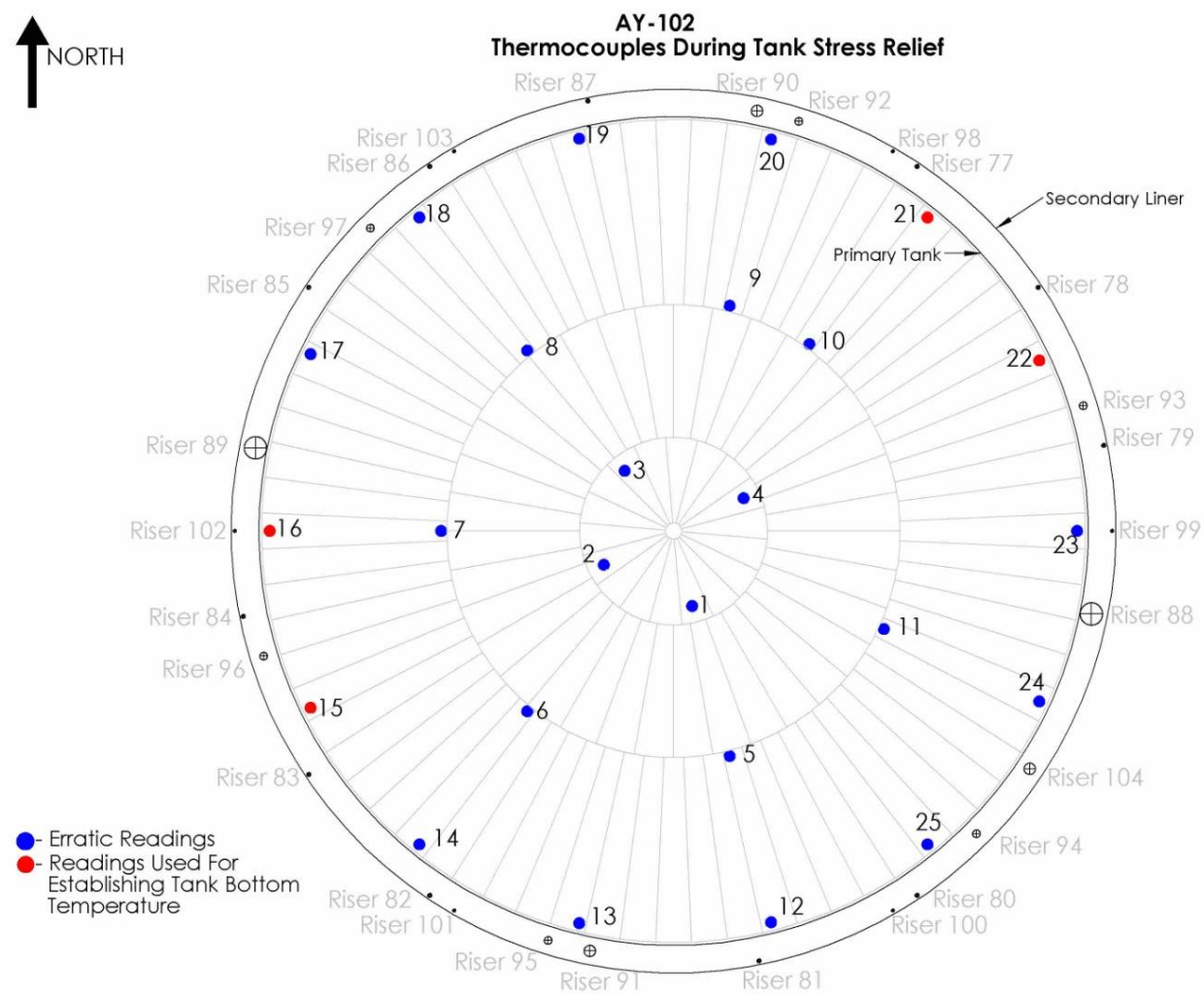


Figure 3-39. Tank AY-102 Thermocouple Operating Status during Stress Relieving

These temperatures were held until 7:30 a.m., when controlled cooling was commenced (Armstrong 1970). With the tank containing 1-in. thick plate, the ASME Code, Section VIII (1965 edition) requires 1,000°F minimum for 3 hours. It was also identified that for a 50°F reduction (950°F), five hours at temperature would be required. Readings from 3:00 a.m. to 8:00 a.m. confirmed that this condition was also met (Schulze 1969c). The evolution of the stress-relieving activities for Tank AY-102 spanned a total of five days, with most of the delay due to the inability to raise the temperature of the tank bottom to within the specification, while attempting to avoid going over the allowable temperature in the tank dome (allowable tank differential temperature constraints).

HES QA Report (1969), "Stress Relief of Primary Steel Tank – Tank 102," states:

> *Assuming that the hot junctions of the M.G.O type bottom couples were hard against the tank was a major cause of concern and probably temperature recording error. A small air gap, over the short temperature rise time caused questionable results. T.C.'s # 26 and 27 were held against the skin firmly, at a little higher elevation, but gave steady and predictable answers.*

Note that the thermocouples used during the tank stress-relieving evolution are the same as those used during the operation of the tank where normal readings were obtained over the service life of the tank.

The stress relieving of Tank AY-101 went much smoother with ten 4-in. vent pipes extended near the bottom of the tank to narrow the spread between the dome and bottom temperatures by more effectively using convection heating. Temporary thermocouples were also installed on the inside face of the tank bottom to aid in correctly monitoring bottom temperature (Armstrong 1970).

The burners supporting the Tank AY-101 stress-relieving effort were fired at 4:30 p.m. on October 31, 1969. At 9:00 p.m., dome temperatures were 500°F. This temperature was held during the night while the base refractory dried out. The stress-relieving hold time of 3 hours was concluded at 1:20 a.m. on November 3, 1969. Ignoring the deliberate hold time to remove water in the refractory, the overall evolution for the Tank AY-101 stress relieving lasted just over two days versus the five days needed to complete Tank AY-102 (Armstrong 1970). Figure 3-40 shows Tank AY-102 insulated prior to stress relieving.

The presence of water in the refractory concrete was noted in multiple construction documents relating to the heat-up of Tank AY-102. It was noted in the QA logbook that "water vapor could be detected all day, escaping from small vents in the insulation" (QA logbook September 28, 1969). The presence of water in the annulus is most likely attributed to rain in the previous weeks. Data shows that over 0.4 in. of rain fell between September 17, 1969 and September 18, 1969 (Hanford Meteorological Station data). This rainfall could potentially equate to several inches of standing water in the annulus based on previous observations from inspectors.

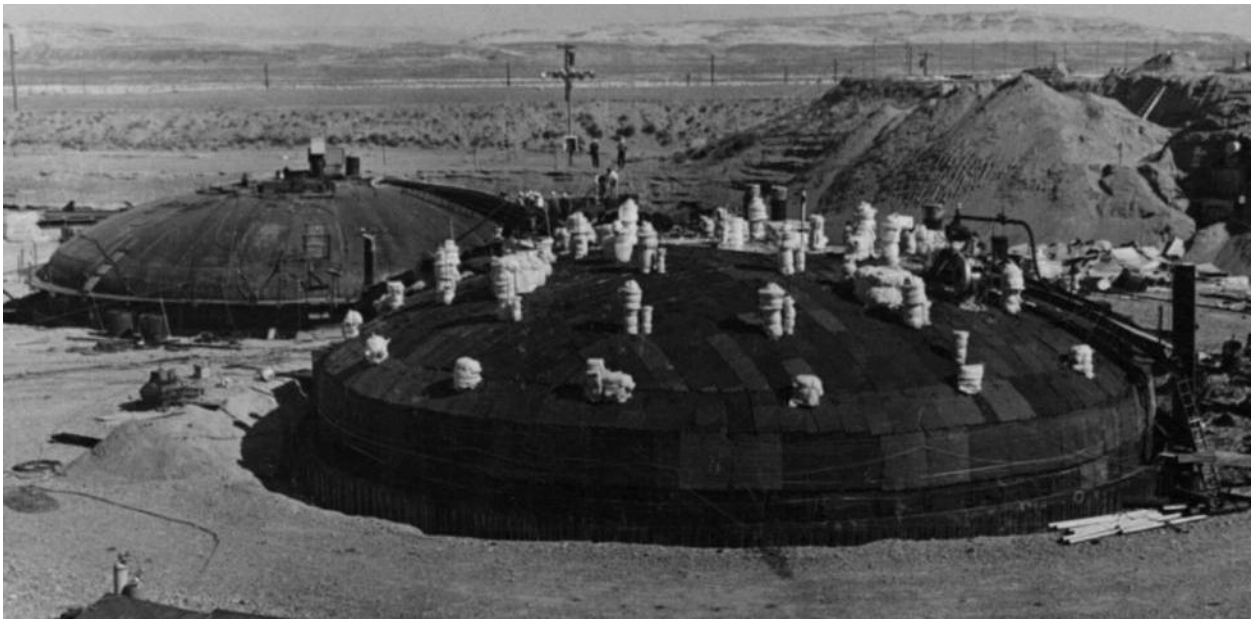


Figure 3-40. Tank AY-102 Insulated Prior to Stress Relieving (50725-18-Photo)

Between April 5, 1969 and April 6, 1969, over 0.5 in. of rain fell (Hanford Meteorological Station data), which was estimated to equate to 3-4 in. of water in the secondary liner at the outside edge of the refractory (QA logbook April 7, 1969). During the September 17, 1969 and September 18, 1969 rainfall, the primary tank dome on Tank AY-102 was near-completed, whereas the tank dome on Tank AY-101 was only in the early phases of installation. The dome provided an umbrella effect that directed rainfall into the annulus. This shedding could have equated to standing liquid in excess of 6-8 in. in the Tank AY-102 annulus. Less water would be expected in the Tank AY-101 annulus. It should be noted that there was no specific mention of standing water in the annulus of Tanks AY-101 or AY-102 by inspectors prior to initiating the stress-relieving process.

The concern about the heat-up of the refractory, in combination with moisture, was documented in the meetings leading up to the construction of AY Farm. It was noted that moisture content within the refractory presents a task of drying and maintaining the moisture content to within limits, such that when the temperature is brought up on the tank above, there is no build-up of internal pressure to break up the slab (work order CE-0283, "Report on a Study of Possible Insulating Materials for Use Between Tank Shells – 241-AY Tank Farm"). This requirement was further reinforced during a trip report entitled, "Computer Study of AY Tank" (Lien 1967), where refractory in general was discussed:

> *Professor Milbradt contacted Mel Averies of Portland Cement Association, Chicago. It was Mr. Averies' opinion that any insulating concrete that was to be exposed to high temperatures such as stress relieving would produce should receive special handling. Care should be taken to ensure that one surface was free and that all moisture was driven off before stress relieving.*

Further recommendations were made and documented in Hatch (1967) (Note: It is assumed that Mel Averies and Mel Abrahms are the same person).

> *Mel Abrahms, a PCA expert in firebrick and insulative concretes was contact by Professor Milbradt. Mr. Abrahms recommended that the moisture be driven from the suggested Kaolite insulating mat under the primary tank. A 150°F temperature should be held for a two week period. He felt that there would be some danger of destroying some of the properties of the insulating mat if it were heated rapidly without previous drying.*

The refractory material absorbs moisture and liquid solutions rapidly and to a large degree. Test data of the AY Farm Kaolite material (Kaolite 2000-LI) shows a dramatic increase in density when placed in a solution. RPP-19097, *Evaluation of Insulating Concrete in Hanford Double-Shell Tanks*, Attachment 5, identifies this increase to be in the range of 70-80 percent by dry weight. Other miscellaneous QA logbook entries cited cases where Kaolite material showed signs of absorbing moisture from the air during early construction.

3.2.5 Evaluation of Refractory after Tank Hydrostatic Test

Once stress relief was completed, the primary tank was hydrostatically tested. After the hydrostatic test of the Tank AY-102 primary tank, an inspection identified cracking in the refractory. This observation was noted in an October 15, 1969 inspection report, "Kaolite insulating concrete is somewhat fractured, presumably from weight of water used in hydro" (HES QA Report 1969).

Additional inspections were made in the Tank AY-102 annulus on October 17, 1969. At the point in time of the inspection, the tank was still filled with water from the hydrostatic test. Highlights of the inspection documented in Lien (1969) included:

- *Considerable cracking and spalling of the surface layer around the tank periphery. A couple of cracks were approximately ¼-in. 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.*

It was the opinion of the individual performing the inspection that the surface cracking and spalling of 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 refractory and stresses produced by skin friction from expansion and contraction of primary tank (Lien 1969). Movement of the primary tank was measured at $7\frac{1}{16}$ in. of expansion in the north-south direction and 7⅛ in. in the east-west direction, as documented in the HES QA Report (1969).

An inspection of Tank AY-102 to gather some quantitative data was made on June 18, 1970. The insulating material in the annulus was visually checked and probed with an 18-in. screwdriver to determine hardness, depth of deterioration, horizontal shear lines within 2 or 3 in. of the surface, and tendency of the surface to spall. The original pour lines were marked off, and all points available were examined to attempt to differentiate each pour from adjacent pours, and identify other pours made on the same day. Two generalizations were noted: (1) surface spalls were deeper as the distance from the edge of the tank decreased, reaching a maximum depth at the metal retainer ring on the periphery, and (2) there is no correlation between the condition of the refractory and the dates on which the sections were poured. This second point was investigated to determine if anything could have been wrong with the installation procedure. Figure 3-41 and Figure 3-42 provide examples of the refractory conditions found.

Figure 3-41. Tank AY-101 Less Than 1/2-in. Surface Deterioration

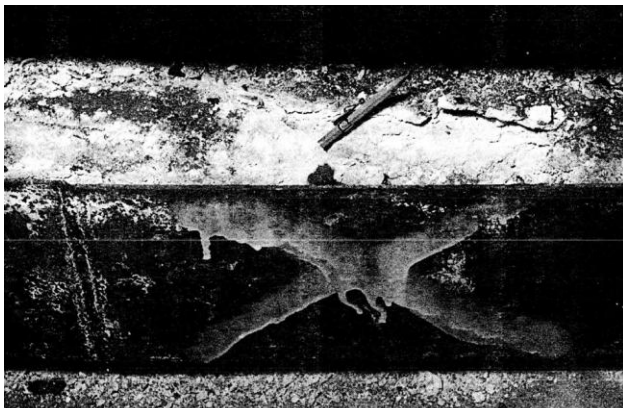


Figure 3-42. Full Depth Crack in Tank AY-102 Refractory

The inspection graded each section of visible refractory. Note that only approximately 8 to 10 in. of refractory are visible from the annulus prior to contact with the primary tank bottom knuckle. The results of the region near Riser 90 are shown in Figure 3-43.

As part of determining the necessary actions to be performed, PDM performed a stress analysis assuming 6 and 12 in. of knuckle support loss. The results of the analysis showed that the structure could likely tolerate 6 in. of foundation deterioration, but that support losses greater than 6 in. would put the tank in questionable status. It was determined that modifications to the AY Farm tanks needed to include replacing the outer 21 in. of the refractory concrete and replacing it with reinforced, shrink-compensating concrete. The outer circumference of the refractory would then be secured with a steel ring to prevent outward movement of the refractory (ARH-1833, *Investigation of the 241-AY Insulating Refractory Task Force Report*).

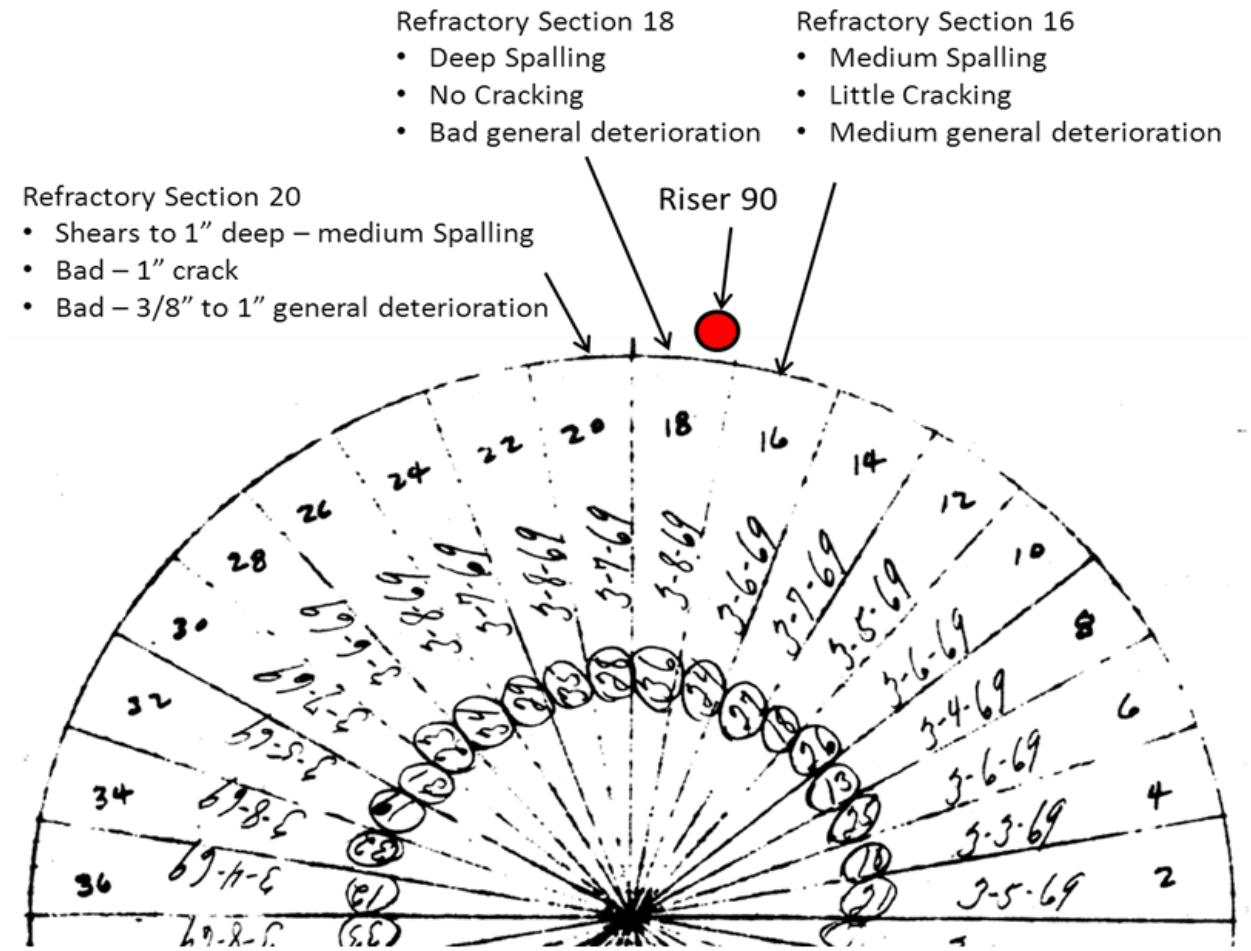


Figure 3-43. As-Found Refractory Condition Near Tank AY-102 Riser 90

A minimum of 21 in. of refractory was removed and replaced with reinforced concrete (H-2-35299, "Structural Modification Insulating Concrete Plan & Details"). On June 26, 1970, Kaolite was removed using various tools, including hammers, chisels, chainsaws, and pneumatic-powered air chisels. Laborers stayed away from the primary tank (QA Logbook June 26, 1970). Figure 3-44 shows the refractory removal process in preparation for concrete installation.

Figure 3-44. Tank AY-101 Refractory Repair

An additional inspection was performed on June 30, 1970, in Tank AY-102 after the first of three refractory groups had been removed in preparation for repair. As documented in Lien (1970):

> *The Phase I repair work was in progress in Tank 102. Approximately two thirds of the Group 1 perimeter refractory concrete had been removed. From observation during the removal and inspection of the removed refractory concrete I noted the following:*
>
> 1. *In all sections inspected there was solid concrete at the point of primary tank bottom contact with the refractory concrete (tangent point of primary tank knuckle) except for an occasional friable layer, approximately ¼-inch thick, at surface.*
> 2. *Most of the refractory concrete was solid or in large pieces from metal retaining band inward except for surface friable layer.*
> 3. *The surface pictures previously taken prior to repair are not representative of the refractory concrete under the tank knuckle.*

Inspections that followed Kaolite removal indicated that areas of the Tank AY-102 primary tank bottom had pulled up from the Kaolite as much as 1½ in. During review of the construction records, there was no reference found of any further investigation as to the cause of the pulled up primary tank bottom.

Notifications were sent out and the decision was made to preserve the void by placing insulating foam (e.g., Styrofoam) to cover the volume of the void. The foam could later crush or melt as weight and heat were added (QA logbook June 30, 1970). Figure 3-45 provides an example of the pull up of the primary tank bottom from the removed refractory, as found during the Tank AY-101 repair work. The specific type of foam used and the exact locations it was applied to relative to the tank is unknown.

Figure 3-45. Example of Tank AY-101 Primary Tank Pull Up From Refractory (52788-8-Photo)

It is likely that chlorofluorocarbons (CFC) were in the styrene foam used at the time of AY Farm construction. The CFCs were blowing agents and would be trapped in the expanded foam. CFCs became heavily regulated in the late 1970s because of their ozone-depleting effects and were phased out starting in the 1980s.

It is possible that any CFCs trapped in the foam potentially used in AY Farm tank repairs would decompose under the conditions of heat and radiation and release decomposition products that could be corrosive to the tank steels. These include chlorine free radicals and chlorodifluoracetic acid (Centre of Environmental Science-Section Substances and Products [CML-SSP] Working Paper 2001.002, *Literature Study on Degradation Products of Known Emissions*). It is possible that some localized damage could occur in the area of these repairs.

Manufacturer representatives for Kaolite were at the construction site on July 21, 1970, for inspection of Tanks AY-101 and AY-102. It was noted that the refractory for both tanks had a friable surface at the top that was not homogenous with the balance of the Kaolite. X-ray diffraction (XRD) analyses performed on samples taken from the top layer of friable material identified only calcium carbonate and anorthite (anhydrous calcium aluminum silicate mineral). The friable material had little or no compressive strength and would break up immediately and crumble under impact or compression.

The friable layer in Tank AY-102 varied from about ¾ in. to 1¾ in. thick; whereas in Tank AY-101, it generally varied from ¼ in. to ½ in. thick. Tank AY-102 was noted to have one area in particular that contained a soft punky material that had no strength whatsoever and evidence of one or two other small locations of like material (Schulze 1970b). Punky is defined as a refractory lining that is abnormally soft and friable (API-936, *Refractory Installation Quality Control – Inspection and Testing Monolithic Refractory Linings and Materials*).

Present-day manufacturers of refractory Kaolite warn against a phenomenon identified as alkali hydrolysis, also known as carbonation, which is the formation of calcium carbonate ($CaCO_3$). This formation is caused by the reaction of lime in cement with carbon dioxide in the atmosphere. The hydrolysis reaction breaks down the cement bond, which creates a volume expansion that weakens the refractory lining surface.

The Pocket Manual Refractory Materials (Routschka 2007) states:

> *The following general rules should be observed if longer time periods have elapsed (weeks or months) until commissioning. The furnace must be subjected to draft conditions so that sufficient ventilation prevails. This will ensure that humidity is not too high and no hydrothermal conditions arise. Otherwise, alkaline hydrolysis is possible when using refractory castables. The result will be complete carbonation or destruction of the lining.*

The refractory in both Tanks AY-101 and AY-102 may have undergone a level of alkali hydrolysis taking into consideration the steam discharge observed during initiation of stress relief, the noted friable material, and the reduction in compressible strength.

Samples taken of Kaolite material below the friable surface were tested and results documented in ARH-1833, as follows:

> *Samples of this material were taken from each tank and compression tested by B&W Refractories Division. The reported results were Tank 101, 425 to 439 psi; Tank 102, 158 to 285 psi.*

During the meeting with the Kaolite manufacturer, various possible causes of the problem were discussed, including the addition of detergent during pours, vibration during pours, screeding, curing, impact of tank stress relief, Kaolite binders, and Kaolite storage prior to use. The Kaolite manufacturer representatives provided their initial view as to the cause of failure:

> *The knuckle forming of the secondary causes a slight reverse curve or "oil can" in the bottom under the outside few feet of the Kaolite location. The Kaolite is poured directly on the surface which will support the Kaolite with little or no deflection. The primary bottom is assembled and it too will have the slight reverse curve, although to a lesser extent than the secondary. During the hydrostatic test the weight causes the secondary bottom to flatten and the tendency toward point. Loading in the primary overstresses the Kaolite in shear thru the reduced section* (Schulze 1970b).

In addition to the thermal and water degradation of the refractory, compression of the Kaolite during the hydrostatic test would have increased the stresses on the material. The bearing weight of 39 ft of water (approximately 2,430 lb/ft^2) would have been distributed by the primary tank bottom, which uses the refractory as its foundation. When compression/flattening of the secondary liner bottom did occur, the refractory composed of a lesser thickness than surrounding regions would have cracked, potentially leaving sections of the primary tank bottom unsupported. Figure 3-46 shows an example of the reverse curve "oil can" of the secondary liner bottom.

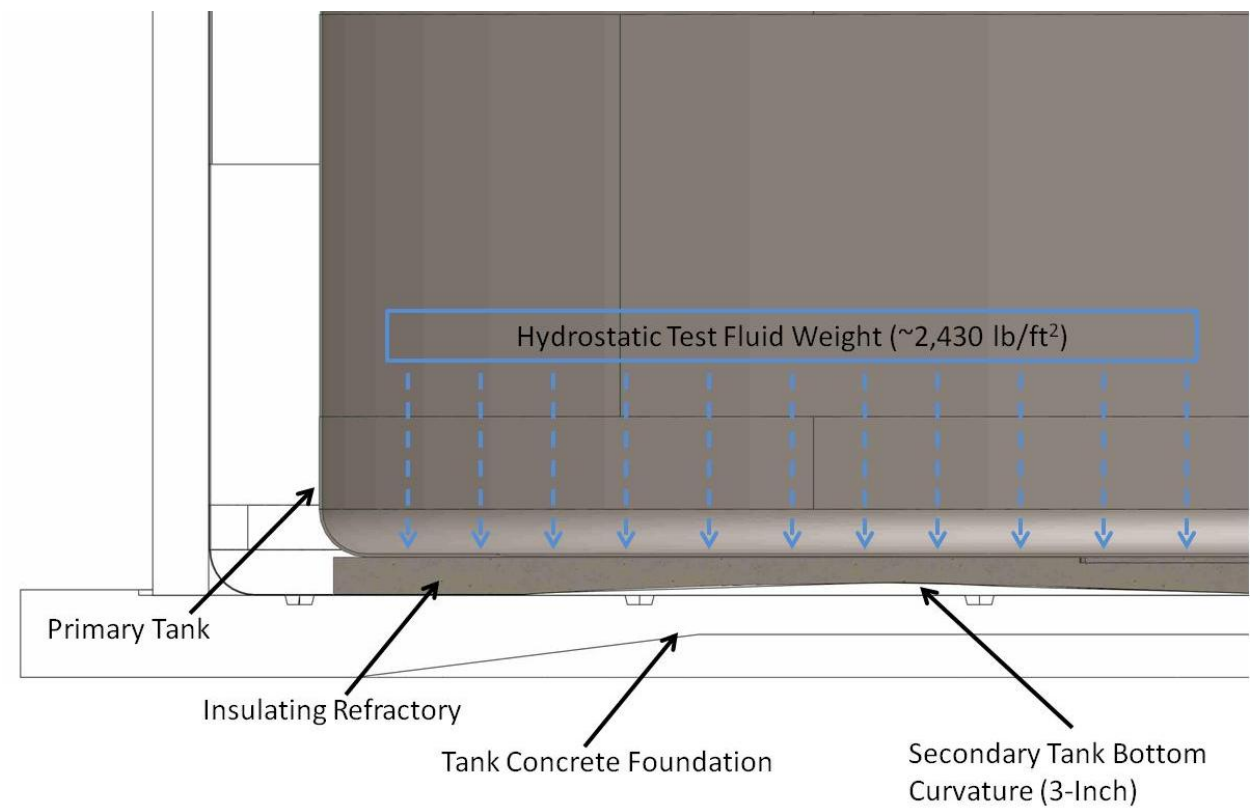


Figure 3-46. Tank Configuration with Three-Inch Secondary Liner Bottom Curvature During Hydrostatic Test

It was noted during an in-tank inspection near the completion of the airlift circulator installation that some downward deflection existed on the primary tank bottom (QA logbook February 2, 1970).

> *In the afternoon I spent considerable time in TK102 making a final inspection. All piping components were satisfactory, but on the due east side of the tank bottom in the 3/8-in. plate, an area approximately 5 in. in diameter was found to be deflected below the upper plane surface of the plate. Maximum deflection at the center of the area was approx. 11/64 in. Not far away (10 ft) was an area that contained four gouges, the longest of which was 2¾-in. long. The locations of all were duly noted.*

While a deflection of approximately $^{3}/_{16}$ in. is not severe, it does indicate that under little to no bearing load, there was some deflection potentially caused by void spaces in the support refractory. What this deflection would equate to under a full hydrostatic load is speculative. After the removal of the hydrostatic test water in Tank AY-102 was completed, it was noted that large puddles existed on the primary tank bottom (QA logbook November 5, 1969). A day later, it was noted that only the southern portion of the primary tank bottom was dry enough to begin changing out the footings of the dome support structure to the timber used for completing the dome concrete installation (QA logbook November 6, 1969).

Figure 3-47. View of South Quadrant on Tank AY-102 After Hydrostatic Test Showing Small Amounts of Pooling (51660-16)

During the construction records review, only two useful images were discovered illustrating the primary tank bottom flatness prior to being placed into service. Figure 3-47 indicates little to no pooling of Tank AY-102 hydrostatic test water remnants in the south quadrant suggesting the tank floor in this region is relatively flat. Figure 3-48 shows the condition of the northeast quadrant of the primary tank bottom in Tank AY-102 after completion of the hydrostatic testing and installation of the in-tank piping.

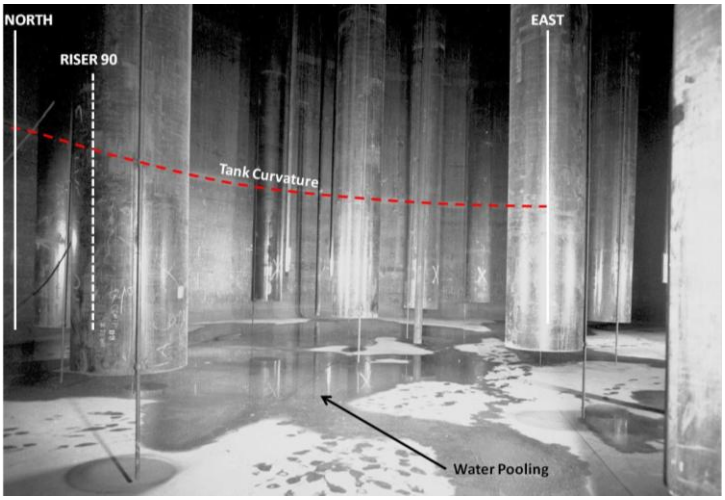


Figure 3-48. View of Northeast Quadrant on Tank AY-102 After Hydrostatic Test Showing Noticeable Amounts of Pooling in Close Proximity to Annulus Riser 90 Location (51660-15)

There appears to be some pooling occurring in the northeast quadrant of the tank. It is possibly only a coincidence that the location of this pool of water is in close proximity to the material found on the annulus floor near Riser 90 (see Section 4.2.6).

Samples of the damaged refractory were gathered for the manufacturer to perform testing at its laboratory. The main concern was the possible effect on the refractory from the introduction of water and then being subjected to freezing temperatures. It was well known that the annuli collected a great deal of water, which could have migrated into the refractory, and subsequent low temperatures transmitted through the primary tank bottom may have caused freezing of moisture in the top of the Kaolite (Schulze 1970a).

The results of the laboratory testing, shown in Table 3-3, confirmed that if the Kaolite used for AY Farm construction was frozen after proper curing procedures were completed, a severely lowered loading carrying capacity results. All samples failed on excessive horizontal loading that simulated the movement of the primary tank during stress relieving (WSI 1970). Approximately one week later, a letter was sent out recommending that a mandatory requirement to protect the refractory, used in AZ Farm construction, from freezing should be adopted (Davis 1970).

Table 3-3. Kaolite Laboratory Test Results After Freezing Samples at 10°F

Sample Wetted Depth (in.)	Sample Size	Compressive Load Applied (psi)	Withstood Vertical Load	Withstood Horizontal Load
0.25	3-in. × 3-in. × 3-in. thick	222	Yes	No
0.25	3-in. × 4-in. × 3-in. thick	167	Yes	No
0.25	3-in. × 6-in. × 3-in. thick	111	Yes	No
0.75	3-in. × 3-in. × 3-in. thick	222	Yes	No
0.75	3-in. × 4-in. × 3-in. thick	167	Yes	No
0.75	3-in. × 6-in. × 3-in. thick	111	Yes	No
Complete	3-in. × 3-in. × 3-in. thick	222	No	N/A
Complete	3-in. × 4-in. × 3-in. thick	167	No	N/A
Complete	3-in. × 6-in. × 3-in. thick	111	Yes	No

The tank fabricator commenced the concrete skip pours to replace the outer refractory material. Concrete pours into the Tank AY-102 annulus for the first ten sections of refractory repair began on July 2, 1970. The concrete pours were skip pours equally spaced around the tank to ensure proper support (H-2-35299). Concrete slump was 5 to 6 in. It was noted that the pours could not be completed with less slump. After the completion of the concrete pours on the first ten sections and forms being removed, it was noted that the concrete did not flow back well as desired. While the entire area in back of the knuckle was filled (a minimum of 8 in.), the area behind that was not always filled. It was determined that the concrete slump would need to be increased. The remaining ten sections were completed on July 7, 1970, with QA noting that the concrete pour worked well (QA logbook July 2, 1970 to July 13, 1970). Figure 3-49A shows the repair work and rebar placement to support the concrete pours. Figure 3-49B shows a poured section adjacent to a section where the refractory has been removed.

Figure 3-49. Refractory Removal and Rebar Placement for Concrete Pours (A) (52735-10), Refractory Section Prepared for Concrete Pour with Adjacent Section Already Completed (B) (52735-1)

A review of the post-refractory repair photos available for Tank AY-102 and the current annulus inspections suggest that the thickness of the reinforced concrete at the completion of the pours was not uniform around the tank perimeter. The amount of concrete revealed above the 6½-in. tall stiffener ring varies throughout the tank annulus. As shown in Figure 3-50 (a photo in the southeast annulus quadrant), the reveal of the concrete above the stiffener ring is no more than ½ in., with the potential of another ½-in. gap of exposed concrete between the stiffener ring and the annulus floor.

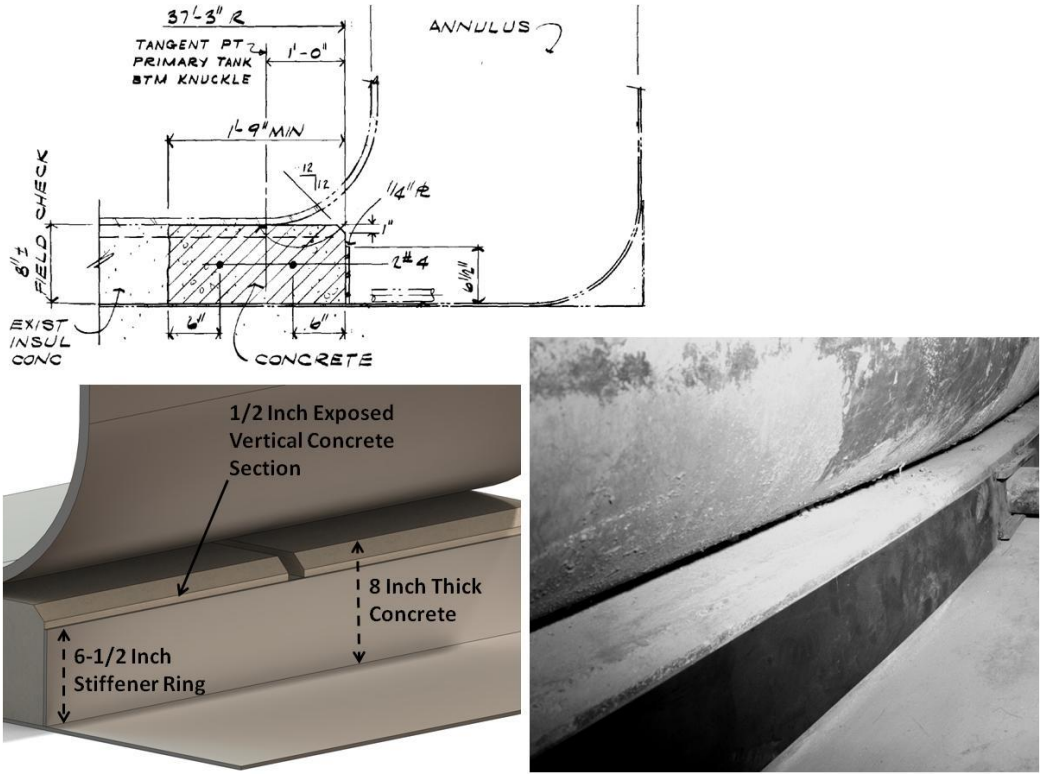


Figure 3-50. Diagram Comparison of 8-In. Thick Concrete Section Thickness to Photo of Southeast Section of the Tank AY-102 Annulus (52720-7)

This configuration is comparable to what an 8-in. thick concrete repair section would be. However, with the known refractory being a total of 10 in. under the primary tank, this would suggest either the curvature in the secondary bottom existed during the repair, or the primary tank bottom knuckle elevation was lower than the adjacent sections of the tank bottom.

The second post-refractory repair photo in the Tank AY-102 annulus is of an unknown location; however, it is noted that the reveal of the concrete under the primary tank bottom knuckle is substantially larger as seen in Figure 3-51 than that shown in Figure 3-50. The photo is comparable to the to-scale diagram showing the visual appearance of what a 10-in. thick concrete section would be. The diagram and the annulus photo provide reasonable confidence that this section of the tank did receive a thicker section of concrete in comparison to the section shown in Figure 3-50.

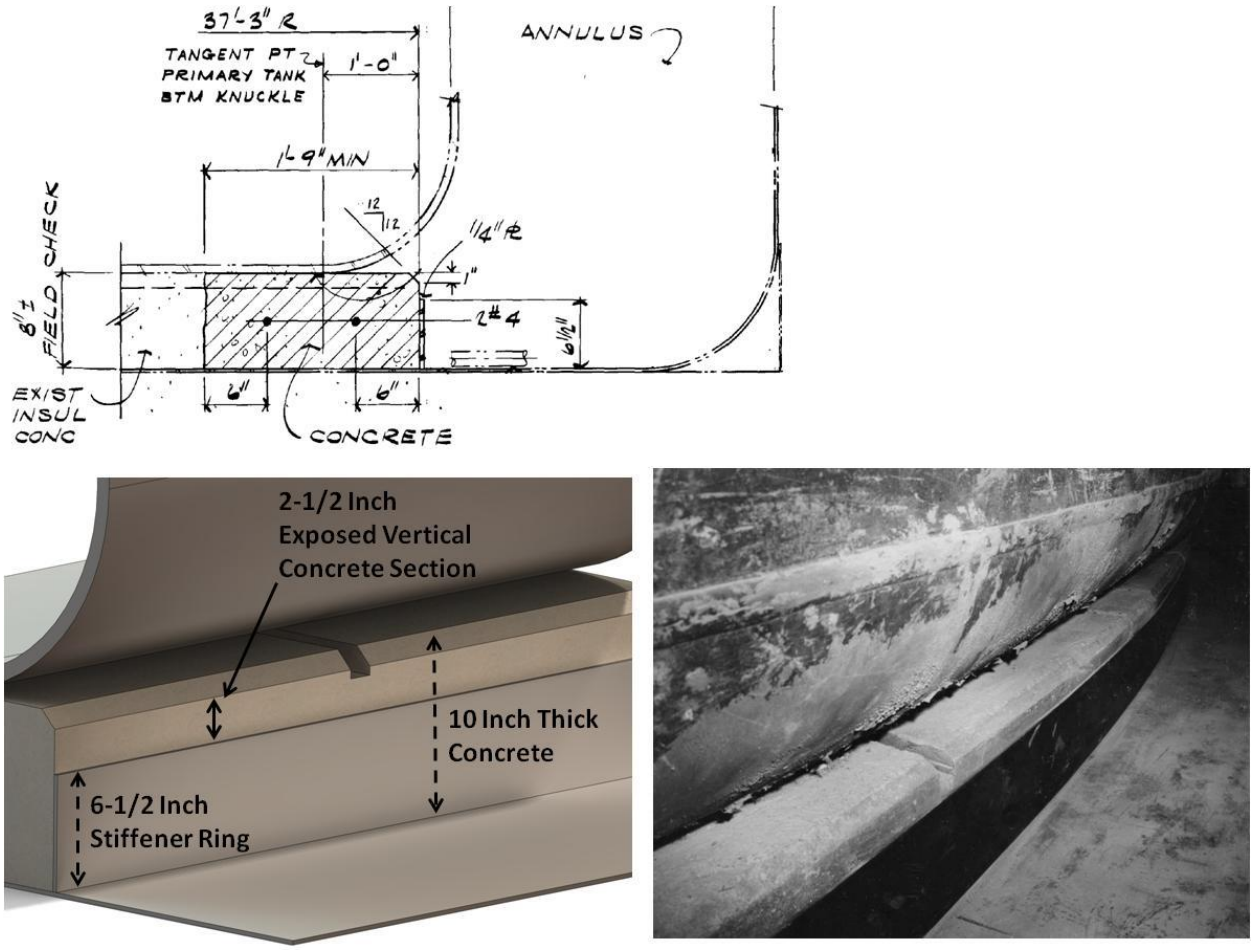


Figure 3-51. Diagram Comparison of 10-In. Thick Concrete Section Thickness to Photo of Unknown Section of the Tank AY-102 Annulus (52720-6)

Of specific interest in the review of the recent tank annulus inspections was the condition of the concrete near the material found around Riser 90. The thickness of the concrete in the direct vicinity to the refractory slot near Riser 90 appears to be less than 8 in. In fact, the thickness of the concrete near Riser 90 appears to be the least of all the perimeter of the tank inspected during the 2012 comprehensive inspection. Figure 3-52 shows the material in the refractory slot nearest to Riser 90. Section 4.2.6 provides further detail on the findings during the Riser 90 inspection.

Figure 3-52. Material in Refractory Slot Near Annulus Riser 90 Found in 2012
(see Section 4.2.6 for further details)

Based on the review of all the construction records, it is apparent that the fabrication of the secondary liner bottom caused substantial issues with the remaining base sections of the tank, including the refractory and the primary tank bottom. The combination of the secondary liner bottom warpage, damage to the refractory possibly caused during the stress relieving/hydrostatic testing, and extensive weld defects requiring repair, may have left Tank AY-102 compromised. The construction issues suggest that constructed primary tank bottom steel plate support was not as intended by the original tank design.

3.3 REFRACTORY- WASTE COMPATIBILITY

As previously discussed, the primary tank was designed to rest on an 8-in. thick layer of refractory that protected the secondary liner bottom and the structural concrete foundation from excessive thermal stresses during the primary tank stress relieving and during high-heat waste storage. The refractory was mixed onsite and “gunned” into strip forms on top of the secondary liner, as discussed in Section 3.1.4. The refractory was found damaged after stress relieving and hydrotest as discussed in Section 3.2.4. The refractory used in AY Farms is Kaolite 2200-LI, which is classified as a general purpose, lightweight castable refractory material. The Kaolite series refractory used a calcium aluminate binder, with the low iron (LI) series having low iron content.

3.3.1 Waste Compatibility Testing

The DST refractory is generically called “kaolite,” which is a general term for a castable refractory that contains a binder of calcium aluminosilicate. Each series of DST used a different kaolite formulation. The construction documentation specified specific properties, including insulating properties, minimum compressive strength, and chemical resistance to tank waste. Kaolites discussed in this section include Kaolite 20, the material originally specified for AY Farm; Kaolite 2200-LI, which was the material actually used in AY Farm; and Kaolite 2000, which was tested and found to lack chemical resistance in the air-dried form but still used later in AZ Farm.

The chemical resistance of all the DST refractory was examined in 2003 through a compilation of existing documentation, testing, and analysis, documented in RPP-19097. Page 3 of RPP-19097 states: "During the preparation of an engineering evaluation in response to PER 2003-3066, a 1971 Battelle Northwest Laboratories test report (BNWL-B-56, *Evaluation of Kaolite-2000 Insulating Concrete*) was found in the files of an engineer" (now found in RPP-19097, as Attachment 7). The test report described samples of Kaolite 2000 that were air-dried and samples that were heated to 1,100°F and then both immersed in simulated tank waste. The heated samples maintained most of their compressive strength after immersion in the waste, but the air-dried samples "decomposed," so no compressive strength values were obtained. The concern was raised that the bottom surface of the refractory would have been much cooler (calculated as only 180°F) during the heat treatment of the primary tank and therefore vulnerable to a tank waste leak.

Kaolite 2000 is the material used for the refractory in AZ Farm. The refractory used in AY Farm, Kaolite 2200-LI, is similar. A comparison of some material properties and chemical composition for both refractory materials is provided in Table 3-4. Kaolite 2200-LI has lower iron oxide and calcium oxide content and higher aluminum oxide, silicon dioxide, titanium dioxide, and magnesium oxide content than Kaolite 2000.

Table 3-4. Comparison of Properties for Kaolite 2000 and Kaolite 2200-LI

Refractory Type	Kaolite 2000	Kaolite 2200-LI	Refractory Type	Kaolite 2000	Kaolite 2200-LI
Density-molded (lb/ft^3)	86	83	Chemical analysis (as wt% oxide)		
			SiO_2	36.4	37.4
Density-fired lb/ft^3)	55	49	Al_2O_3	34.7	40.7
			Fe_2O_3	5.6	0.9
Cold crushing strength (psi)			TiO_2	1.2	1.7
220°F	440	260	CaO	21.1	18.6
1,000°F	375	260	MgO	0.2	0.4
1,500°F	350	260	Na_2O	0.3	0.3

From Babcock & Wilcox insulating castables datasheet found in IAP-614 project files.

3.3.1.1 Testing of Kaolite 2200-LI Refractory

The refractory for AY Farm was originally specified to be Kaolite 20, manufactured by Babcock and Wilcox at the time and used at the Savannah River Site. Kaolite 20 was tested by Battelle Northwest Laboratory in 1968 under various temperature, moisture, and waste contact conditions (BNWL-797, *Evaluation of Kaolite-20 Insulating Castable*, included as Attachment 3 of RPP-19097).

Tests were done typically using 2-in. cubes. Samples met compressive strength requirements (200 psi) under all conditions. Kaolite 2200-LI was substituted for Kaolite 20, with the stated reason that Kaolite 2200-LI is more resistant to waste that contains sulfates (RPP-19097, Attachment 4). Supplementary testing in 1968 was done for Kaolite 2200-LI following the protocols of BNWL-797.

The testing was documented in an unpublished report found later in project records and included as Attachment 5 of RPP-19097. The attachment, entitled "Evaluation of Kaolite 2200," does not have a document number and the LI notation is only handwritten on the title page. There is a castable refractory produced designated as Kaolite 2200, which is not low in iron oxide content (2.4 wt%). Therefore, there is some uncertainty about which Kaolite 2200 refractory material was actually tested by Battelle. The material reported as Kaolite 2200-LI met the compressive strength requirements, even after samples were immersed in simulated tank waste. The simulant used for testing both Kaolite 20 and samples reported as Kaolite 2200-LI was a complex solution, moderately caustic, high in nitrite, and lower in nitrate and carbonate than current AY Farm supernatant (see Table 3-5). (Note that although BNWL-797 specified two stimulant compositions for testing Kaolite 20, identified as Table I and Table II, only Table II solutions were used in testing the reported Kaolite 2200-LI samples. That composition is shown in Table 3-5.)

Table 3-5. Synthetic Waste Solution Tested on Kaolite 20 and Kaolite 2200-LI

Chemical	Table II Stored Boiling Waste Composition[a] M	Current Tank AY-102 Supernatant Composition[b] M	Chemical	Table II Stored Boiling Waste Composition[a] M	Current Tank AY-102 Supernatant Composition[b] M
Fe	0.10	7.5E-05	NO_3	0.20	2.1
Al	0.12	0.30	NO_2	0.80	1.03
Na	2.0	6.39	SO_4	0.20	0.045
Cr	0.005	3.7E-03	CO_3	0.54	0.67
Ni	0.002	1.2E-04	OH	0.05	2.6
Ca	0.001	2.2E-04	F	0.02	0.11
Zr	0.02	1.75E-05	K	1.08	0.95
SiO_2	0.25	1.93E-03	Cl	0.651	0.049

Source: BNWL-797, 1968, *Evaluation of Kaolite–2200-LI*, Unpublished (RPP-19097, Attachment 5), Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Washington.

[a] Composition is for as prepared simulant, which formed about 50% by volume sediment after standing for a few minutes per BNWL-797, page 14.

[b] Tank AY-102 supernatant composition obtained September 18, 2012 from Hanford tank waste information network best-basis inventory (https://twins.labworks.org/twinsdata/Forms/About.aspx).

From the test report, Test Condition B was a water soak after a seven-day cure. The strength was decreased slightly compared to no water soak, 362-425 psi versus 487-575 psi. Test Condition E was a room temperature, air-cured specimen that was soaked for 14 days in synthetic waste solution (see Table 3-5 for composition). Strength was reduced (337-382 psi) but still met the 200 psi design specification. This is in contrast to the testing of air-dried Kaolite 2000 where samples disintegrated after exposure to simulated tank waste solution. An examination of the differences in composition (Table 3-5), shows very little difference in composition of the refractory and differences in chemical resistance behavior is not well explained. The test solution used in the refractory tests and shown in Table 3-5, when compared to current Tank AY-102 solution, is generally more dilute, especially in caustic and nitrate. More chemical attack could be anticipated with actual Tank AY-102 waste solution.

Supplemental Test 1 involved heating the specimens to 350°F or 1,100°F, allowing the specimens to completely cool to room temperature, then exposing them to synthetic waste solution for 10 days and testing them while wet. The strength was similar to the air-cured

specimens, 331 psi for 350°F cured, and 387 psi for the 1,100°F cured. This testing showed that the material reported as Kaolite 2200-LI could meet the design requirement.

3.3.1.2 Examination of Damaged Refractory in AY Farm

As discussed in Section 3.2.5 during tank construction, the AY Farm refractory was found severely damaged after heat treating and leak testing of the primary tank (see Figure 3-53). The refractory was examined by a task force and the results were documented in ARH-1833 (Attachment G of RPP-19097).

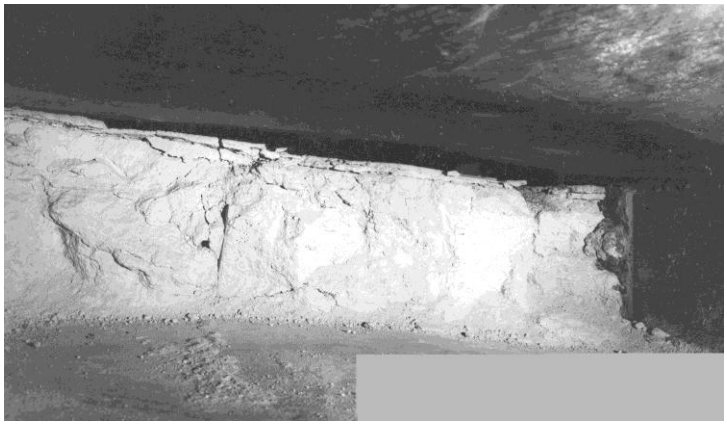


Figure 3-53. Damaged Refractory in AY Farm after removal of 21 in. of periphery, still showing friable top layer (Photo 52788-8)

Visual examination of the accessible refractory is reported in ARH-1833, and is shown graphically for Tank AY-102 and Tank AY-101 in Figure 4 and Figure 10, of ARH-183, respectively. Approximately 3 percent of the accessible refractory examined for Tank AY-102 was described as being "good," ~5 percent was described as "very poor" and the remaining ~92 percent described as "surface deterioration of ¾ to 1 in." Approximately 20 percent of the accessible refractory examined for Tank AY-101 was described as being "good condition," ~45 percent was described as "surface deterioration <½ in.," ~33 percent was described as "surface deterioration ≈¾ in.," and ~2 percent described as "badly fractured at periphery."

Samples of the refractory were taken from each tank for laboratory analysis. One of the samples from each tank was the top, dark-colored, crusty material and the other sample was the bottom, lighter-colored, competent material. The chemical analysis of these samples is reported in Table 3-6, along with the manufacturer's data on Kaolite 2200-LI. The binder in the cement, calcium aluminate, is reduced in all the samples, most notably in Tank AY-101. The iron content in the Tank AY-101 top sample is very elevated and the source is unknown. The top layer should have been in contact with the primary tank bottom, but no signs of bottom liner degradation are noted in the inspection results.

Table 3-6. Analysis of Damaged Refractory from Tanks AY-102 and AY-101

Element as Oxide (wt%)	AY-102 Light (competent)	AY-102 Dark (top, crusty)	AY-101 Light (competent)	AY-101 Dark (top, crusty)	Kaolite 2200-LI Manufacturer's Data
SiO_2	37.6	38.1	37.0	33.0	37.4
Al_2O_3	35.4	36.9	35.4	31.2	40.7
Fe_2O_3	0.99	1.04	0.92	16.6	0.9
TiO_2	1.4	1.6	1.6	1.4	1.7
CaO	15.5	15.7	16.2	12.1	18.6
MgO	0.6	0.4	0.8	0.4	0.4
Na_2O	1.1	1.5	0.7	2.3	0.3
Specific Gravity	0.53	--	0.75	--	0.785
Moisture	12.5	9.3	12.7	8.9	

Source: ARH-1833, 1970, *Investigation of the 241-AY Insulating Refractory Task Force Report*, page 3, Atlantic Richfield Hanford Company, Richland, Washington.

Using XRD analysis, calcium carbonate was determined to be present in a sample from the top friable layer obtained from Tank AY-101. A deteriorated friable refractory was also observed for Tank AY-102, but not analyzed by XRD. In ARH-1833, page 4, it is stated:

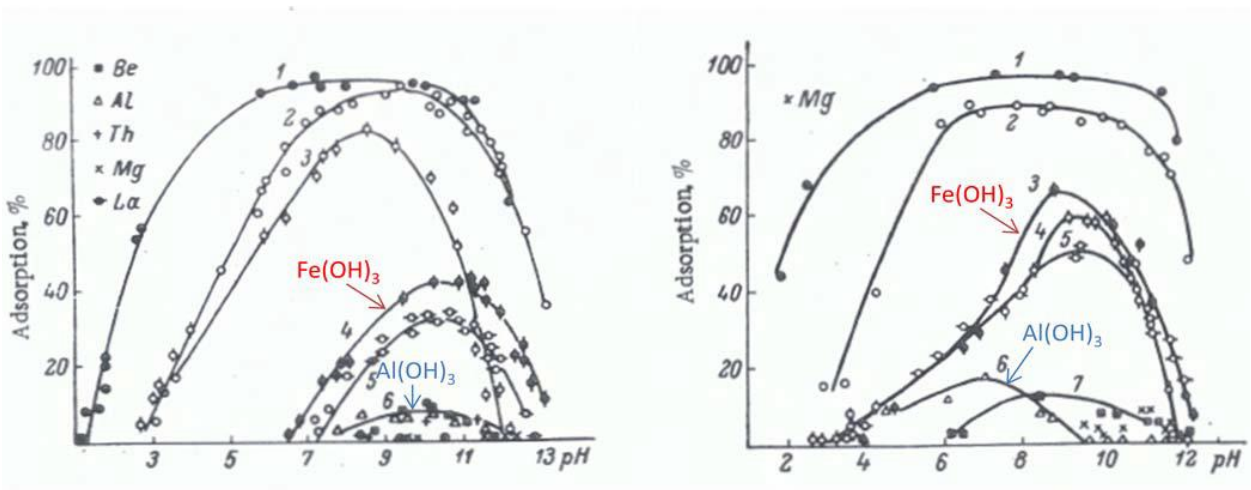
> *Two samples for X-ray diffraction analysis were taken from Tank 101, one from the top or friable layer and one from the bottom, competent portion of the kaolite pad. Both samples contained the anhydrous calcium aluminum silicate ($CaAl_2Si_2O_8$) mineral called anorthite. The bottom sample, in addition, contained several hydrous compounds: $Al(OH)_3$, $3CaO\text{-}A1_203\text{-}6H_20$, and $Ca_2SiO_4\text{-}1/2H_2O$. The sample from the top contained only $CaCO_3$ in addition to anorthite.*

The calcium carbonate ($CaCO_3$) was likely formed by alkali hydrolysis in the cement. Alkali hydrolysis, also known as carbonation, is by the reaction of calcium oxide in cement and carbon dioxide in the atmosphere. The hydrolysis reaction breaks down the cement bond, which creates a volume expansion that weakens the refractory surface. This weakened surface is friable and can be easily degraded. The high porosity and alkali content of refractories make them susceptible to alkali hydrolysis, which can occur in unprotected pours exposed to weather conditions, such as rain. Manufacturers of refractories indicate that alkali hydrolysis is more likely to occur when (1) materials are cast and cured at low temperatures (less than 70°F), (2) the material is not dried soon after initial cure to remove excess water (dry out should occur at high temperature, 500°F to 750°F, to ensure the formation of stable cement hydrates), and (3) unmixed material should be kept dry prior to mixing and application. A review of the construction conditions indicated that none of these conditions were prevented and suggests that alkali hydrolysis of the refractory for Tanks AY-101 and AY-102 is likely to have occurred.

ARH-1833, page 4, also states "*Intact samples of the deteriorated surface from both tanks were examined and found to afford negligible resistance to compressive and sliding loads. The samples crumbled to a cohesionless state when subjected to these loadings.*" Samples of the competent refractory layer were also tested for compressive strength and found to be 425 to

439 psi for Tank AY-101 and 272 to 279 psi for Tank AY-102, which met the design requirement of ≥200 psi.

Also of note in ARH-1833, page 4, is the analysis of refractory samples for the supernatant retention test, where the refractory samples gained approximately 80 percent by weight in the synthetic waste solution or the equivalent of 39.2 lb of solution per ft^3 of material. This indicates the material is very porous and capable of retaining a fairly large amount of liquid. The ion exchange properties of the refractory were tested with ^{137}Cs in the synthetic supernatant solution. The test results showed that less than one percent of the ^{137}Cs was adsorbed. It is assumed that component portions of the refractory were tested. Adsorption on degraded refractory could be more significant. For example, Pacific Northwest National Laboratory (PNNL) evaluated the cesium adsorption of K Basin sludge in PNNL-21836, *Characteristics of STP Pre-2004 Archived KE Basin Sludge Samples Before and After Re-Jarring in the RPL – April 2012*. Figure 3.5 from this report (reproduced below as Figure 3-54) shows the ^{137}Cs adsorption by various freshly precipitated and aged metal hydroxides versus pH. Compounds identified in the damaged refractory, $Fe(OH)_3$ and $Al(OH)_3$, can remove a significant fraction of ^{137}Cs at solution pH of 6 to 9.



Source: PNNL-21836, 2012, *Characteristics of STP Pre-2004Archived KE Basin Sludge Samples Before and After Re-Jarring in the RPL – April 2012*, Pacific Northwest National Laboratory, Richland, Washington.

Figure 3-54. Adsorption of ^{137}Cs on Freshly Prepared Metal Hydroxides (left) and on the Metal Hydroxides after Ten Days of Aging (right) as a Function of the pH of the Solution.

The presence of calcium carbonate in samples of the degraded refractory suggests the chemical resistance testing of the refractory samples prepared and tested under laboratory conditions as reported in RPP-19097, Attachment 5, may not represent the true chemical resistance of the AY Farm refractory which could be much higher. Calcium carbonate generally has poor solubility in water and caustic, but solubility increases with dissolved CO_2 content. Most mineral formations of carbonates are facilitated by the transport of dissolved CO_2.

In response to the observed damage to the refractory, approximately 21 in. of the Kaolite 2200-LI refractory was removed from the perimeter underneath the AY-101 and AY-102 primary tanks in 1970. Kaiser "Chem-Comp" expansive reinforced concrete containing ⅜-in.

minus aggregate was used to replace the removed Kaolite 2200-LI refractory, as shown on drawing H-2-35299.

3.3.1.3 2003 Expert Analysis of Double-Shell Tank Refractory

In 2003, an internationally known expert on castable refractory, Dr. M. S. Crowley, provided an evaluation of the materials used in the different DST farms as to present strength, expected life remaining, and the susceptibility to loss of compressive strength if the refractory concrete is immersed in tank waste. Dr. Crowley estimated that the present refractory retained about 80 percent of its original compressive strength and that there was sufficient margin to conclude that the tanks were safe to operate now and for an additional 30 years or more. The analysis is included in RPP-19097.

Regarding chemical resistance, the chemical reaction that would cause one of the refractory materials to "decompose" when immersed in waste was not clear from the data available showing the constituents of the simulated tank waste. Dr. Crowley estimated it would take well in excess of one month for any reduction in strength of the refractory due to immersion in tank waste.

RPP-19097 states, "This would allow sufficient time to remove waste from the annulus area before any deleterious structural effects would occur." In other places in the document, he suggests that it will take as long as a year for waste to diffuse throughout the refractory.

It was further noted by Dr. Crawley that since the castables made in the 1960-1970s were usually 80-90 percent aggregate by volume with the remainder being cement, in the extreme case of complete destruction of the bond system within the castable by prolonged exposure to tank waste, there would still be a large volume of loose aggregate that would be restrained by the steel retainer ring around the perimeter of the refractory. The nature of the aggregate in the AY Farm refractory is unknown and none seems apparent from photographs of the damaged materials, nor is the addition of aggregate to the refractory concrete identified in the AY Farm construction specification HWS-7789, Section 9, "Insulating Concrete," but it is stated as a fact in RPP-19097.

> *The loose aggregate would consist of crushed insulating fire brick and other light weight fired materials which would continue to provide support for the primary tank. It is estimated that the primary tanks could settle only up to 1 in. even in the hypothetical event of total bond loss within the insulating concrete pad due to immersion in tank waste.*

3.3.1.4 Degradation Observed in the Refractory Concrete during In-Service Inspection

In the summer of 2003, an ultrasonic thickness inspection crew was performing a demonstration using the remote ultrasonic test inspection (RUTI) device on the bottom of Tank AZ-102 via the air slots in the refractory concrete. The camera showed material had fallen from the sides of the air slots and from cracks in the refractory. The apparent degradation and observed spalling raised concerns with the current and planned use of the AZ Farm and AY Farm tanks. The concern was documented in PER-2003-3066, "AZ-102 UT Discovers Concrete Insulation Pad Degraded." Recent inspections have also shown signs of concrete spallation in the air channels in Tank AY-102 (see Section 4.2.6).

Although the video evidence indicated that Tank AZ-102 had deteriorated more than expected, it was determined to be capable of meeting its structural and functional requirements. This conclusion was based on the following:

- An operability evaluation concluded that the leak detection systems were still operable and waste would still drain to the annulus leak detectors (Operability Evaluation #OE-03-0009, *Operability Evaluation for AZ-102 Primary Tank Leak Detection Systems*).
- An engineering evaluation previously performed for AW Farm demonstrated that some crushing of the refractory concrete was expected near the primary tank lower knuckle (RHO-C-17, *Additional Analyses of Underground Waste Storage Tanks 241-AW*). The video taken by the RUTI shows that most of the spalled material is under the knuckle region of the primary tank, where the bearing stresses were predicted to be higher. This analysis performed for AW Farm assumed that a 0.10-in. reduction in slab height near the lower knuckle of the primary tank would not result in overstressing of the primary tank. If all of the slots were filled with existing refractory concrete, the reduction in slab height would be approximately 0.1 in.
- Based on the video information available, there was no indication that enough refractory concrete had spalled into the cooling channels to preventing adequate cooling airflow under the primary tank.

Note that in AY Farm, 21 in. of the perimeter refractory was removed and replaced with structural concrete (see Section 3.2.5), so assumptions of uniform settlement do not apply and the analysis may not represent the condition in the AY Farm tanks. Additional structural analysis was recommended to better understand the expected performance of the refractory and its impact on the primary tank.

3.3.1.5 Settlement of the Primary Tank from Refractory Failure

Refractory Failure Analysis

In response to the PER-2003-3066 and concerns about chemical degradation of the refractory concrete discussed earlier and evaluated in RPP-19097, additional PNNL structural analysis was performed and reported in PNNL-14706, *DST Primary Tank Settlement Evaluation*. The results of the PNNL analysis concluded that, given extremely conservative conditions related to the failure of the refractory concrete, there would be no significant reduction in structural integrity of the primary tank.

In this PNNL study, settlement from postulated thermal cycling degradation of the refractory was estimated at a theoretical maximum uniform settlement of 0.1-in. Potential settlement in the event of waste leakage was estimated at a maximum uniform settlement of 1.0-in. In addition, a bounding uniform settlement of 2.0 in. was evaluated to provide a sensitivity measure of the effect of the settlement on the tank structure. The finite element analyses considered design live loads, dead loads, hydrostatic loads induced by stored waste, and temperature contributions. The concrete was assumed to start in a degraded strength condition based on a 350ºF waste design temperature. As discussed previously, 21 in. of the perimeter refractory in AY Farm was removed and replaced with structural concrete, so assumptions of uniform settlement do not apply and the analysis may not represent the condition seen in the AY Farm tanks.

Stress analysis results for the 0.1-in. settlement of the primary tank showed little change in the stress state of the overall DST response. The maximum additional displacement of the dome for the 0.1-in. settlement was approximately 0.038 in.

Uniform settlement of 1.0-in. results in plastic strain developing in the primary tank upper knuckle. The primary tank wall stress moves from compressive to tensile. The concrete stress increases only slightly and remains acceptable, except for the one section at the outer edge of the bottom foundation slab with a predicted code-based demand-to-capacity ratio of 1.08 (a noncritical area; does not indicate structural failure). A maximum dome displacement of 0.043 in. was predicted for the 1.0-in. settlement case.

Uniform settlement of 2.0 in. shows plastic strain in both the upper and lower knuckles of the primary tank. The tensile stress in the primary tank wall increases in magnitude. The concrete demand/capacity ratios show only a modest increase. Evaluation using a load-moment interaction diagram demonstrates acceptable section demand in all locations. A maximum dome displacement of 0.064 in. was predicted for this case (see Section 3.4).

Based on the assumptions of uniform settlement and the PNNL analysis, no design and operating limits needed to be changed as a result of the analysis of degradation of the refractory.

Primary Tank Settlement Effect

The refractory Kaolite between the primary tank and secondary liner was severely damaged during stress relieving of the AY Farm tanks. The outer 21 in. of the refractory was replaced with reinforced concrete to provide structural support to the side walls of the tank. Thus, the vast majority of the damaged (described as punky in the inspection reports and defined in Section 3.2.5) refractory concrete remained in place.

The punky material had little compressive strength remaining following the heat treatment. Prior to placement of the primary tank bottom, problems were noted with maintaining the depth of the refractory concrete. The four ventilation supply pipes run through the refractory concrete, which are supposed to have a minimum of 1 to 1¼ in. covering of refractory assuming an 8-in. refractory bed. A 10-in. pad was poured, which would have increased the covering to 3 to 3¼ in. Since the refractory surface deterioration was measured as ¾ to 1 in. deep, the thicker pad should provide adequate separation between the ventilation supply pipes and the tank bottom. Inspection worsened toward the edge of the pad. If the damaged refractory doesn't provide an adequate layer of insulation and cushioning for the ventilation supply pipes, a portion of the primary tank may be resting on the pipes.

Contact between the primary tank and the ventilation supply piping would lead to crevice corrosion if moisture is present. Crevice corrosion is analogous to galvanic corrosion, which involves two connected materials in a single environment. Crevice corrosion is one metal part in two connected environments. Normally, crevice corrosion can decrease with time because a gap could grow between the two surfaces in contact, disrupting the corrosion process by creating a single environment. However, the primary tank would have to continue to settle to maintain contact, thereby continuing crevice corrosion. As such, the corrosion could have occurred along any of the four ventilation pipes under Tank AY-102, which could allow waste to leak to the central plenum under the tank.

Although inconsistent with the observed condition and thickness of the refractory, the possibility of such a mechanism present in Tank AY-102 seems unlikely but cannot be entirely dismissed.

3.3.1.6 Caustic Chemical Resistance of Related Materials

The effect of caustic tank waste solutions on materials with aluminosilicate structures similar to the refractory material used for Tanks AY-101 and AY-102 was previously evaluated.

At B Plant, zeolite resins used for ion exchange, Linde AW-500 zeolite (chabazite, $[Na_4(AlO_2)_8(SiO_2)_{16}\bullet 26H_2O]$) and Zeolon 900 (mordenite, $[Na_8(AlO_2)_8(SiO_2)_{40}\bullet 24H_2O]$), were inadvertently dissolved and formed agglomerates from contact with high caustic solution (RHO-RE-SA-169, *Sixteen Years of Cesium Recovery Processing at Hanford's B Plant*). Hanford Site researchers evaluated dissolution of Linde AW-500 in sodium hydroxide solutions (Benton 1967). Similar tests were done with Zeolon 900 (RHO-RE-SR-83-26, *Process Aids – A Compilation of Technical Letters PUREX and B-Plant Processes, Miscellaneous Studies*, Book A, Volume 15, "Dissolution of Zeolon with Caustic Solutions," pages 337 – 342*)*. The dissolution mechanism appears to be dissolution of silicon and aluminum components from the zeolite crystals forming soluble $Si(OH)_4$ and $Al(OH)_4$.

Other studies were done by Choi et al. (2005), using a simulated tank waste leachate (2M Na^+, 1M OH^-, 1M NO_3^-) and various aluminum silicates mineral clays, montmorillonite $(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2{\cdot}nH_2O)$, illite, $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)])$, and vermiculite, $((Mg,Fe,Al)3(Al,Si)_4O_{10}(OH)_2\bullet 4(H_2O))$. The chemical structure of these clays is more complex than the refractory, but all contain an aluminum and silicon component. After 190 days of contact with the simulant, all the samples showed evidence of incongruent clay dissolution and the accumulation of secondary aluminosilicate precipitates.

These studies suggest that given enough time, it is likely that the caustic in the tank waste would dissolve at least the silicon and aluminum components of the refractory. The extent that this would need to occur to cause damage to the tank is not certain.

3.3.2 Summary of Chemical Resistance

The Kaolite 2200-LI used in the AY Farm was tested prior to use and showed reasonable resistance to simulated caustic tank waste based on laboratory studies and short-term exposure. Some decrease in strength in unfired, air-dried samples was noted, suggesting slight chemical attack of the cement binder, calcium aluminate.

Testing of unfired, air-dried samples of Kaolite 2000 showed poor resistance to simulated tank waste, with samples noted as decomposed after a 14-day exposure in tank waste. The chemical composition of Kaolite 2000 and 2200-LI is similar and there is no good explanation for the differences seen in testing of the air-dried samples. Additionally, the waste simulant used for chemical resistance testing on Kaolite samples is more dilute in caustic and nitrate than actual Tank AY-102 waste solutions; more attack could be anticipated with actual waste.

Based on chemical analysis of the damaged refractory found in the AY Farm and reported in ARH-1833, significant carbonation of the refractory occurred in the AY Farm. Chemical resistance tests of carefully prepared and properly cured laboratory samples may not be representative of the actual material in the refractory of the AY Farm tanks.

The refractory is very porous and capable of retaining a large amount of liquid in the event of a tank leak. The aluminum and silicon components of the refractory are likely to dissolve in caustic tank waste given enough time. They may reprecipitate as other aluminum-silicon compounds.

A recognized expert in the refractory industry reviewed all the DSTs in 2003 and concluded chemical resistance of the concrete was "unclear" based on the data presented. He also concluded that little settlement of the primary tank would occur in a worst-case condition, because of the presence of fired aggregate materials. However, there is no record that aggregate material was used in AY Farm construction.

A structural analysis done by PNNL in 2004 evaluated up to a 2-in. uniform settlement of the primary tanks from loss of refractory and concluded additional stresses were within allowable margins. This analysis might not be applicable in Tank AY-102, because uniform settlement would likely not occur due to the 21-in. structural concrete repair to the refractory.

3.4 DOME ELEVATION SURVEY AND HISTORY

3.4.1 Dome Load Controls

The loads placed on the soil surface above the buried Tank AY-102 are controlled by procedure TFC-ENG-FACSUP-C-10, *Control of Dome Loading*. The procedure requires that loads are tracked on dome load record summary sheets (DLRSS), which provide Operations information regarding the existing dome loads for comparison against the allowable concentrated load for each tank. Permanent dome loads for AY Farm are recorded and tracked in RPP-20260, *241-AY Tank Farm Historic Dome Load Record Data*.

The domes of the DSTs are periodically surveyed in accordance with RPP-25782, *DST Dome Survey Program*. Section 3.6 of RPP-25782 states that deflection of the tank dome up to approximately 0.5 in. is within dome load limits, according to RPP-RPT-25608, *Hanford Double-Shell Tank Thermal and Seismic Project-Increased Concentrated Load Analysis*. RPP-25782 also states that a measurable DST dome deflection of approximately 0.25 in. could be expected, but deflection in excess of 0.25 in. (approximately = 0.02 ft) would require further review. Dome deflection can be determined by subtracting the elevation at the center of the dome from the elevation at the perimeter of the tank. Settlement of the tank can be determined by subtracting the most current elevation at the perimeter of the tank from the first or oldest survey elevation at the perimeter of the tank.

3.4.2 Tank AY-102 Dome Survey Benchmarks

The dome deflection for Tank AY-102 is determined by reviewing the dome elevation survey data and the benchmark configuration of the tank dome. The general layout of the benchmarks for Tank AY-102 is shown in Figure 3-55. There are a total of eight benchmarks currently installed on Tank AY-102, attached to rectangular concrete structures (pits) or steel pipes (risers) that are directly connected to the tank domes. The two oldest benchmarks on the AY-02C sluice pit and Riser 77 have documented surveys dating back to 1984. The six newer benchmarks on the AY-02A pump pit and Risers 66, 72, 88, 89, and 91 have documented surveys starting in 2006. Locations of the dome risers and pits to which benchmarks are attached are shown on H-14-010506, "Dome Penetration Schedules (WST/WSTA) Tank 241-AY-102."

Tank AY-102 dome elevation surveys were last performed in June 2011. Once the dome elevation survey is recorded, it is documented in a revision of RPP-20260. A plot of the dome elevation data to-date is provided in Figure 3-56. The plot also contains two baselines at ±0.02 ft to show upper and lower bound limits that would require additional review by the structural engineering discipline lead.

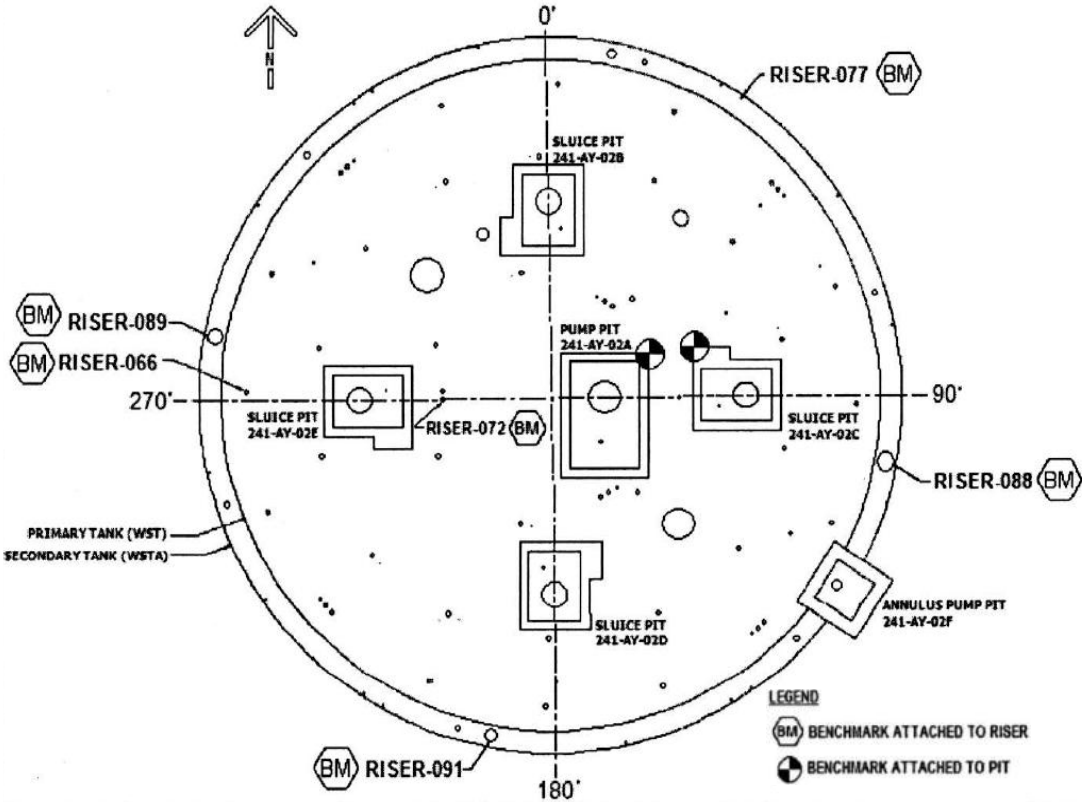


Figure 3-55. Tank AY-102 Dome Survey Benchmarks

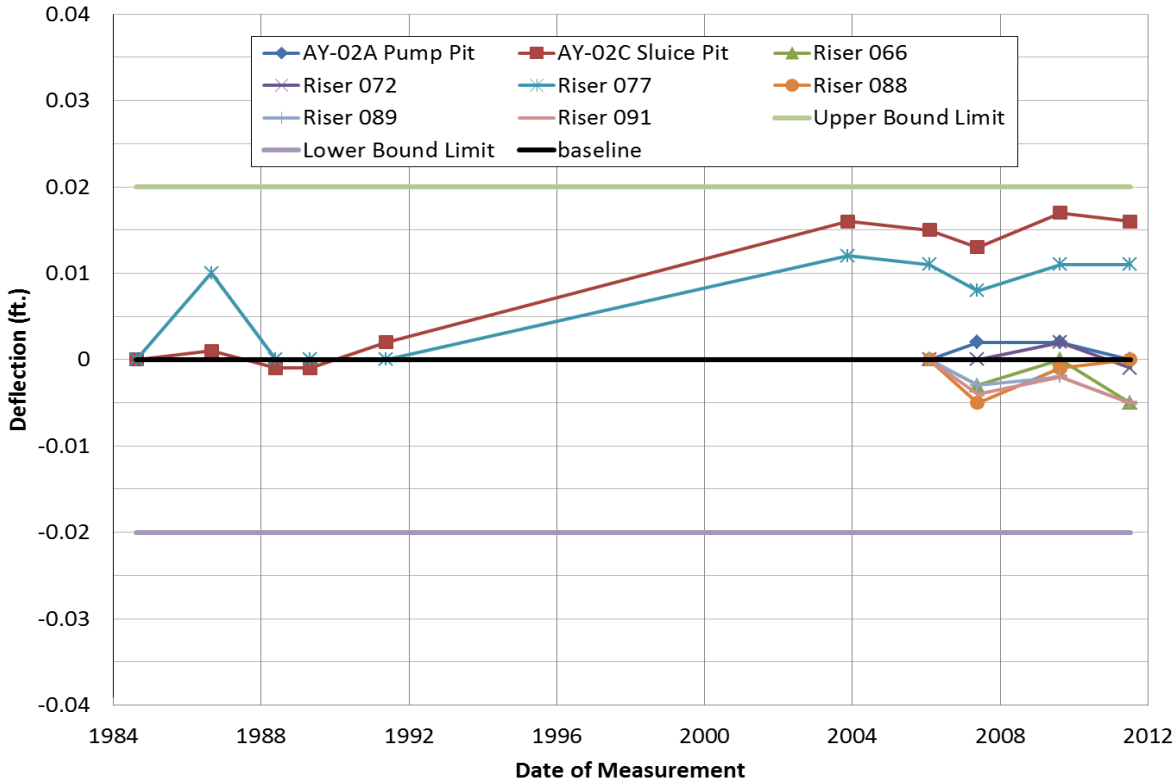


Figure 3-56. Tank AY-102 Dome Elevation Survey Data

3.4.3 Tank AY-102 Dome Survey Results

The dome survey data presented in Figure 3-56 shows the elevation changes dating back to 1984. All elevation changes are a result of comparing the initial elevation to the elevation recorded from the dome survey. The data for Riser 77 and AY-02C present the oldest recorded changes in dome elevation. Examination of the survey data reveals the greatest difference between benchmarks on Riser 77 and AY-02C is 0.016 ft or 0.192 in, which is well below the deflection criteria. The recorded dome elevation survey data for Tank AY-102 indicates excessive deflection of the Tank AY-102 dome has not occurred and that the dome structural integrity is intact.

3.5 TEMPERATURE ANALYSIS – DOME, REFRACTORY, CONCRETE PAD

Tank AY-102 is equipped with thermocouples embedded in the concrete foundation, refractory, and the tank dome. The available thermocouple data since 2006 was examined for indications of trends or other anomalies. Although historical data back to 1995 is available from the personal computer surveillance analysis computer system (PCSACS), 2006 was selected as the cut off because no unexplained material was observed in the annulus during the 2006 visual inspection (see Section 4.2.6).

3.5.1 Thermocouple Layout and Description

The thermocouples were procured in accordance with the AY Farm thermocouple procurement specification, HWS-7793, *Procurement Specification For Thermocouple & Strain Gage*

Assemblies Bldg 241-AY PUREX Tank Farm Expansion Project IAP-614, referencing the Instrument Society of America (ISA, now International Society of Automation) Recommended Practice ISA-RP1.3, *Thermocouples and Thermocouple Extension Wires*, Section 1.3, "Terminology, Limits of Error, and Wire Sizes." The thermocouples are ungrounded Type J (iron-constantan) of nominal 0.02-in. wire diameter, insulated with fused MgO, and sheathed with any 300-series stainless steel or Inconel tubing. The leads are insulated with an unspecified material, and the junction with the sheath is epoxy coated.

Refractory thermocouples were placed in contact with the bottom of the primary tank, as shown on H-2-64372, "Instrumentation Insulating Concrete Plan & Details." Concrete foundation thermocouples were recessed 3 in. from the bottom of the secondary liner (H-2-64374, "Instrumentation Concrete Foundation Tank 102 - Plan & Details"). Dome thermocouple placement is shown in H-2-64375, "Instrumentation Concrete Dome Plan & Details." Figure 3-57 and Figure 3-58 show the layout and operating status of thermocouples in the Tank AY-102 refractory and concrete foundation.

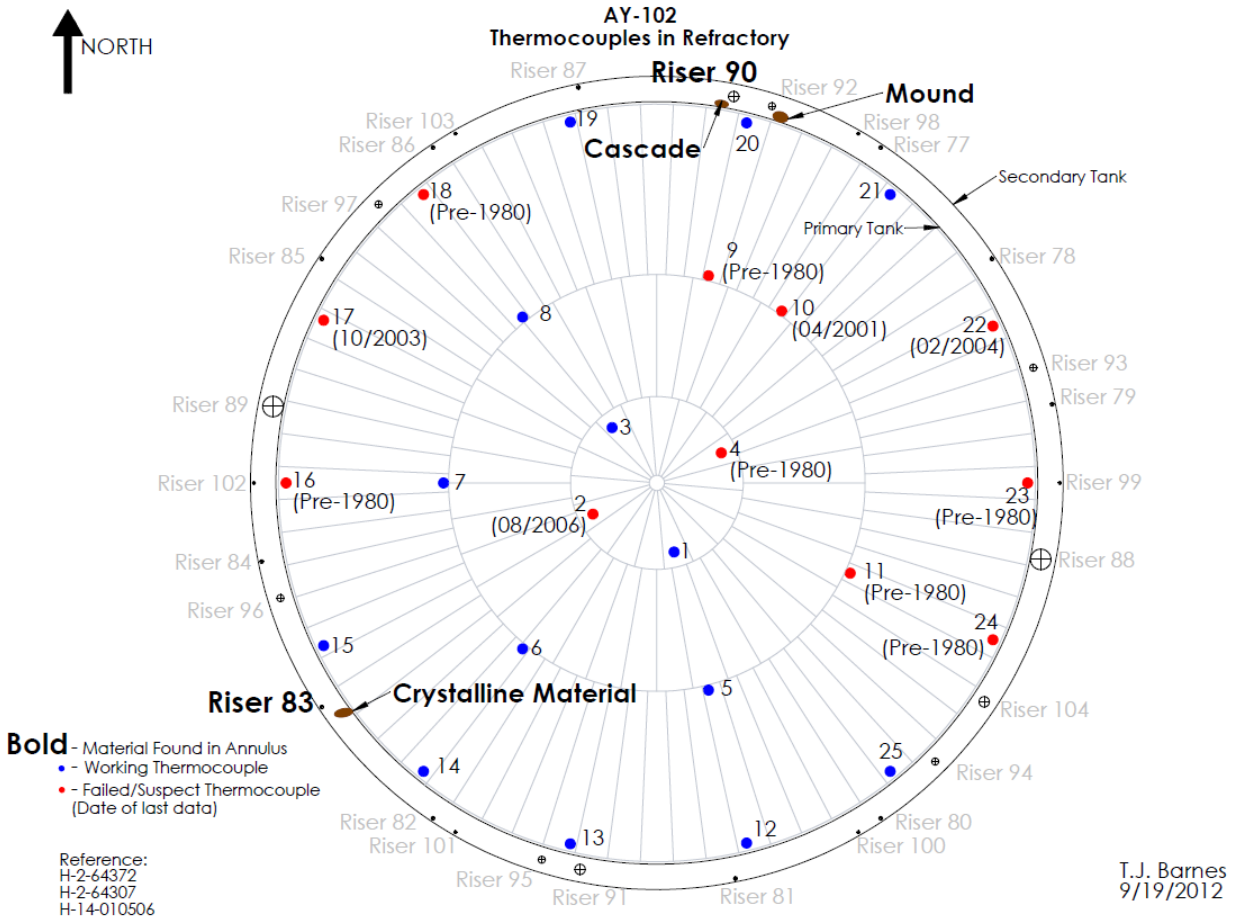


Figure 3-57. Tank AY-102 Refractory Thermocouple Operating Status as of August 2012

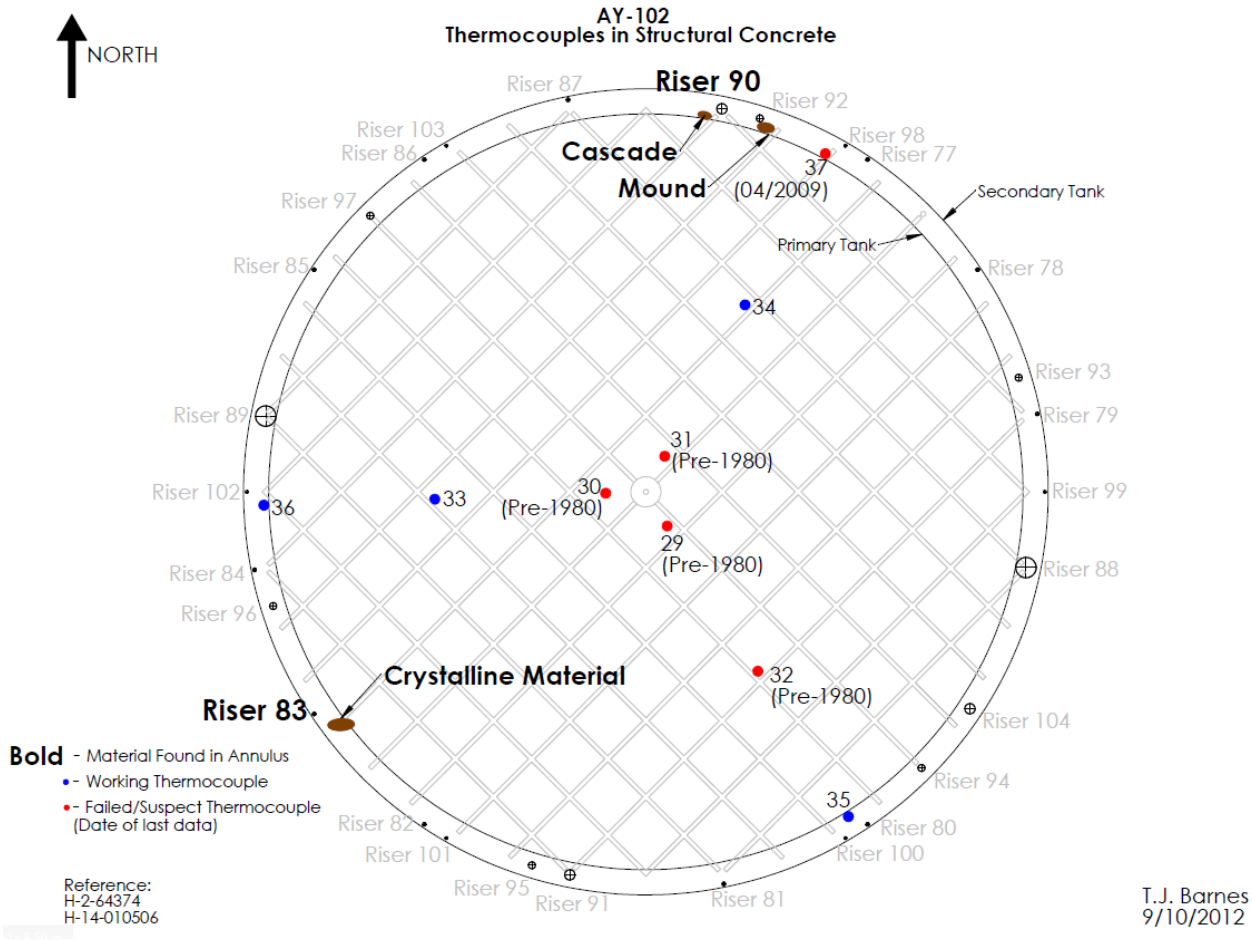


Figure 3-58. Tank AY-102 Foundation Thermocouple Operating Status as of August 2012

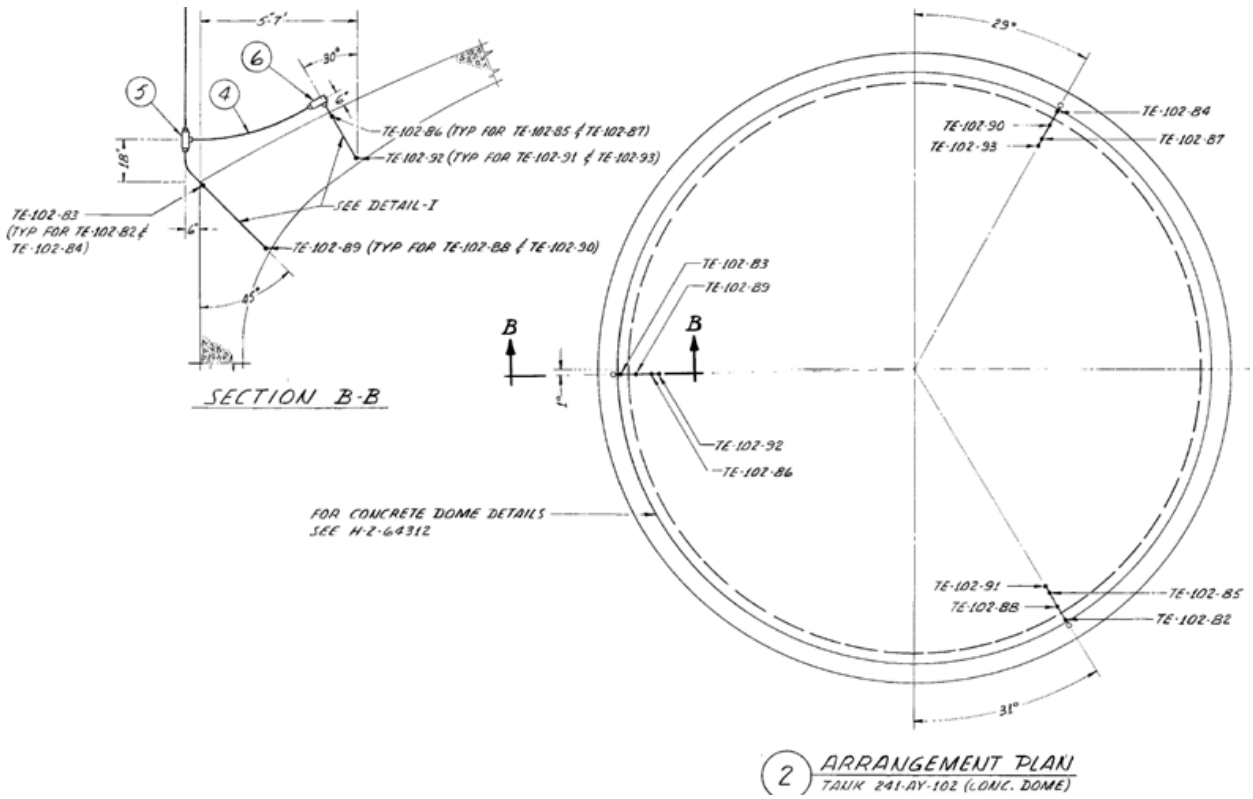


Figure 3-59. Tank AY-102 Dome Thermocouple Locations

Thermocouples labeled 1 to 25 are embedded in the refractory between the primary and secondary steel tanks. They are organized in three concentric rings with radii of 7 ft, 21 ft, and 36.5 ft (see Figure 3-57 for locations). Thermocouples 26 and 27 are mounted on the tank knuckle, but have no available data and are not discussed further. Thermocouples 29 to 37 are embedded in the concrete foundation underneath the secondary liner. They are organized in sets of three in three laterals located 4, 21, and 38 ft from the center of the tank, 120° apart (see Figure 3-58 for locations). Thermocouples 82 to 93 are organized in the haunch region of the tank, in two sets of internal and external pairs, spaced 120 degrees apart, as shown in Figure 3-59.

Table 3-7 presents the operating status of the thermocouples since 1995, based on available good or transcribed data in PCSACS. There are no records available for years prior to 1995.

Table 3-7. Tank AY-102 Thermocouple Operation Status Since 1995

Thermocouple	Operation Status	Thermocouple	Operation Status
TE-102-1	1/1995-current	TE-102-25	3/01-11/04, 8/06-current
TE-102-2	3/01-11/04, 8/06	TE-102-26	None
TE-102-3	8/06-current	TE-102-27	None
TE-102-4	None	TE-102-29	None
TE-102-5	3/01-current	TE-102-30	None
TE-102-6	8/06-current	TE-102-31	None
TE-102-7	8/06-current	TE-102-32	None
TE-102-8	3/01-11/04, 8/06-current	TE-102-33	8/06-current
TE-102-9	None	TE-102-34	8/06-current
TE-102-10	1/95-4/01	TE-102-35	8/06-current
TE-102-11	None	TE-102-36	8/06-current
TE-102-12	8/06-current	TE-102-37	8/06-4/09
TE-102-13	8/06-current	TE-102-82	8/06-current
TE-102-14	3/01-11/04, 8/06-current	TE-102-83	None
TE-102-15	8/06-current	TE-102-84	8/06-current
TE-102-16	None	TE-102-85	None
TE-102-17	3/01-10/03	TE-102-86	8/06-current
TE-102-18	None	TE-102-87	None
TE-102-19	8/06-current	TE-102-88	8/06-current
TE-102-20	8/06-current	TE-102-89	8/06-current
TE-102-21	8/06-current	TE-102-90	8/06-current
TE-102-22	3/01-9/03	TE-102-91	8/06-current
TE-102-23	None	TE-102-92	None
TE-102-24	None	TE-102-93	None

For purposes of this analysis, it is assumed that those listed in Table 3-7 with “None” failed prior to 1995. Thermocouples TE-102-02, TE-102-10, and TE-102-22 failed between 2001 and 2004. TE-102-37 failed in 2009, the only thermocouple to do so since the 2006 visual inspection.

3.5.2 Tank Concrete Temperature Operating Specifications

OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*, establishes the structural concrete temperature limits for the tank. The limits include maximum temperature, maximum temperature rate of change, and maximum temperature gradient. The requirements relative to concrete temperature are listed in Table 3-8.

Table 3-8. Double-Shell Tank Operating Specification Document Concrete Temperature Requirements

Maximum Temperature	Dome	160°F
	Wall	350°F
Bulk Temperature Change	<125°F	10°F/hr
	≥125°F	≤3°F/day or ≤24°F/day if tank temperature kept constant at ±3°F for 8 days thereafter
Temperature Gradient	≤18°F/ft	

3.5.3 Temperature History Data

The temperature history data in Figure 3-60 through Figure 3-64 are organized by configuration; for example, the thermocouples in the refractory are grouped by concentric rings. Temperature patterns and discontinuities become apparent using this relative comparison technique. During analysis, it was found that the temperature data had a strong correlation with annulus ventilation operations and with seasonal temperatures, as expected. The operating status of the ventilation systems was gathered from system logbooks and is included with the presented thermocouple data. Only outages of approximately a day or longer were included. The ventilation outages displayed are for graphical comparison purposes only and are not all-inclusive. Periods of operation characterized by greater downtime than operation were grouped together as downtime for display. Ventilation operating status is discussed in Sections 4.1.5 and 4.2.2.

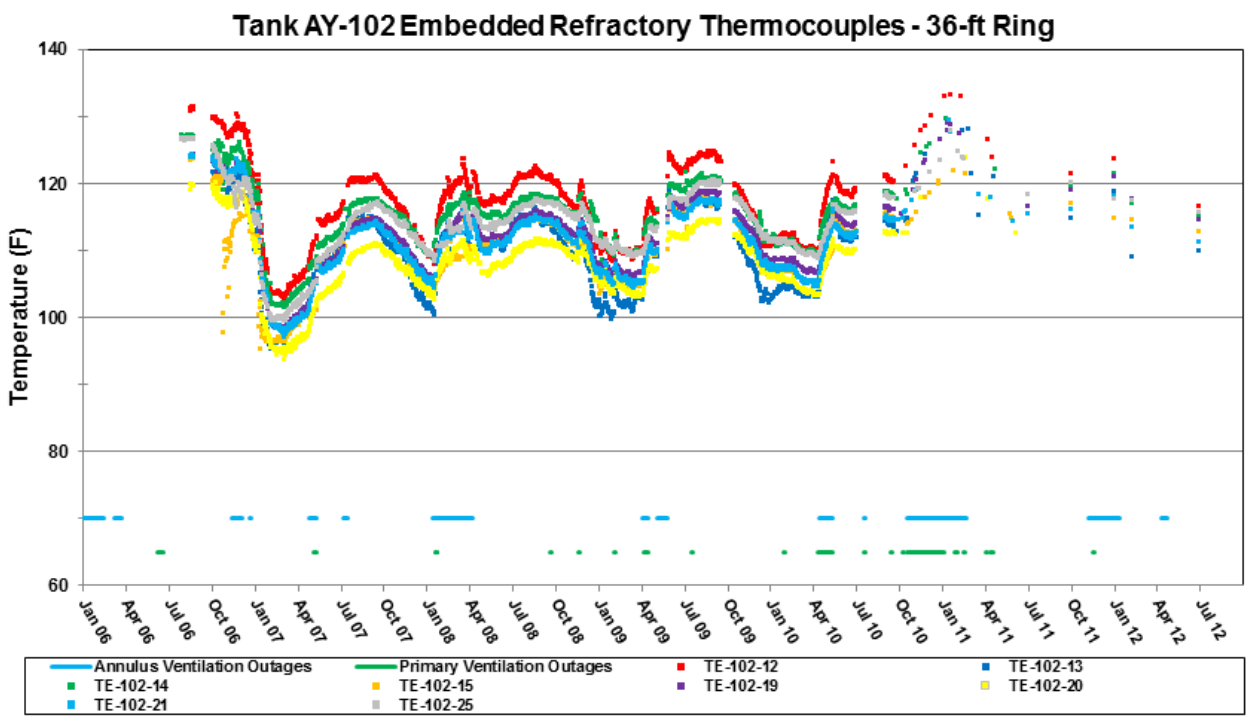


Figure 3-60. Tank AY-102 Refractory Thermocouple History since 2006 – Outer Ring

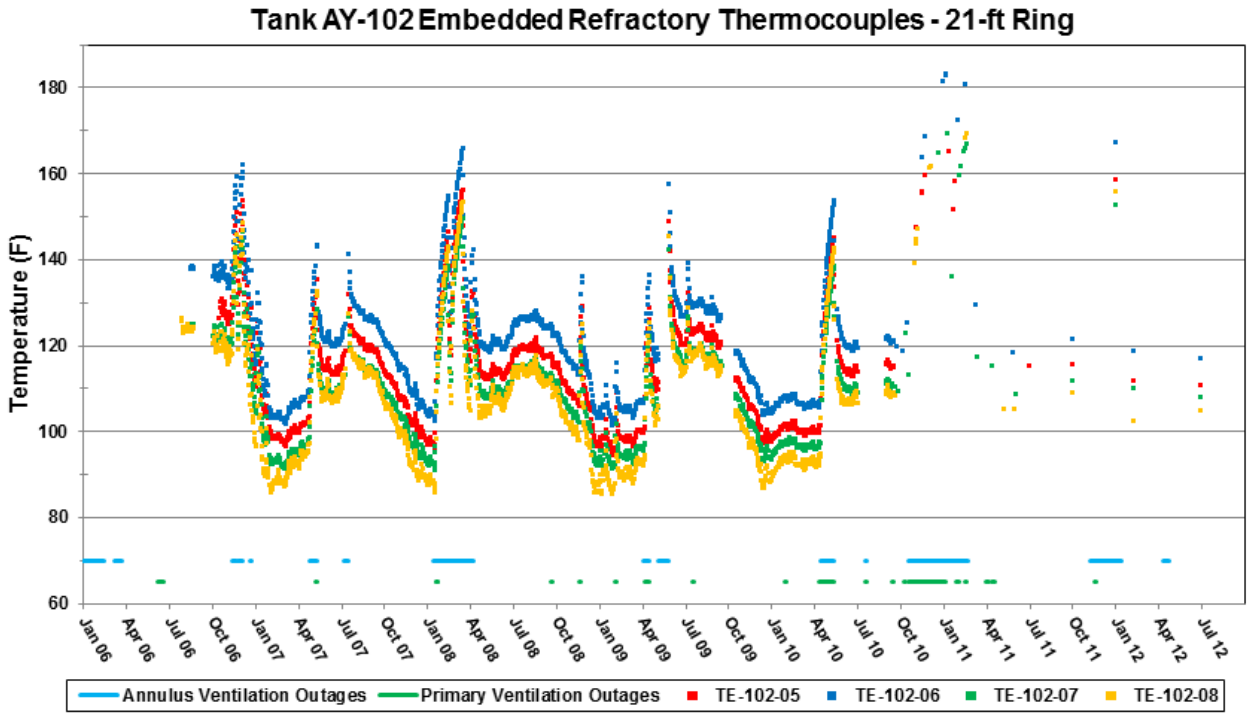


Figure 3-61. Tank AY-102 Refractory Thermocouple History since 2006 – Middle Ring

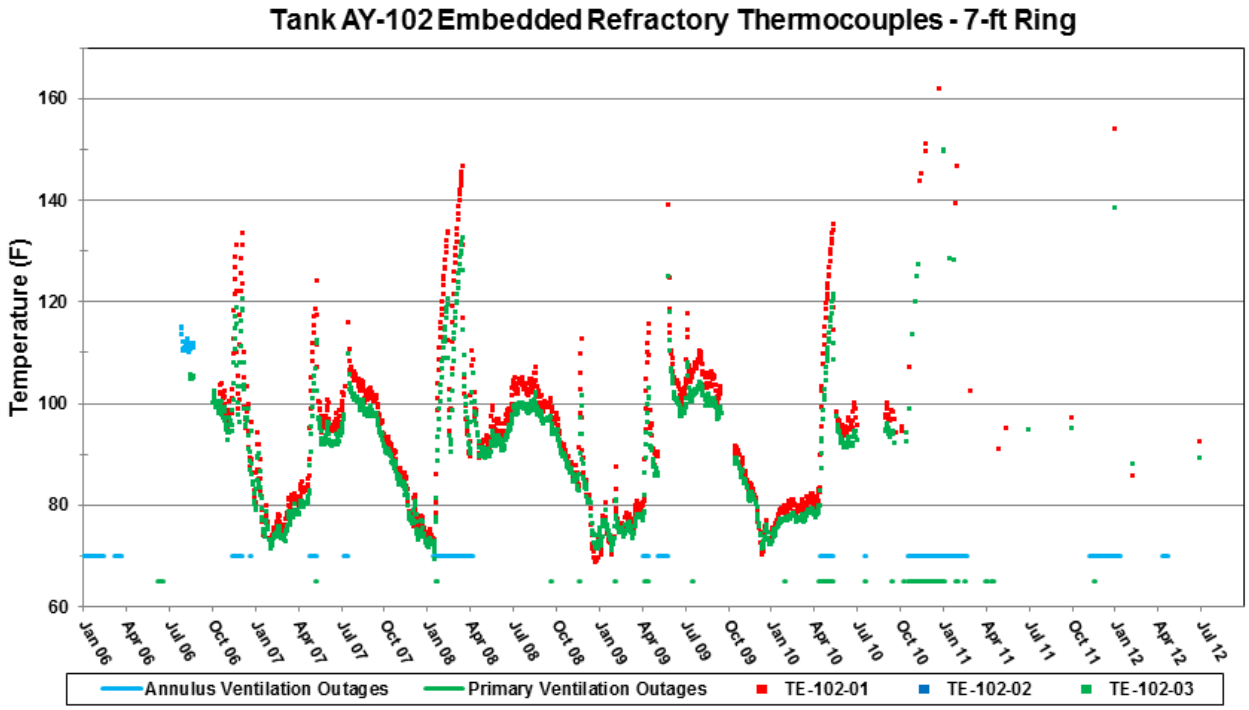


Figure 3-62. Tank AY-102 Refractory Thermocouple History Since 2006 – Inner Ring

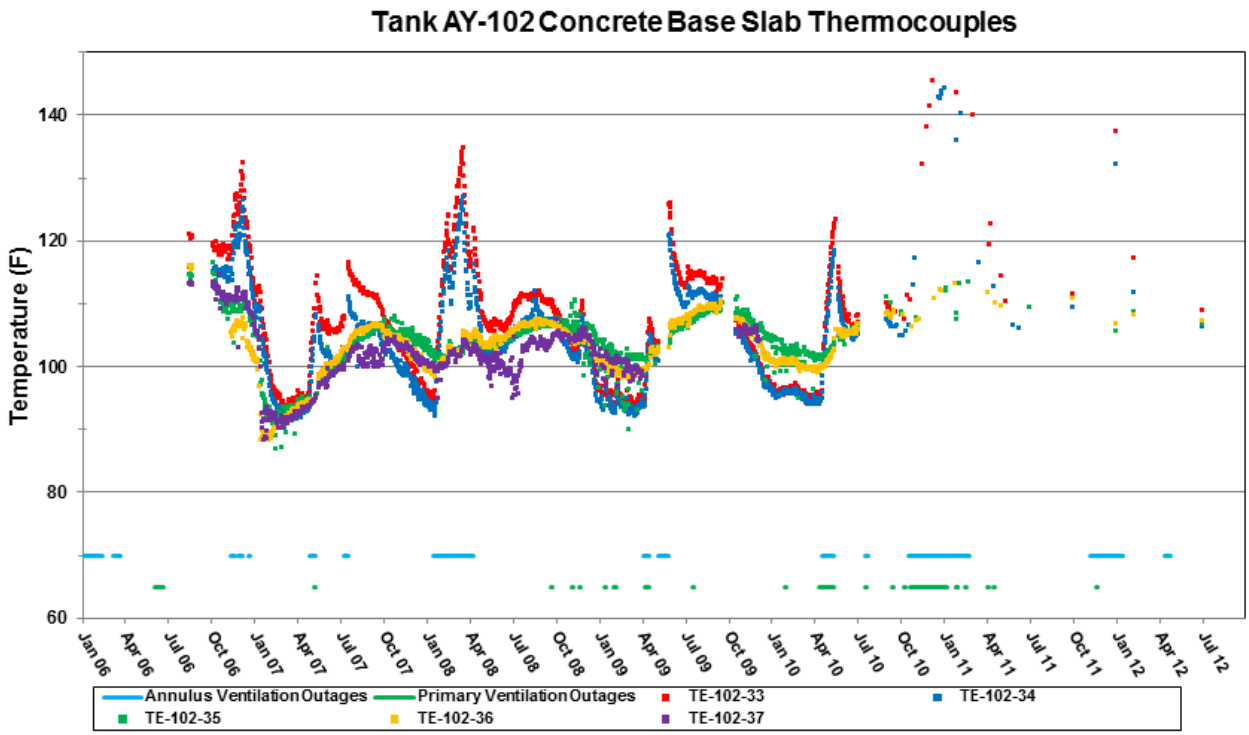


Figure 3-63. Tank AY-102 Concrete Foundation Thermocouple History Since 2006

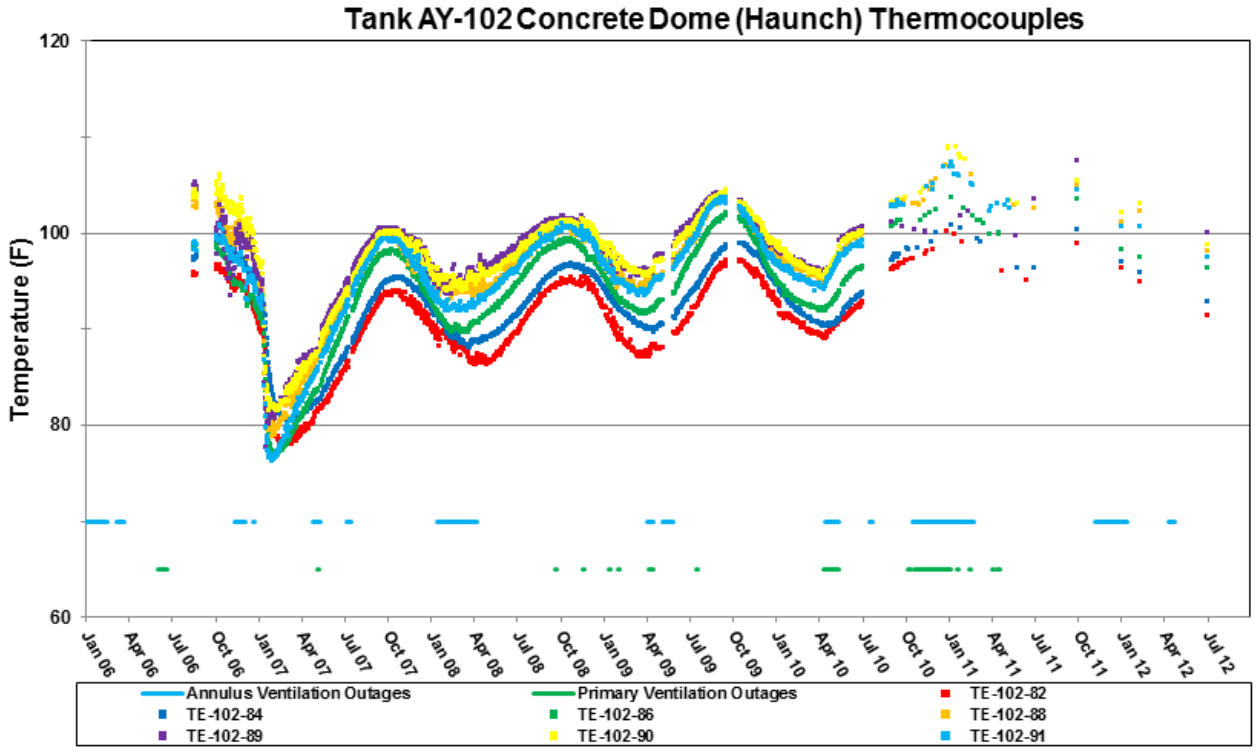


Figure 3-64. Tank AY-102 Concrete Dome Thermocouple History Since 2006

3.5.4 Annulus Ventilation Outages and Temperature Rise

The dependence of tank concrete temperature on annulus ventilation operating status is readily visible for thermocouples in the inner portions of the tank, including those in the foundation. The operating status of the primary ventilation has a minor impact by comparison.

To determine whether or not changes in the annulus ventilation system operation could result in a concrete bulk temperature operating specification violation, the behavior of thermocouples TE-102-01 and TE-102-06 was reviewed for the January 2008 outage. Beginning on January 17, 2008, the temperature of TE-102-01 increased within the 10°F/hr limit, while the refractory temperature was ≤125°F. The temperature increased within the 3°F/day limit, while above 125°F until February 14, 2008, when the ventilation was then briefly operated. During the time between ventilation startup and its shutdown on February 20, 2008, the temperature decrease rate exceeded 3°F/day for this particular thermocouple. Similar changes were experienced between March 16 and March 18, 2008, as illustrated in Table 3-9, and at other times. From inspection of Figure 3-60 through Figure 3-64, it is apparent that the most dramatic temperature changes occur toward the centerline of the tank, with the effects of the annulus ventilation restart less significant as the distance from the tank center increases. The aggregated bulk temperature of the concrete experiences temperature change in response to annulus ventilation changes, but the operating specification limits are challenged only in localized areas.

Table 3-9. Thermocouple TE-102-01 Refractory Temperature Data – January 2008 (2 pages)

Date/Time	°F	°F/day	Date/Time	°F	°F/day
01/17/2008 09:10	70.9	-	02/18/2008 03:00	94.5	-4.0
01/18/2008 04:51	78.5	9.3	02/19/2008 00:00	92.5	-2.3
01/18/2008 10:50	80.6	8.4	02/20/2008 03:00	90.6	-1.7
01/19/2008 04:30	86	7.3	02/21/2008 02:50	98.9	8.4
01/22/2008 03:40	98.6	4.2	02/22/2008 01:50	107	8.5
01/23/2008 00:00	101.1	3.0	02/23/2008 01:40	112.3	5.3
01/24/2008 00:00	104	2.9	02/24/2008 00:00	116	4.0
01/25/2008 00:00	106.5	2.5	02/25/2008 00:00	119.2	3.2
01/26/2008 00:00	108.6	2.1	02/26/2008 00:00	121.7	2.5
01/27/2008 00:00	110.9	2.3	02/27/2008 00:00	124.1	2.4
01/28/2008 00:00	113	2.1	02/28/2008 00:00	126	1.9
01/29/2008 00:00	114.7	1.7	02/29/2008 00:00	127.8	1.8
01/30/2008 00:00	116.1	1.4	03/01/2008 00:00	129.2	1.4
01/31/2008 00:00	117.4	1.3	03/02/2008 00:00	130.6	1.4
02/01/2008 00:00	118.5	1.1	03/03/2008 00:00	131.9	1.3

Table 3-9. Thermocouple TE-102-01 Refractory Temperature Data – January 2008 (2 pages)

Date/Time	°F	°F/day	Date/Time	°F	°F/day
02/02/2008 00:00	120.1	1.6	03/04/2008 00:00	133.2	1.3
02/03/2008 00:00	121.6	1.5	03/05/2008 00:00	134.4	1.2
02/04/2008 00:00	123.2	1.6	03/06/2008 00:00	136.2	1.8
02/05/2008 00:01	124.4	1.2	03/07/2008 00:00	137.4	1.2
02/06/2008 00:01	125.1	0.7	03/08/2008 00:00	138.8	1.4
02/07/2008 00:00	126.4	1.3	03/09/2008 00:00	139.9	1.1
02/08/2008 00:00	126.7	0.3	03/10/2008 00:00	141.1	1.2
02/09/2008 00:00	128.2	1.5	03/11/2008 00:00	142.1	1.0
02/10/2008 00:00	129.9	1.7	03/12/2008 00:00	142.9	0.8
02/11/2008 00:00	131	1.1	03/13/2008 00:00	143.9	1.0
02/12/2008 00:00	132.2	1.2	03/14/2008 00:00	144.7	0.8
02/13/2008 01:10	133.7	1.4	03/15/2008 00:00	145.7	1.0
02/14/2008 00:00	133.8	0.1	03/16/2008 00:00	146.7	1.0
02/15/2008 03:40	112.5	-18.5	03/17/2008 02:10	131.3	-14.1
02/16/2008 03:20	102.9	-9.7	03/18/2008 02:20	116.8	-14.4
02/17/2008 01:30	98.8	-4.4	03/19/2008 03:40	109.4	-7.0

The specification for linear temperature gradients is 18°F/ft. No instances were identified in which the linear temperature gradient was exceeded.

3.5.5 Tank AY-101 and AY-102 Thermocouple Failure Patterns

A comparison of Tank AY-101 and AY-102 thermocouple failure patterns was performed for the concrete foundation and the refractory thermocouples on the premise that significant unexplained differences could suggest if, where, or when a change in the Tank AY-102 integrity status occurred. The two tanks are mirror-images, as are their thermocouple layouts. Table 3-10 summarizes the operating thermocouples in the concrete foundation and the refractory for each tank. The thermocouple location and current operating condition are illustrated graphically in Figure 3-65 and Figure 3-66.

Table 3-10. Tank AY-101 and AY-102 Thermocouples Operable as of August 2012

Refractory	AY-101	AY-102
7-ft ring	3 of 4	2 of 4
21-ft ring	8 of 8	4 of 8
36-ft ring	9 of 13	8 of 13
Base slab	0 of 9	4 of 9

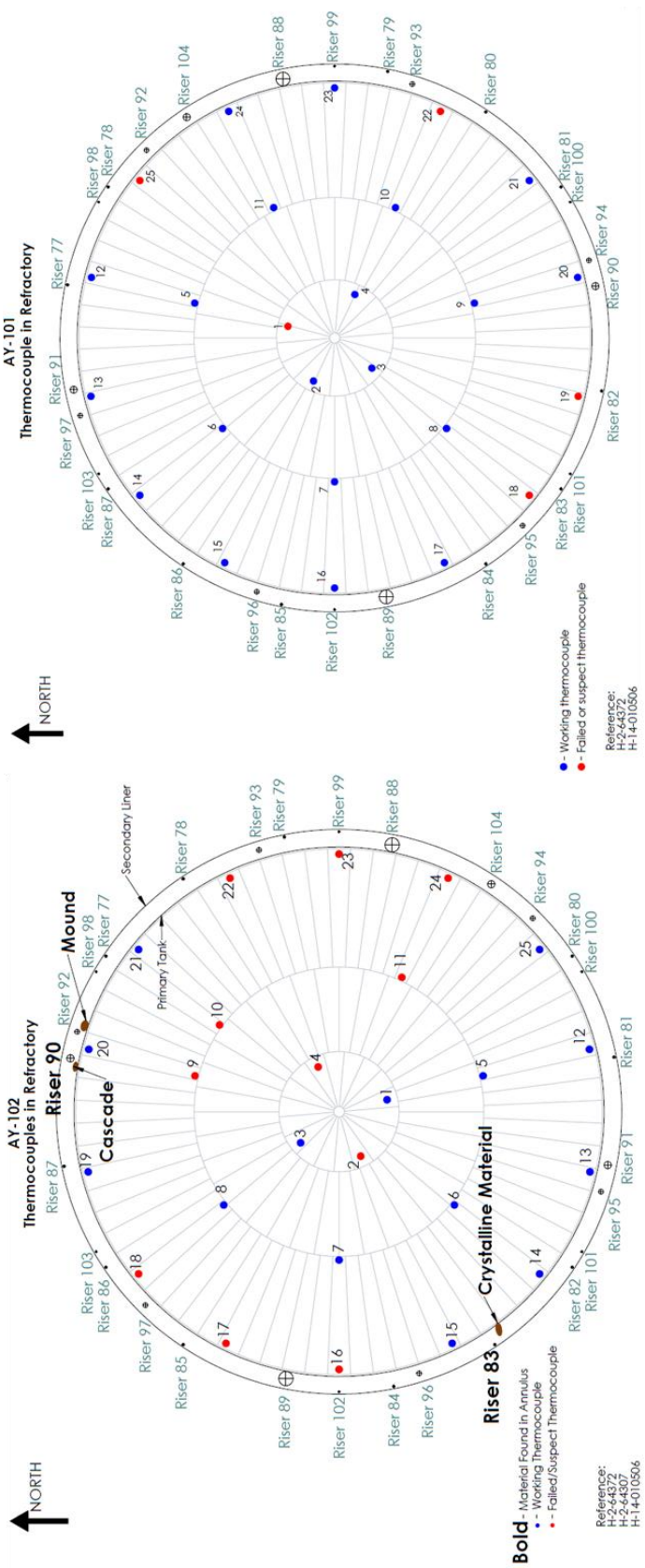


Figure 3-65. Tank AY-102 Refractory Thermocouple Comparison to Tank AY-101

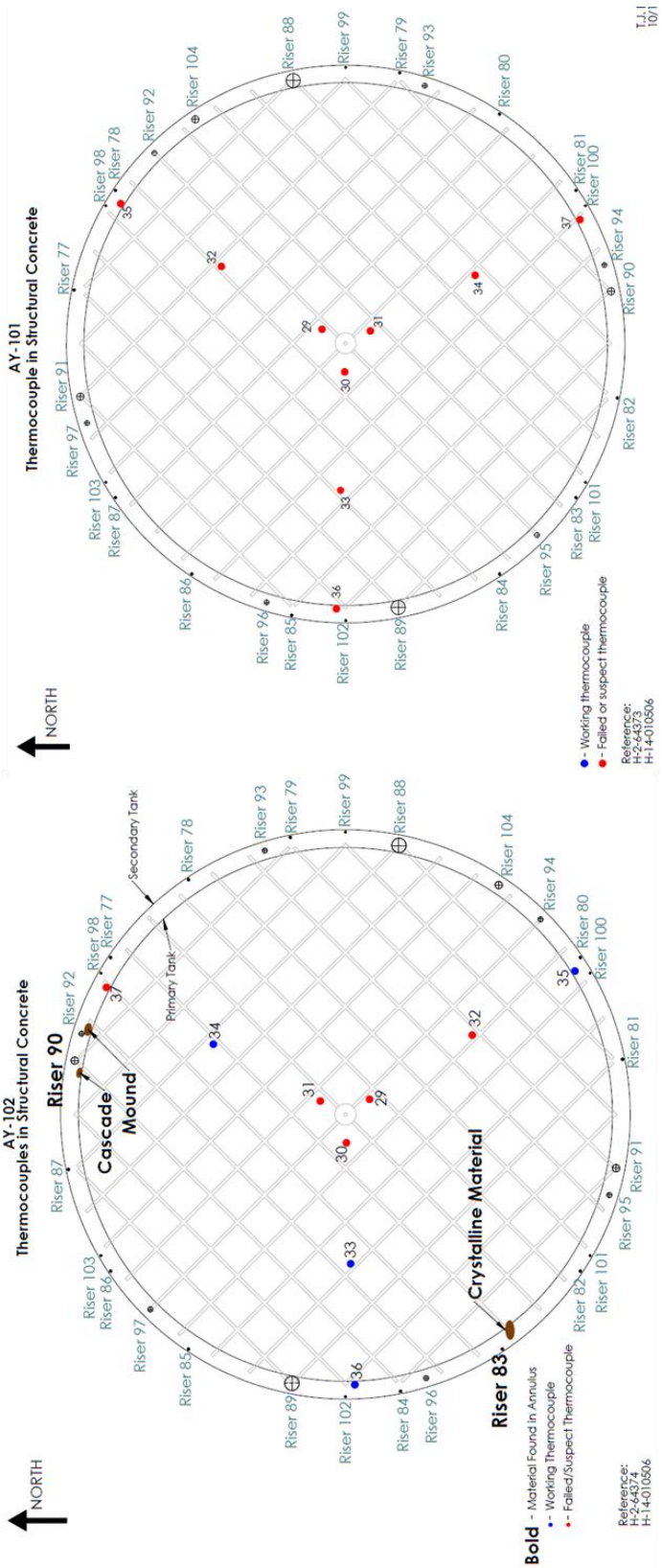


Figure 3-66. Tank AY-102 Concrete Foundation Thermocouple Comparison to Tank AY-101

In general, the thermocouples in the Tank AY-101 refractory have fewer failures than those in Tank AY-102, while the reverse is true for the foundation thermocouples. The construction history of Tank AY-102, including secondary liner bulges that are suspected to have left cracks in the refractory, suggest that the failure pattern differences in the refractory thermocouples are a construction artifact.

There is no failure pattern evident that suggests a leak site location, or gives any indication of when a leak might have occurred.

Thermocouple TE-102-37, located in the concrete foundation, is the only thermocouple to have failed since the previous annulus video inspection in 2006. No documentation was found explaining this failure.

3.5.5.1 Summary

Tank AY-102 was built with 48 thermocouples outside the primary tank, located in four areas: 25 in the refractory, two on the primary tank knuckle, nine in the concrete foundation, and 12 in the dome haunch region. Of those 48 thermocouples, 14 in the refractory, four in the foundation, and seven in the dome haunch are functional and recording data in PCSACS. The thermocouples show no failure pattern that would be indicative of a change in tank integrity.

Since the annulus visual inspection in 2006, TE-102-37 is the only thermocouple to have failed (April 2009). TE-102-37 is embedded in the concrete foundation below Riser 98, which is in proximity (10-15 ft) to Risers 90 and 92 where the mound and cascades of material were discovered.

Graphical comparisons of thermocouple failures in the refractory and the concrete foundations for Tanks AY-101 and AY-102 do not identify any meaningful differences that can be attributable to a change in the leak integrity of Tank AY-102 (see Figure 3-65 and Figure 3-66).

3.6 STRUCTURAL UPGRADES HISTORY

The project history for Tank AY-102 was examined in order to determine where the source of the unexplained annulus material could have been external to the tank. Table 3-11 lists the structural projects that affected Tank AY-102 and may have provided an entry route for foreign materials to enter the annulus space.

Project B-131, Terminal Liquor Transfer Facility AX-AY-AZ, took place in the 1977 to 1980 timeframe. The project installed transfer lines and jumpers connecting Tanks AY-101, AY-102, AZ-101, and AZ-102 to Valve pits 241-AX-A and 241-AX-B, allowing a route to the 242-A Evaporator (H-2-70760, “Engineering Flow Diagram Valve Pits to 241-AX, AY, and AZ Tanks”).

A crack or failure could have occurred near one of the inlet pipes (since installation under Project B-672), allowing debris and runoff to be sucked into the annulus at such a point, though there is no evidence supporting this scenario. Any dirt or debris from construction activities would have been present in the 2006 video inspections.

Table 3-11. Upgrade Projects in the AY Farm and for Tank AY-102 (2 pages)

Project Number	Title (Reference)	~Date Range	Brief Summary	Relevance
B-131	Terminal Liquor Transfer Facility AX-AY-AZ (H-2-70760[a])	1977 – 1980s	Installation of transfer lines and jumpers connecting Tanks AY-102, AY-101, AZ-101, and AZ-102 to valve pits 241-AX-A and 241-AX-B.	Allowed a route to the 242-A Evaporator.
B-181	241-AX Valve Pit Drain Reroute (B-181 [1010050556][b])	1980 – 1982	Isolated tanks (including Tank AY-102) from water intrusion by removing cleanout boxes from service, and sealing risers, pipes, pit covers, catch ways, surface condensers, water, steam, and air lines.	Protection from water intrusion.
B-220	Waste Transfer Facilities (H-2-94019[c])	1985 – 1986	Made structural modifications to pits 241-AY-01D, 241-AY-02D, 241-AY-01A, 241-AY-02A, and installed additional transfer piping, installed cathodic protection and associated instrumentation.	Allowed additional waste transfer routes and upgraded corrosion protection for buried systems.
B-672	241-AY Annulus Ventilation Duct Upgrade (H-2-77323[d] and H-2-77324[e])	1987 – 1989	Abandoned the original annulus ventilation system in place, cut and capped piping, installed new/upgraded ventilation system.	Severely corroded annulus piping was discovered. New piping was designed with corrosion protection.
W-020H/ W-430	Waste Management Facility Cathodic Protection Upgrade (WHC-SD-W020H-OTP-001[f])	1989 – 1996	Provided cathodic protection around the A Farm complex (including AY Farm).	Upgraded corrosion protection.
W-030	Tank Farm Ventilation Upgrade (HNF-SD-600-FDC-001[g])	~1990 – 1998	Construction of the 702-AZ ventilation system replaced the 702-A ventilation system, provided tank inlet stations, and sealed cover blocks.	Existing system was contaminated and degrading as it approached its design life. It had not been designed to allow repairs.

Table 3-11. Upgrade Projects in the AY Farm and for Tank AY-102 (2 pages)

Project Number	Title (Reference)	~Date Range	Brief Summary	Relevance
W-211	Initial Tank Retrieval Systems (H-14-106417,[h] H-14-106418,[i] and H-14-030007[j])	1990s	Installed a dilution-flush system and the electrical system needed to supply power to transfer and mixer pumps.	Neither the transfer nor the mixer pumps were installed in Tank AY-102. The electrical system was installed though never used. System has never gone through operational acceptance.
W-314	Tank Farm Restoration and Safe Operations (RPP-6012[k])	1990s	Modified 241-AY-01A and 241-AY-02A pit cover blocks and walls to install leak detection probes, ball valves, and transfer piping.	Improved monitoring capabilities to support transfers through these pits.
W-320	Tank 241-C-106 Sluicing	1990s – 1998	Modified the transfer piping, Tank AY-102 annulus ventilation system, conduit, core drilled concrete, installed both a vertical and a horizontal booster pump.	Upgrades to the annulus ventilation system were made to allow SST C-106 to be emptied into Tank AY-102.
E-525	DST Transfer System Modifications	2000s	Bypassed the 241-AZ-151 catch tank and installed a new 1,200-gal 241-AZ-301 condensate receiver tank that provides secondary containment and pumps condensate to receiver Tank AY-101.	Not relevant as the distribution line back to Tank AY-102 has not yet been installed.

[a] H-2-70760, 2003, "Engineering Flow Diagram Valve Pits to 241-AX, AY, and AZ Tanks," Rev. 2, Vitro Engineering Corporation, Richland, Washington.

[b] RHO-CD-738-FDL, 1982, *Functional Design Criteria Isolation of Single-Shell Tanks, 100 Areas Project B-181*, Rev. 2, Rockwell Hanford Operations, Richland, Washington (IDMS 1010050556).

[c] H-2-94019, 1986, "Piping Supports and Details Line V720," Rev. 1, Kaiser Engineers Hanford Company, Richland, Washington.

[d] H-2-77323, 1996, "Abandoned Annulus Vent Piping Tank 241-AY-102," Rev. 2, Kaiser Engineers Hanford Company, Richland, Washington.

[e] H-2-77324, 1996, "Annulus Vent Piping TK-102 241-AY Tank Farm," Rev. 2, Kaiser Engineers Hanford Company, Richland, Washington.

[f] WHC-SD-W020H-OTP-001, 1992, *Final Energization Survey Report Project W-020H, Primary 1, A-Tank Farm Complex*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

[g] HNF-SD-600-FDC-001, 1997, *Functional Design Criteria for the Tank Farm Ventilation Upgrade, Project W-030*, Rev. 4, Numatec Hanford Company, Richland, Washington.

[h] H-14-106417, 2004, "W-211 Initial Tank Retrieval Systems AY Tank Farm 3" PW-404-M9 Installation, Drawing List and Area Map," Rev. 0, CH2M Hill Hanford Group, Inc., Richland, Washington.

[i] H-14-106418, 2004, "W-211 Initial Tank Retrieval Systems AY Tank Farm 3" PW-404-M9 Installation, Drawing List and Area Map," Rev. 0, CH2M Hill Hanford Group, Inc., Richland, Washington.

[j] H-14-030007, 2010, "Electrical (EDS) Panelboard Schedule," Rev. 18, Washington River Protection Solutions, Richland, Washington.

[k] RPP-6012, 2003, *Project W-314, Phase 1 AY Tank Farm Upgrade Acceptance for Beneficial Use*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

DST = double-shell tank. SST = single-shell tank.

The line specific to Tank AY-102 is the 2-in. SL-504-M25 with 4-in. ENC-M26α, which connects to the 241-AY-01D pit. Also added was the 2-in. DR-700-M25 drain line connecting to a cleanout box (COB-AY-1).

Project B-181 took place in the 1980 to 1982 timeframe and removed from service and sealed cleanout boxes connected to Tank AY-102 (H-2-90252, "Piping Plan Electrical Plan," and H-2-90253, "Piping Plan and Drawing List"). The purpose of this project was to isolate tanks by sealing tank dome risers, sealing pipe lines and pit covers, removing surface condensers and sealing the catch ways, providing ventilation systems, and severing and sealing water, steam, and air lines (RHO-CD-738-FDL, *Functional Design Criteria Isolation of Single-Shell Tanks, 100 Areas Project B-181*).

During 1985 and 1986, Project B-220 made structural modifications to the 241-AY-01D and 241-AY-02D sluice pits and the 241-AY-01A and 241-AY-02A pump pits, and also provided transfer piping, cathodic protection, and instrumentation.

In March 1986, the AY Farm annulus ventilation underground ductwork was found to be severely corroded. Project B-672, completed by 1987-1988, replaced and upgraded the underground annulus ventilation piping for Tanks AY-101 and AY-102. Drawing H-2-77323, "Abandoned Annulus Vent Piping Tank 241-AY-102," shows the original abandoned annulus vent piping, while H-2-77324, "Annulus Vent Piping TK-102 241-AY Tank Farm," shows the annulus vent piping installed by Project B-672.

Project W-020H/W-430 took place in the 1989 to 1996 timeframe. It provided cathodic protection around the A Farm complex, including Tank AY-102 and the associated jumpers/transfer lines (WHC-SD-W020H-OTP-001).

Project W-030 Tank Farm Ventilation Upgrades, a multi-phase project had the purpose of constructing the 702-AZ ventilation system. It serves as the replacement of the 702-A ventilation system to support Tanks AY-101, AY-102, AZ-101, and AZ-102. Additionally, it provided installation of tank inlet stations, sealing of the pit cover blocks, a new condensate drain line to Tank AY-101, raw water lines for building fire protection systems, and evaporative cooling units. The first phase, installation of site utilities and site grading, was completed in the spring of 1993 under W-030-C1. The second phase, W-030-C2, completed work on the 702-AZ ventilation building, control building, and generator building. The final phase of construction completed tie-ins under W-030-C3. The system began operational acceptance around 1997-1998.

According to H-2-131086, "Piping Plan AY Tank Farm," Sheet 4, general note 2, the abandoned annulus vent piping that was originally installed under Project IAP-614 which interfered with the upgrade's construction installation could be cut and removed provided an expansion plug was installed for closure. Line 10-in. C-AY2200-M9 in a 14-in. ENC-M26 was installed connecting from riser. To accommodate installation of the 10-in. VAY2200-M9 (102AY), the following lines were cut and capped: ½-in. RW-3567-M5; ½-in. IA-2507-M7; 2-in. DR-0064-M9.

Project W-211, in the 1990s, provided lines to the 241-AZ valve pit and connections to Tank AY-102. The project installed a 3-in. process water line and heat trace and electrical racks in the AY Farm (H-14-106417, "W-211 Initial Tank Retrieval Systems AY Tank Farm 3" PW-404-M9 Installation, Drawing List and Area Map").

Project W-314 in 1985 made additional modifications to the 241-AY-01A and 241-AY-02A cover blocks, modified the walls of these pits, and installed leak detection probes, ball valves, relay cabinets, and double containment piping (RPP-6012).

Project W-320 modified the Tank AY-102 annulus ventilation system to support sluicing of Tank C-106. It included process piping, installation of jumpers, installation of a vertical submersible pump and horizontal booster pump into risers, cathodic protection equipment, installation of a pit cooling system at 241-AY-02E pit, and foundations for small structures (W-320-C7 original issue 1995).

Project E-525, as it relates to Tank AY-102 created a 1,200-gal condensate receiver tank, 241-AZ-301, located adjacent to the 241-AZ-702 Building. An automatic low-volume (4.5 gpm) pumping system is used to alternately pump it to Tanks AY-101, AY-102, AZ-101, and AZ-102 (E-525-TP-1.0, *Test Plan for Project E-525 DST Transfer System Modifications*). Only the routes to Tanks AY-101 and AZ-102 have been connected.

Project B-672 AY Farm Annulus Ventilation Duct Upgrade

By 1987, the original system buried annulus ventilation ductwork had become severely corroded. Project B-672 cut the 4-in. inlet lines, the 6-in. inlet lines, and the 6-in. exhaust lines at the annulus tank wall and replaced them with new piping that interfaced with an entirely new ductwork system located around the perimeter of the tank, as shown in Figure 3-67. The new piping had a protective coating to protect against corrosion. The remaining piping was left abandoned in place with polyurethane plugs installed at cut ends (H-2-77323; H-2-77324).

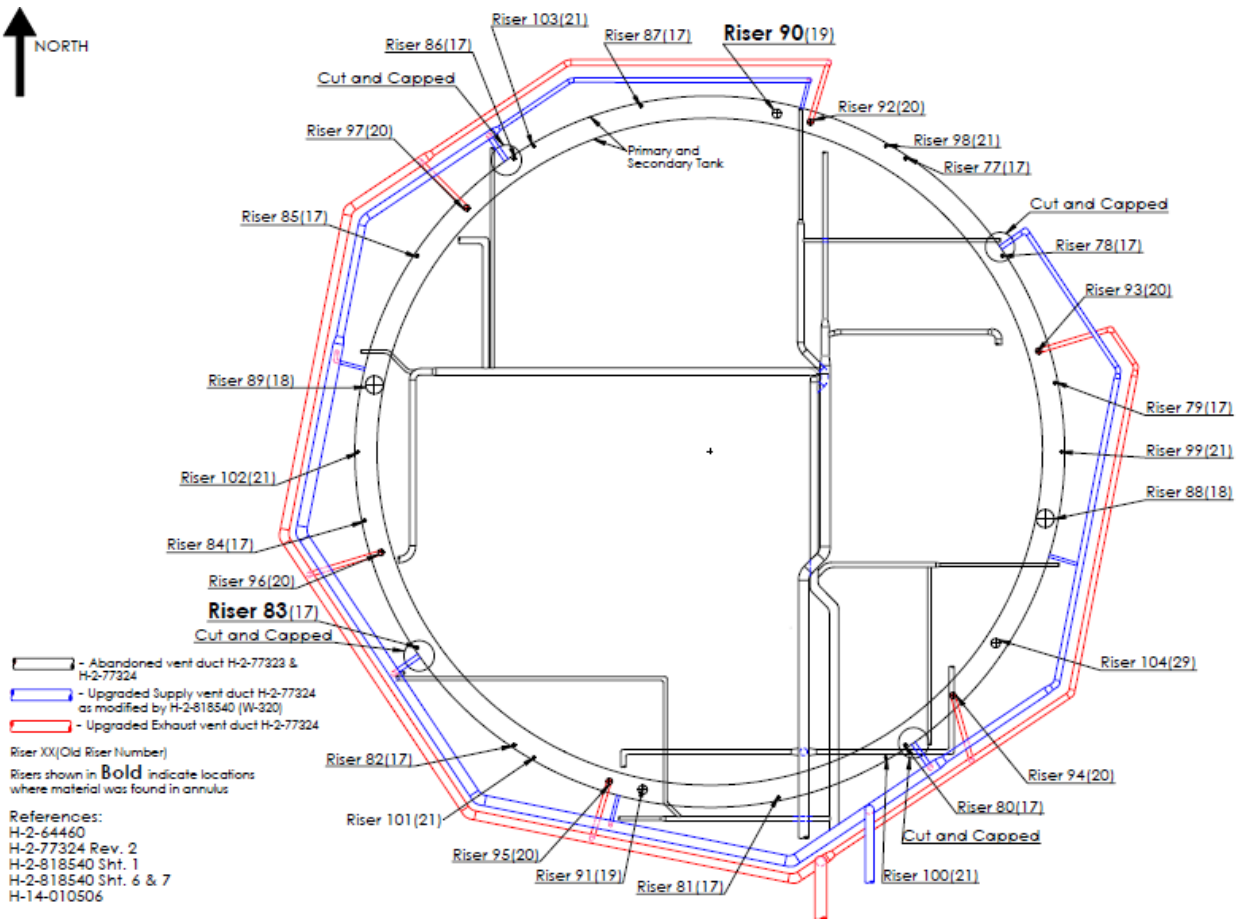


Figure 3-67. Tank AY-102 Annulus Ventilation Duct Upgrade

Material present on the annulus floor includes pieces of rigid polyurethane insulation. The source of the insulation is likely to be the insulated coating on the abandoned underground ductwork. When the sidewall ductwork was severed, an access path to the annulus was created until the path was capped. Since insulation debris is found in the annulus, it is also likely the soil entered the annulus as well, using the same path.

Project W-320 241-AY Tank 241-C-106 Sluicing

Figure 3-68 shows the existing annulus vent lines. Project W-320 modified the annulus ventilation system in preparation for transfer of high-heat Tank C-106 sludge into Tank AY-102. All air supply pipe was cut and capped except for the four 4-in. supply lines terminating in the air distribution ring beneath the center of the primary tank bottom. The isolated 6-in. pipes (H-2-818540, "Piping Tank 241-AY-102 Sections & Details") are shown in Figure 3-68 and marked as "Cut and Capped" in Figure 3-67.

The purpose of this upgrade was to direct all of the annulus ventilation airflow along the bottom of the tank where the high-heat producing waste would be located. Additional information on the upgraded annulus ventilation system is provided in HNF-SD-W320-ER-002, *W-320 Project Thermal Modeling*, and HNF-2317, *Project W-320 High Vacuum 241-AY-102 Annulus Ventilation System Operability Test Report*. It is possible that construction debris or soil entered the annulus through the cut 6-in. pipes before they were capped.

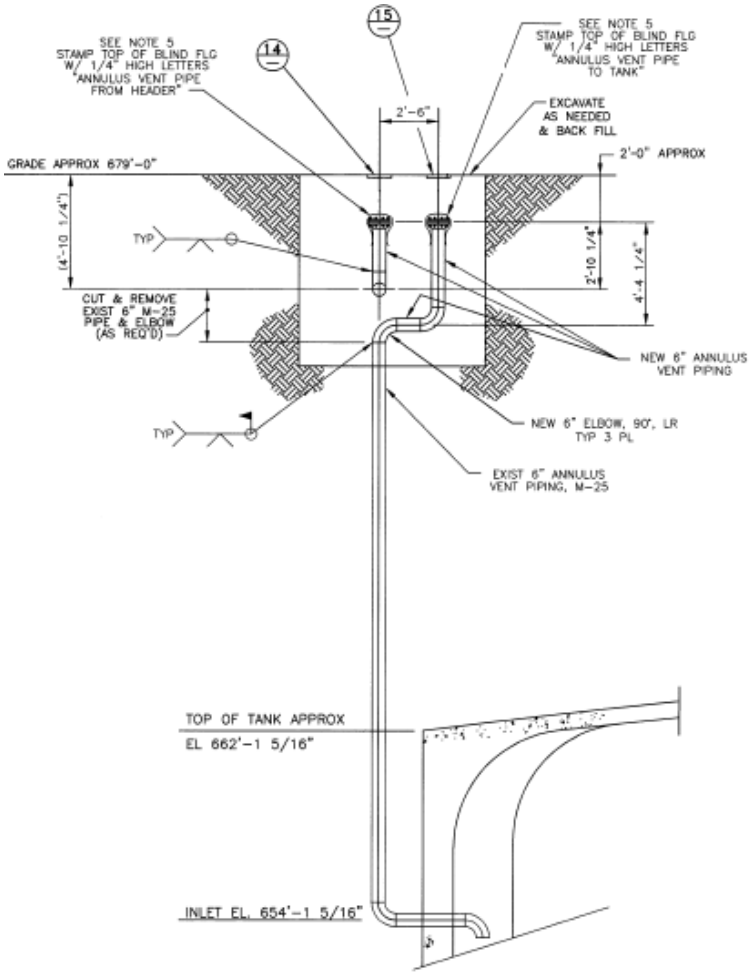


Figure 3-68. Existing Annulus Vent Lines

Project W-030 Tank Farm Ventilation Upgrade

This project affected only the primary tank. Although, it was noted on the construction drawings (H-2-131086) that if abandoned annulus vent piping presented interference with the new construction it could be cut and removed provided expansion plugs were provided for closure.

Summary

Between 1980 and 1998, multiple construction projects interfaced with the Tank AY-102 annulus. A number of these included annulus ventilation system modifications that created temporary opportunistic access for construction debris and soil to enter the annulus. Pieces of polyurethane foam insulation observed on the annulus floor are most likely remnants of external ductwork insulation that fell into the tank through severed ductwork. The presence of soil in the annulus via the same mechanism is likely.

4.0 TANK AY-102 OPERATIONAL HISTORY

4.1 PRIMARY TANK

4.1.1 Waste Transfers and Liquid Level

Tank AY-102 was initially filled in February 1971 with approximately 264 kgal of water to preheat the tank prior to receiving high heat waste (WHC-SD-WM-TI-689, *Waste Status and Transaction Record Summary for the Southeast Quadrant of the Hanford 200 Area*, page C-67). Tank AY-102 was designated as the aging waste spare. Tank AY-102 received waste water from Tank A-104, 62 kgal in the first quarter of 1972 and 60 kgal in the second quarter (WHC-MR-0132, *A History of the 200 Area Tank Farms*; ARH-2456A, *Chemical Processing Division Waste Status Summary, January 1, 1972 through March 31, 1972*, page 9; and ARH-2456B, *Chemical Processing Division Waste Status Summary, April 1, 1972 through June 30, 1972*, page 9). The temperature was maintained at approximately 160°F to 180°F to evaporate the added water from Tank A-104. Additionally, condensate was periodically transferred from Tank A-417 (collected condensate from A, AX, and AY Farm tanks) into Tank AY-102 to maintain the liquid level between 72 in. and 80 in. (Womack 1972). The liquid in Tank AY-102 was sampled in May 1974 and showed a pH of 11.1 (Occurrence Report 74-30, *Failure to Obtain Routine Monthly Samples in Tank 102-AY*). It is plausible that the liquid was at pH 11.1 due to the waste water transferred from Tank A-104 and/or the condensate added from Tank A-417 was alkaline.

In November 1975, Tank AY-102 received approximately 2,750 gal of waste solution from B Plant due to a misrouting that was intended for Tank A-103 (Occurrence Report 75-127, *Misrouting of Process Solution*). It was reported in ARH-LD-211 B, *Atlantic Richfield Hanford Company Monthly Report for November 1975*, page 11, "There were no adverse or significant effect of the transfer on Tank 102-AY other than a liquid level rise of about 1 in. This tank was normally kept at a temperature of about 120° to 140°F with about 6 ft of liquid and is maintained as a boiling waste spare." In the fourth quarter of 1975, Tank AY-102 received 7 kgal from the 152-AX catch tank (ARH-CD-336 D, *Production and Waste Management Division Waste Status Summary October 1, 1975 through December 31, 1975*, page 12) and 172 kgal from the 151-AX and 152-AX catch tanks in the first quarter of 1976 (ARH-CD-702 A, *Production and Waste Management Division Waste Status Summary January 1, 1976 through March 31, 1976*, page 9).

In October 1976, approximately 154 kgal of waste was transferred from Tank AY-102 to Tank A-101 (ARH-LD-222 B, page 14, *Atlantic Richfield Hanford Company Monthly Report October 1976*) for processing in the 242-A Evaporator, leaving 55 kgal of waste in this tank (ARH-CD-822 OCT, *Production and Waste Management Division Waste Status Summary October 1976*, pages 2 and 6). During this time, the tank liquid level was pumped down to 15 in. on October 22, 1976, which was less than the minimum liquid level specification of 17 in. with the annulus ventilation system pulling a vacuum between -1.7 to -1.9 in. wg (Occurrence Report 76-148, *Possible Specification Violation: Liquid Level Decrease to Below a Minimum Level*; and ARH-1601, *Specifications and Standards for the Operation of Radioactive Waste Tank Farms and Associated Facilities*). This opened a pathway for contamination to enter the annulus pump pit and the leak detection pit via the unsealed drain legs. The contamination

pathway exists when the tank liquid level drops below 60 in., which exposes the annulus pump pit and leak detection pit drain legs. On October 29, 1976, the annulus ventilation was shut off and process condensate was added to raise the tank liquid level to 20 in. (approximately 55 kgal). Approximately 6 kgal of waste (probably condensate from Tank A-417) was added to Tank AY-102 in March 1977, resulting in a total of 61 kgal in this tank (ARH-CD-822 MAR, *Production and Waste Management Division Waste Status Summary March 1977*, page 8).

Tank AY-102 was designated as an aging waste receiver tank; however, Tank AY-102 only received small volumes (approximately 68 kgal) of evaporator feed "aging waste" (dilute supernatant) beginning in the second quarter of 1977 (WHC-SD-WM-ER-454, *Tank Characterization Report for Double-Shell Tank 241-AY-102*, and ARH-CD-822 APR, *Production and Waste Management Division Waste Status Summary April 1977*, page 8). In the second quarter of 1977, Tank AY-102 began receiving 198 kgal of Battelle Northwest Laboratory (BNW) waste (PNNL waste) from a commercial vitrification process test (ARH-CD-822 MAY, *Production and Waste Management Division Waste Status Summary May 1977*, page 8). This 198 kgal of waste apparently included 16 casks of liquid high-level waste (HLW) received from BNW at B Plant, 130 kgal of waste from B Plant that was low in ^{137}Cs and ^{90}Sr, and 35 casks in preparation for the Commercial Nuclear Waste Vitrification Program and subsequent waste transfers (ARH-LD-229 B, *Atlantic Richfield Hanford Company Monthly Report for May 1977*, page 31). In the first two quarters of 1978, another transfer was made to Tank AY-102 of approximately 157 kgal of commercial vitrification process test waste (WHC-SD-WM-TI-689).

In the third and fourth quarter of 1978, Tank AY-102 received approximately 14 kgal of double-shell slurry feed (DSSF). DSSF is non-complexed waste that has been concentrated in an evaporator until the solution is nearly saturated with sodium aluminate (WHC-SD-WM-ER-454). The first solids (sludge) level was determined on September 14, 1978 at 6 kgal (WHC-MR-0132). As reported in WHC-MR-0132, no transfers were made into or out of Tank AY-102 until the second quarter of 1980, when approximately 302 kgal of DSSF was added (RHO-CD-14 MAY, *Waste Status Summary May 1980*, page 14, and RHO-CD-14 JUN, *Waste Status Summary June 1980*, page 14). A new solids level was recorded at 21 kgal on June 20, 1980, after this transfer (WHC-SD-WM-ER-454 and RHO-CD-14 JUN, *Waste Status Summary June 1980*, page 14). Beginning in the third quarter of 1980, 22 kgal of non-complexed waste was transferred to the tank with the total volume reported at 712 kgal (WHC-MR-0132 and RHO-CD-14 AUG, *Waste Status Summary August 1980*, page 14).

It was reported in WHC-SD-WM-TI-689 that 606 kgal was sent to Tank A-102 in the third quarter of 1980, leaving the volume at 239 kgal in Tank AY-102. In October 1980, the volume of Tank AY-102 was reported at 203 kgal (182 kgal supernatant and 21 kgal solids) (RHO-CD-14 OCT, *Waste Status Summary October 1980*, page 14). In November and December 1980, Tank AY-102 received 24 kgal of non-complexed waste, with the volume reported at 227 kgal at the end of December 1980 (RHO-CD-14 NOV, *Waste Status Summary November 1980*, page 14, and RHO-CD-14 DEC, *Waste Status Summary December 1980*, page 14).

Beginning in the first quarter of 1981 until the second quarter of 1985, Tank AY-102 received plutonium uranium extraction miscellaneous waste (PXSMC), low-level dilute non-complexed waste from B Plant, other dilute non-complexed wastes, and water. During this time, the tank

also received saltwell liquid and 100 N Area dilute non-complexed waste (RPP-RPT-42920, *Auto-TCR for Tank 241-AY-102*). In January and May 1986, when supernatant was transferred from Tank AY-102 to Tank AW-102, the liquid level was recorded below 60 in., the minimum operating specification after the 1983 AY Farm ventilation modification with the annulus ventilation system on (see Section 4.2.2) (PCSACS). This opened a pathway for contamination to enter the annulus pump pit and leak detection pump pit Tank AY-via the unsealed drain legs, with the annulus pulling a vacuum greater than the primary tank.

From the second quarter of 1985 until the first quarter 1996, Tank AY-102 received dilute non-complexed wastes from N Reactor, B Plant vessel cleanout, and B Plant low-level wastes from B Plant, low-level non-complexed waste from T Plant, and laboratory wastes from the 200, 300, and 400 Areas. Large transfers were made to Tanks AW-102, AW-106, AP-103, AP-104, A-106, and AP-108 during this time (RPP-RPT-42920).

In 1994 during the flushing of line SL-503, which connects the AY-102 sluice pit 02D to the central pump pit 02A, a ½-in by ¾-in hole was discovered in the carbon steel section of the pipe wall (Occurrence Report RL-WHC-TANKFARM-1994-0059, *During a Flush of Waste Transfer Line SL-503, a Leak within the 241-AY-102 02D Sluice Pit was Discovered*). The hole appeared to have developed from the inside and progressed through the pipe wall. The stainless steel section of the pipe appeared to be in good condition. Previously in 1984, it was reported that line SN-233 from B Plant to 244-A failed, which was only in service since 1975 (WHC-SD-RE-TI-148, *Metallurgical Analysis of Leak Failure of 241-A-B Valve Pit Jumper*). Both failures occurred on routes used to receive waste into Tank AY-102. Neither failure was sufficiently investigated to determine whether or not process chemistry contributed to the failure. The causes remain indeterminant.

A transfer of 11 kgal of dilute complexed waste was made to Tank AY-102 from Tank AY-101 in September 1997 (Tank Waste Information Network System [TWINS]). In July 1998, 389 kgal of dilute non-complexed waste was transferred out of Tank AY-102 to Tank AW-102 (TWINS). Between 1999 and 2006, the tank chemistry was reported to be out-of-specification on several occasions and sodium hydroxide and sodium nitrite additions were made (Aromi 2005).

Beginning in November 1998 to October 1999, 97 percent of the high-heat sludge from Tank C-106 (187 kgal) was sluiced to Tank AY-102 using the supernatant in Tank AY-102 as the sluicing medium (RPP-19919, *Campaign Report for the Retrieval of Waste Heel from Tank 241-C-106*). From July 2002 until October 2005, Tank AY-102 received dilute non-complexed condensate transfers from Catch Tank AZ-151. The condensate formed a “cold cap” on top of the waste, and was reported to be out-of-specification. Caustic additions were made to increase the pH (Aromi 2005). In April 2003, approximately 29 kgal from Tank C-106 retrieval decant operation was also added to Tank AY-102 (RPP-19919).

The sludge in Tank AY-102 was selected as the HLW hot commissioning feed to be used in the initial hot runs of the Waste Treatment and Immobilization Plant (WTP). Similarly, the concentrated supernatant in Tank AP-101 was selected as the low-activity waste (LAW) commissioning feed. On September 27, 2005, the U.S. Department of Energy (DOE), Office of River Protection (ORP) approved consolidation of the WTP hot commissioning feed stored in Tanks AP-101 and AY-102 (Schepens 2005). Beginning in December 2006, 715 kgal of

supernatant from Tank AY-102 was pumped out to Tanks AW-102 and AN-106. In January 2007, as authorized by Schepens (2005), 782 kgal of supernatant from Tank AP-101 was added to Tank AY-102. This was the last transfer for Tank AY-102. The calculated supernatant concentration after the Tank AP-101 supernatant addition was 2.19M hydroxide, 0.87M nitrite, and 1.73M nitrate (SVF-1342, *AY102 FY07 Q3 Supernatant PK Vector*).

As of August 2012, the liquid level in Tank AY-102 was approximately 308 in. and slowly declining due to evaporation (see Section 4.1.2). It was reported on May 1, 2012 that the tank contained 702 kgal of supernatant, 119 kgal of sludge solids, and 32 kgal of sludge interstitial liquid (TWINS).

Figure 4-1 provides the liquid level history of Tank AY-102 from 1971 to present.

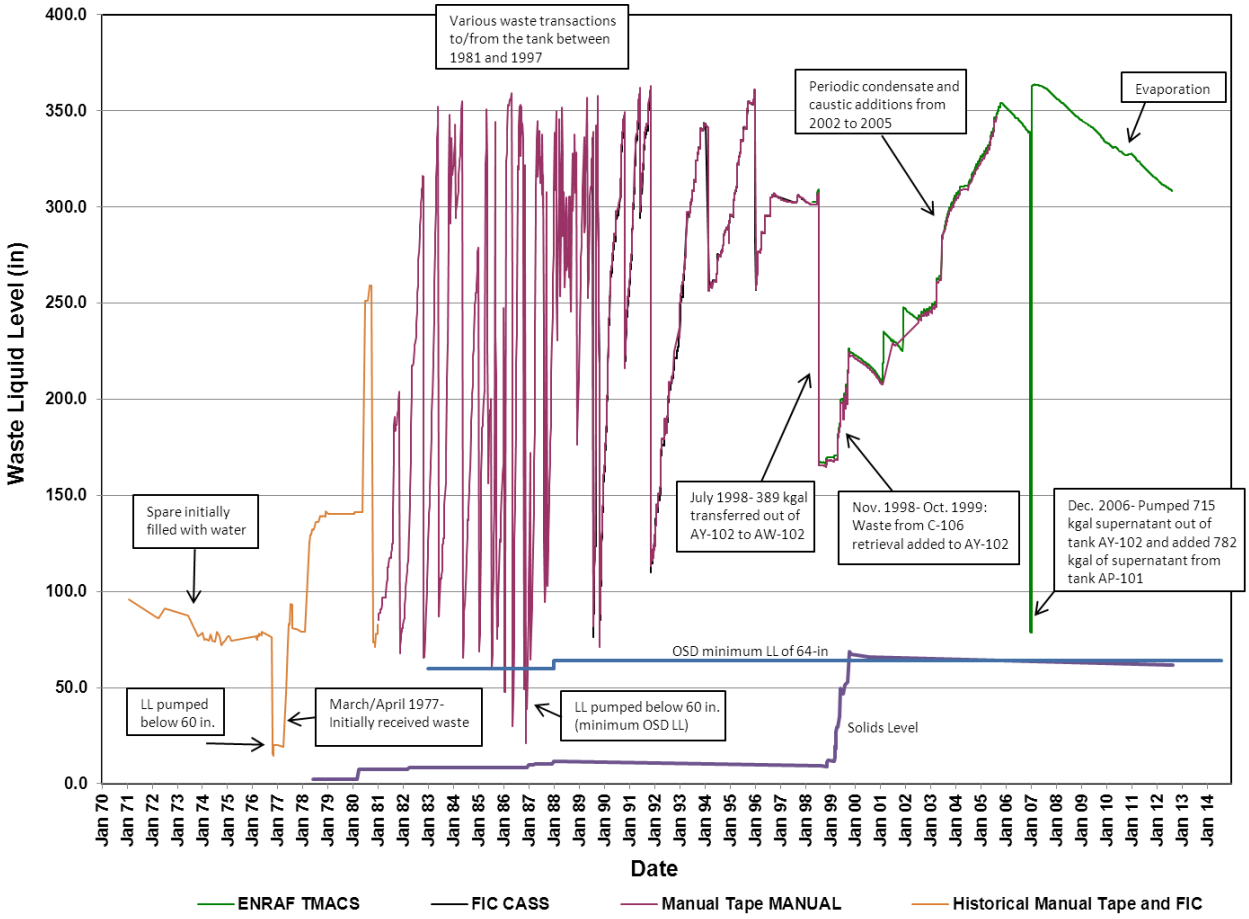


Figure 4-1. Tank AY-102 Liquid Level History (1971-2012)

Fill Cycle Fatigue Effects on Double-Shell Tank Structural Integrity

In 1968, the AY Farm design was analyzed for three hot waste load cases to predict the extent of primary tank yielding on first fill. The meridional stresses were calculated to be modest in the three cases except for a small width adjacent to one fixed node in the roof plates. Here the calculated stresses ranged from 41.8 ksi to 84.2 ksi.[2]

The analysis estimated that the roof plates would yield between 0.22 percent and 0.36 percent in this area during the first two or three fill cycles and never yield again. The extent of yield was judged to be inconsequential. To qualify that opinion, a design fatigue curve from the 1968 ASME Code, Section III, was consulted.[3] From the fatigue curve, it was determined that for the allowable stress amplitude, defined as one-half of the alternating stress range from zero to 84.2 ksi—equivalent to filling the empty tank to its maximum operating limit using the most aggressive load case—then the number of safe stress cycles given was 17,600. For the lowest stress cycle ranging from zero to 41.8 ksi, the number of safe stress cycles was 63,000.

The analysis also estimated the impact of partial fill cycles, because once the tank was first filled, it would be more likely to experience frequent partial fill cycles rather than complete fill cycles. When the fatigue cycle for partial fill cycles was examined, assuming the beginning partial fill stress was 41.8 ksi and the final, filled stress 84.2 ksi, the number of safe stress cycles was determined to be 76,000 cycles. All of these greatly exceeded the number of expected fill cycles over the life of the tank. Figure 4-1 indicates, for example, that Tank AY-102 has only experienced three large fill and empty cycles since 1990, a period of 22 years.

In 2008, a refined finite element structural analysis was completed for the DSTs using an annual temperature cycle between 50°F and 350°F and a completely filled tank (RPP-RPT-28968, *Hanford Double-shell Tank Thermal and Seismic Project – Summary of Combined Thermal and Operating Loads with Seismic Analysis*). These temperatures adequately bracket the recorded waste temperatures for Tank AY-102. Since 1995, the highest recorded tank waste temperatures have been no more than one-half of the analyzed temperature (see Section 4.1.3).

The 2008, analysis determined that the maximum stress on the primary tank was approximately 60 ksi using the AY Farm tanks as the bounding model. For 60 ksi stress, the allowable stress amplitude is 30 ksi, and the number of safe stress cycles is approximately 25,000.[4] The number is far greater that the number of credible fill cycles Tank AY-102, or the other DST, is likely to experience. Low temperatures and infrequent fill cycling make it improbable that cycle fatigue could become a factor in loss of tank integrity.

[2] Letter, Pittsburgh-Des Moines Steel Corporation to George Kligfield, Hanford Engineering Service, December 18, 1968, transmitting eight copies of the asymmetric shell computer program analysis of the primary tank. The letter summarizes the cases and included a 126-page calculation output enclosure for each of the three cases. The enclosures have become separated from the letter in the archives and were not recoverable.

[3] Cited in the Pittsburgh-Des Moines Steel Company 1968 letter as Figure N-415.

[4] ASME Code, Section III, Division 1, "Rules for Construction of Nuclear Facility Components," Appendices, Figure I.9-1, "Design Fatigue Curves for Carbon, Low Alloy, and High Tensile Steels for Metal Temperatures not Exceeding 700°F," 2010 Edition, 2011a Addenda.

4.1.2 Tank AY-Evaporation Rates

Liquid Level Decrease

The last transfer into or out of Tank AY-102 occurred in January 2007 with the addition of the Tank AP-101 supernatant. Liquid levels were reported at approximately 363 in. following this transfer (PCSACS).

Figure 4-2 shows the declining liquid level attributed to evaporation from February 2007 to present on a year by year basis. The average evaporation rate from February 26, 2007 to August 10, 2012 was 0.028 in./day (77 gal/day) or 10.1 in./yr (~28,000 gal/yr) at temperatures ranging from approximately 90°F to 130°F. A small leak could occur undetected within the evaporation rate.

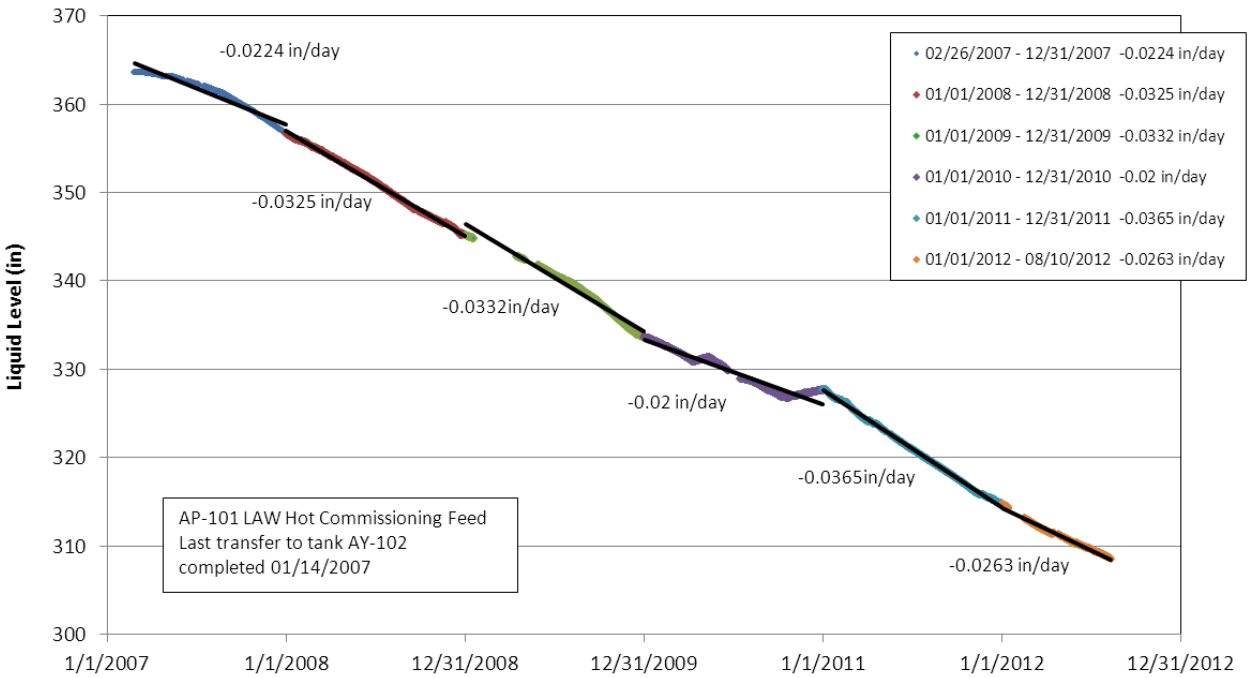


Figure 4-2. Liquid Level Decrease for Tank AY-102 2007-2012

Liquid Level Increases 2010-2011

Extended primary and annulus ventilation outages in Tank AY-102 resulted in increasing waste temperatures and small measured waste volume increases. Calculations indicate that waste level increases were caused by thermal expansion of the liquid waste. Primary and annulus ventilation was off between April 10, 2010 and May 13, 2010, and the measured waste liquid level increased by 0.43 in. The estimated level rise from thermal expansion of the tank liquid level was calculated to be 0.55 in. (see Appendix B). The measure 0.43 in. generally agrees with the theoretically calculated 0.55 in. and falls well within calculation uncertainties.

Primary and annulus ventilation was off between October 18, 2010 and January 12, 2011, and the measured waste liquid level increased by 0.92 in. The estimated level rise from thermal expansion of the tank liquid level was calculated to be 0.82 in (see Appendix B).

The measured 0.92 in. generally agrees with the theoretically calculated 0.82 in. and falls well within calculation uncertainties.

Therefore, the two periods of increasing liquid level are an effect of thermal expansion as opposed to any other reason.

4.1.3 Temperature

4.1.3.1 Temperature Monitoring

There are 59 thermocouples installed in Tank AY-102 to measure waste temperatures. Of these, 37 were installed as part of the original construction, and 22 were installed later. The locations are shown in Figure 4-3.

All of the 22 airlift circulators have attached thermocouples that extend to 3 in. above the tank bottom. These thermocouples were placed at a point where the movement of the waste would have swept the immediate area free of sludge. An airlift circulator malfunction would have been indicated by a temperature rise at the associated thermocouple, which would have indicated sludge accumulation.

Twelve thermocouples installed in wells are used to measure the temperature gradient in the stored waste at four different locations, 90° apart (N, S, E, and W) and 18 in. from the tank wall (Risers 40, 41, 42, and 43). There are three thermocouples in each well, and vertical placement is at approximately 3 in., 13 ft-1 in., and 24 ft-1 in. from the tank bottom. Three more thermocouples are installed at equidistant locations about a circle 12 ft from the tanks' center and approximately 3 in. above the bottom (Risers 70, 71, and 72). These are designated sludge thermocouples and are used to measure temperature at points undisturbed by the airlift circulators.

One multi-functional instrument tree, consisting of 22 thermocouples ranging from 7 in. to 430 in. inside the tank, is located in Riser 29 and provides a temperature profile for multiple elevations in the tank.

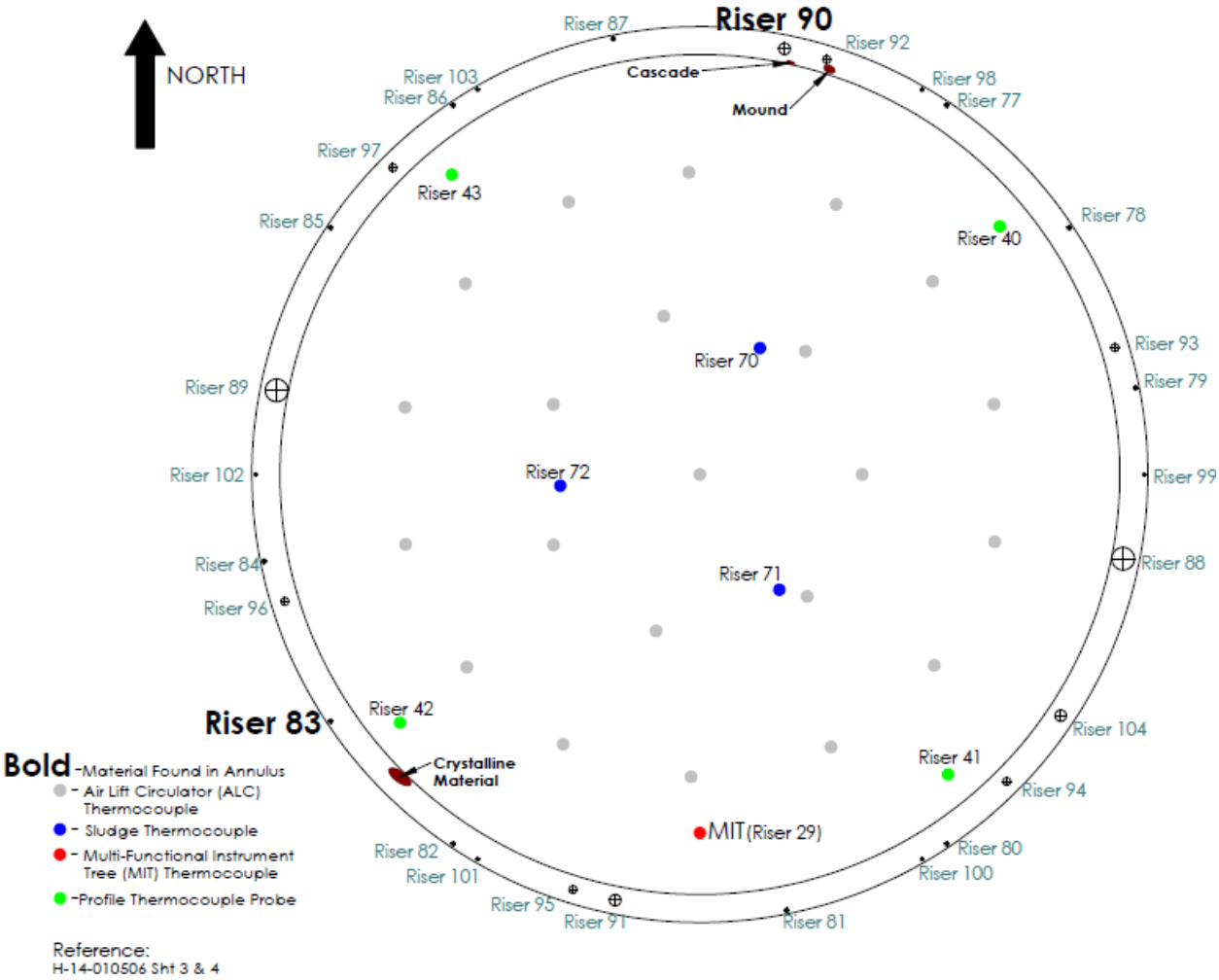


Figure 4-3. Location of Tank AY-102 In-Tank Temperature Monitors

Temperature specifications for Tank AY-102 are provided in OSD-T-151-00007. The maximum allowable temperature for waste and steel for AY and AZ Farm tanks is 260°F. For temperatures less than 125°F, the bulk temperature change over time for the solution is limited to ≤10°F/hr, and for temperatures ≥125°F, the bulk solution temperature change is limited to ≤3°F/day or ≤24°F/day provided the tank temperature is kept constant ±3°F for 8 days thereafter. The temperature gradient for the solution is limited to ≤55°F/ft. The rate of change limits apply to both the tank structure and the tank contents (see Section 3.5).

4.1.3.2 Early Operating History

Tank AY-102 was initially designated as the aging waste spare tank. The first five years of operation consisted of preparation and maintenance of Tank AY-102 for use as the aging waste spare tank if needed.

The March 1971 monthly report, PPD-429-DEL, *Monthly Report for March 1971*, Page AIV-16, discussed the initial operations of Tank AY-102.

> *"The second double-shell tank in the AY Farm is being prepared as a spare by bringing its temperature up to 180°F. Waste has been added to a depth of eight feet to seal several pump and sluice-pit drains and to prevent the bottom liner from buckling upward. This tank also is being heated slowly with a steam coil to prevent abnormal temperature stresses on the concrete dome. The current temperature is 160°F, with maximum dome differential temperature being regulated at slightly less than 30°F/foot of concrete. The average heat up rate of this tank has been 6°F/day."*

The use of the steam coil for maintaining Tank AY-102 at higher temperatures was eliminated in 1976 as calculations showed that a large heat sink was not required to receive warm wastes into cold DSTs (ARH-LD-222 B).

The airlift circulators were originally used to ensure that the vertical temperature gradient throughout the waste was minimized. This reduced the potential for steam bumping. The airlift circulators are no longer operated in Tank AY-102.

4.1.3.3 Temperature Data

Temperature data from the first five years of operation are available and provide a temperature history for the heated water in the tank. The location inside the tank at which the temperatures were recorded for this time is unknown. Figure 4-4 shows the reported temperature data during 1971 through 1975. As discussed in Section 4.1.1, approximately 264 kgal of water was heated using a steam coil. Records from November 1975 show that the tank was maintained at temperatures between 120-140°F.

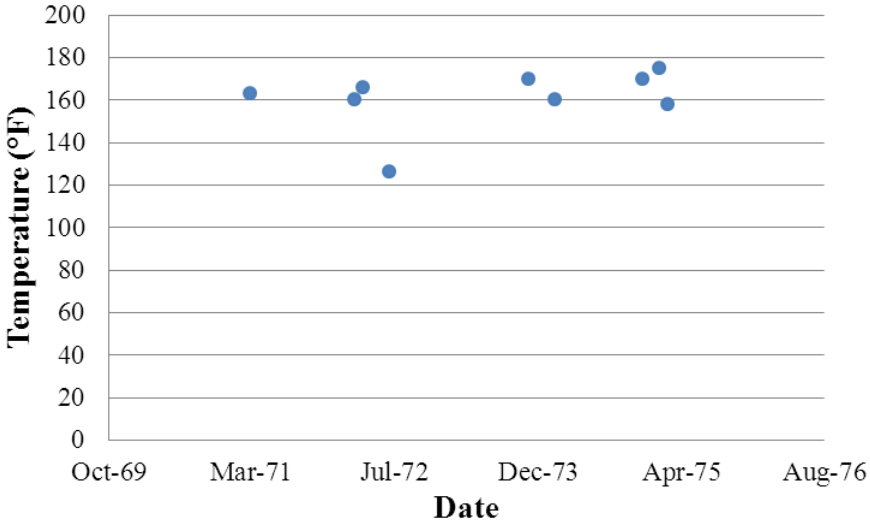


Figure 4-4. In-Tank Temperatures for Tank AY-102 in Use as the Aging Waste Spare Tank from 1971-1976
("Status Report 241-AY Tank Farm 11/02/1973 through 03/30/1975," IDMS 1007130427; PPD-429-DEL; PPD-493-4-DEL; PPD-493-7-DEL)

The 1971 monthly report, PPD-429-DEL, did state that the average rate of temperature increase while heating the tank was 6°F/day. This is greater than the current specification of 3°F/day.

Other than isolated readings, temperature data from 1976 through 1983 are not available. It is likely that the waste temperatures remained below 180°F due to the replacement of the steam coil with a seal loop steam addition in 1976. Tank AY-102 only received small volumes of aging waste over the period of time, which would have been diluted by the other waste in tank. The waste types transferred to Tank AY-102 from 1976 to 1983 consisted of dilute, non-complexed wastes with low heat loads. Temperatures in Tank AY-102 during this time period were probably in the 75-100°F range.

Temperature data from 1983-1989 indicate temperatures in the range of 70-100°F with one period in 1988 nearing 125°F (HNF-SD-WM-ER-317, *Supporting Document for the Historical Tank Content Estimate for AY Tank Farm*).

Temperature data available from 1991-1994 indicate the maximum tank temperature was 87°F (WHC-SD-WM-TI-591, *Maximum Surface Level and Temperature Histories for Hanford Waste Tanks*). The maximum reported in-tank temperature was measured at approximately 15 in. from the tank bottom.

Continuous in-tank temperature measurements for Tank AY-102 were recorded in the PCSACS database starting in 1994. For illustration purposes, the measurements taken from the 59 thermocouples have been organized into three groups: the solids temperatures near the center of the tank bottom, outer radial solids temperatures, and bulk supernatant temperatures. Distinct temperature differences can be identified between each of these categories. The transfer of high-heat Tank C-106 sludge into Tank AY-102 increased the temperature profiles. The temperature profiles for each region are shown in Figure 4-5 through Figure 4-7.

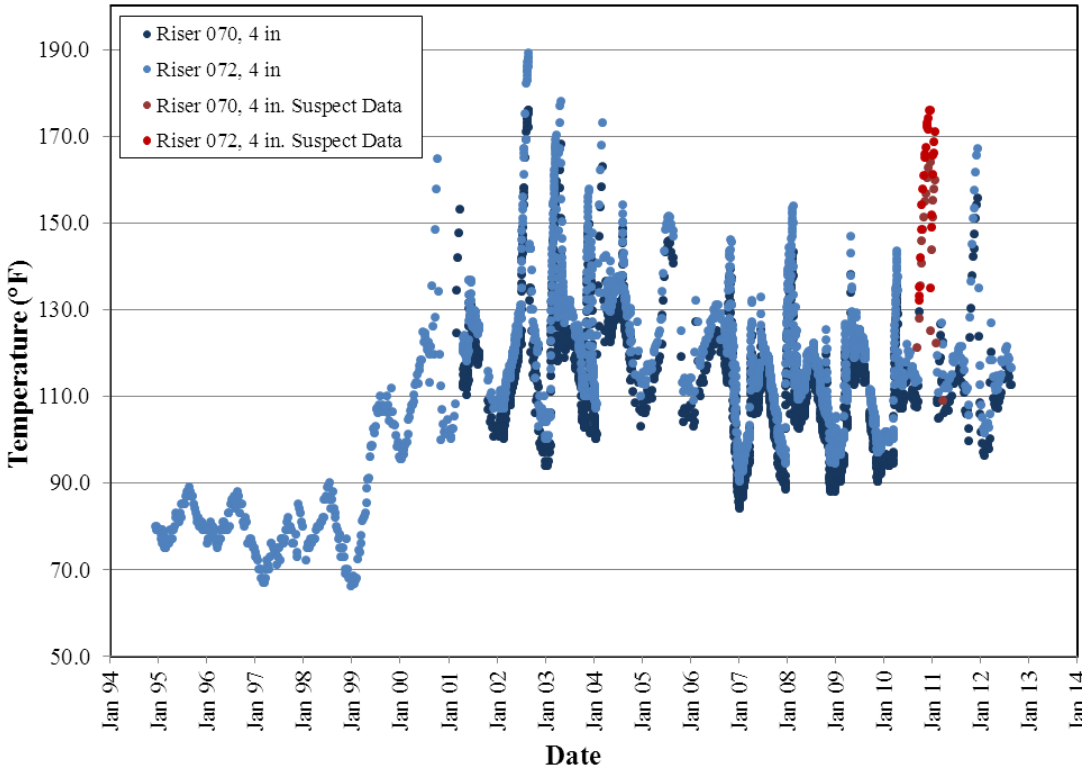


Figure 4-5. Tank AY-102 4 in. Thermocouple Readings in Risers 70 and 72 (Center-Solids) from 1994 – Present

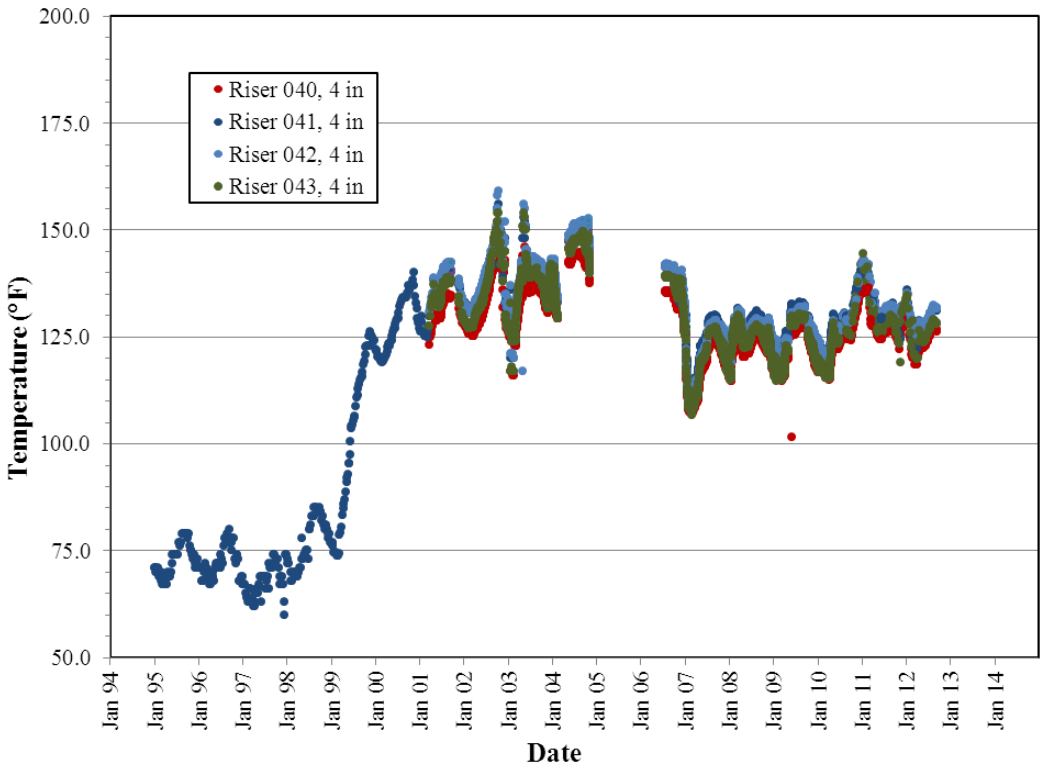


Figure 4-6. Tank AY-102 4-in. Thermocouple Readings in Risers 40, 41, 42, and 43 (Outer Radial Solids) from 1994 – Present

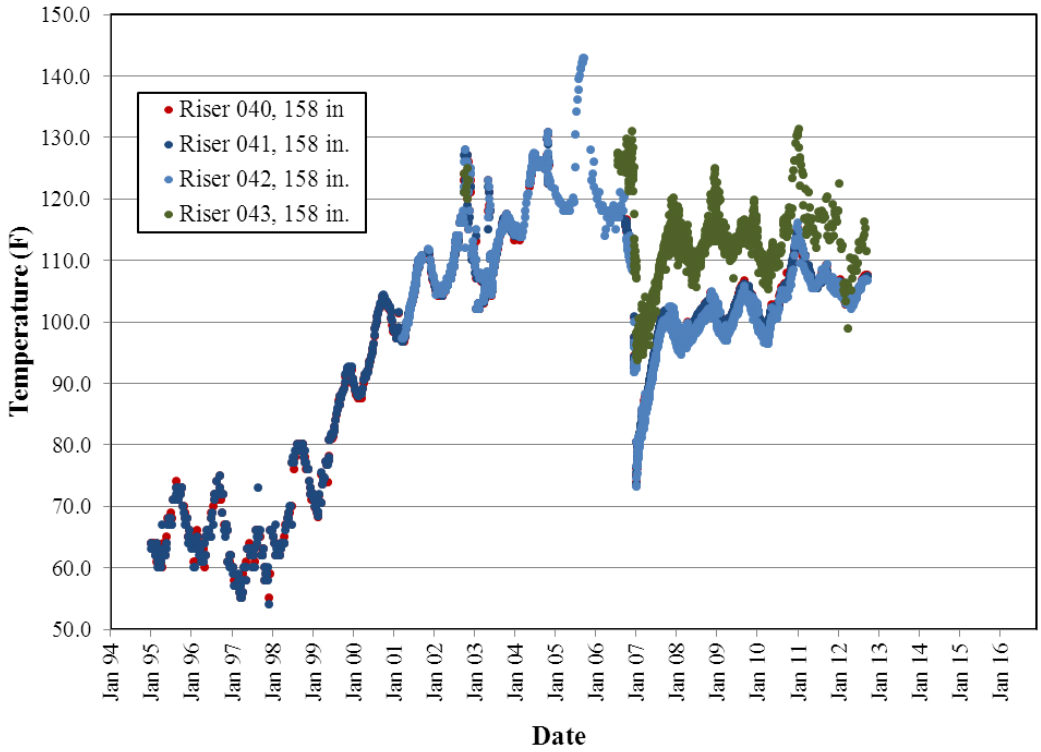


Figure 4-7. Tank AY-102 158-in. Thermocouple Readings in Risers 40, 41, 42, and 43 (Bulk Supernatant) from 1994 – Present

The maximum temperature identified in Tank AY-102 was recorded on September 24, 2002, in the bottom center of the tank at 189°F in Riser 72.

The annulus ventilation system greatly influences the temperatures in the bottom of the tank. The bottom center of the tank has highest temperatures during ventilation outages, with temperatures decreasing radially from the center of the tank. This results from the distribution of air only to the central distribution chamber below the primary tank (see Section 3.3). Most of the significant temperature changes coincide with annulus ventilation outages that last over a period of one week (see Section 4.2.2 for outage events). Nine out of the ten temperature peaks over 140°F in the center sludge region coincided with annulus ventilation outage events from 2003 to 2012.

During the October 2010 through February 2011 primary and annulus ventilation outage event (Sections 4.1.5 and 4.2.2, respectively), the temperature readings on the thermocouples located in the center-bottom of the tank increased at a rate of 5°F per week for the first few weeks after the annulus ventilation was shut down. The annulus ventilation outage lasted 129 days and the primary ventilation outage lasted 80 days. These thermocouples are located at a 12.5-ft radius from the tank center line and reached a maximum temperature of 175.9°F. Thermocouples located at a 34.75-ft radius were much cooler and reached a maximum of 134°F (see Figure 4-5).

By December 6, 2010, two thermocouples located in Riser 70 and Riser 72 increased to temperatures of 165.5°F and 154.2°F. The Riser 70 thermocouple exceeded the HNF-IP-1266, Section 5.9.1 DST Time to Lower Flammability Limit of 161°F. As a result of this event, WRPS-PER-2012-0008 was written to document the issue. A surveillance frequency of 3.5 days was implemented to bound the temperature increase until 169°F would have been reached (RPP-RPT-25731, *System Health Report for East Base Operations AY/AZ Farm Waste Tank Structures Mixing and Monitoring Systems for the Fourth Quarter CY 2011*).

The temperatures recorded during the December 2010 through January 2011 ventilation outage are currently labeled as suspect data in the PCSACS database. If all temperature measurements during this period were reliable readings, the maximum temperature recorded was 175.9°F, recorded by the master pump shutdown system in Riser 72.

The most recent annulus ventilation outage occurred from October 2011 through January 2012. The maximum recorded temperature was 167°F during this event.

4.1.3.4 Summary

The temperature data available indicate that the in-tank waste temperatures are influenced by annulus ventilation outage events, with the center bottom of the tank showing the largest temperature increases during outage periods. The available temperature measurements all remained within the OSD-T-151-00007 temperature specifications.

4.1.4 Chemistry

4.1.4.1 Introduction

Tank AY-102 has been actively operated since 1971. Several compositionally different wastes have been present in the tank, including waste water and wastes that were rich in either nitrate ion or carbonate ion. The changes in the chemical composition of the tank waste layers can be conveniently grouped into five time intervals, as shown in Table 4-1.

Table 4-1. Time Intervals Based on the Waste Types Stored

Time Interval	Date Range
1	1971-1977
2	1977-1984
3	1984-1998
4	1998-2006
5	2007-present

The analytical measurements of the waste composition and the results of corrosion testing programs provide a technical basis for assessing the propensity of the different waste compositions for pitting corrosion, corrosion at the liquid air interface, and for the initiation of stress corrosion cracking (SCC) in these five time intervals.

The corrosion mechanisms are outlined in Section 4.1.4.2. The operational and compositional information for the five time intervals and the propensity for corrosion by the wastes are discussed in Section 4.1.4.4.

4.1.4.2 Corrosion Mechanisms

The types of corrosion that may occur in the DSTs include general corrosion, SCC, pitting and liquid-air interface corrosion. These types of corrosion were identified from a general list of corrosion mechanisms by the DST Life-Extension Expert Panel (PNNL-13571, *The Expert Panel for Hanford Double-Shell Tank Life Extension*). General corrosion isn't a concern at the pH found in tank waste and further discussion of it isn't included in this report. The following sections discuss SCC and pitting and liquid-air interface corrosion potential in Tank AY-102.

4.1.4.2.1 Stress Corrosion Cracking

Stress corrosion cracking is the growth of cracks in a corrosive environment. It can lead to unexpected sudden failure of normally ductile metals subjected to a tensile stress, especially at elevated temperatures. Stress corrosion cracking is highly chemically specific in that certain alloys are likely to undergo SCC only when exposed to a small number of chemical environments. The chemical environment that causes SCC for a given alloy is often one which is only mildly corrosive to the metal otherwise.

Nitrate Ion-Induced Stress Corrosion Cracking

Nitrate ion-induced SCC is the predominant threat to the integrity of the steel liners in the DSTs at the Hanford Site and many investigations have been performed to establish the parameters under which the tanks can be protected from this threat. This work, together with the efforts of many others, led to the adoption of the waste chemistry control limits for SCC prevention in 1983. The fact that the waste tanks had cooled significantly prompted a review in 2010 of the information that was available for more than 400 tests defining the propensity for cracking in

nitrate ion-rich wastes under conditions similar to or somewhat more aggressive than the conditions that prevail at open circuit potentials (OCP). The OCP is the potential of the working electrode relative to the reference electrode when no potential or current is being applied to the cell.

The factors governing the rates of nitrate ion-induced SCC cracking by Hanford Site wastes were recently reviewed (RPP-RPT-47337, *Specifications for the Minimization of the Stress Corrosion Cracking Threat in Double-Shell Tank Wastes*). In brief, the test results led to the conclusion that the rates of nitrate ion-induced SCC depended on the properties of the steel, the applied potential versus the OCP, the temperature and the concentrations of aggressive substances such as nitrate ion, and the potential inhibitors such as nitrite ion.

The technical work has shown that SCC is promoted by high temperatures, high nitrate ion concentrations, high hydroxide ion concentrations, low nitrite ion concentrations, and low nitrite ion/nitrate ion concentration ratios. The specifications in Table 4-2 were designed to control these factors and to minimize the threat of SCC of the nitrate ion-rich solutions to the integrity of the DSTs.

Table 4-2. Proposed Specifications for the Control of Stress Corrosion Cracking in Nitrate Ion Wastes in Double-Shell Tanks with Temperatures Less Than 50°C

DST Specification Criteria	Limit
Maximum temperature	50°C
Maximum concentration of nitrate ion	6.0 M
Maximum concentration of hydroxide ion	6.0 M
Minimum pH	11
Minimum concentration of nitrite ion	0.05 M
Minimum nitrite ion/nitrate ion ratio	0.15

DST = double-shell tank.

Nitrate ion-rich wastes were present in the supernatant layer of Tank AY-102 in two of the five intervals that will subsequently be examined. The propensity for SCC in the waste layers of Tank AY-102 with significant concentrations of nitrate ion is discussed in Section 4.1.4.4.

Carbonate Ion-Induced Stress Corrosion Cracking

The interstitial liquids in the lower solid layer of Tank AY-102 that formed during the first 25 years of operation and the larger upper solid layer formed after the transfer of solids from Tank C-106 are solutions of sodium carbonate with very low concentrations of nitrate ion.

Although the focus of the technical work on corrosion has centered on the nitrate ion-rich wastes, the propensity for carbonate (bicarbonate) ion-induced SCC has been investigated. There is also a very rich literature on this subject because of its industrial importance. The pH of the solution plays an important role because the relative amounts of bicarbonate and carbonate ion are determined by the concentration of hydrogen ion in the solution (Pourbaix 1974).

$$\log [CO_3^{2-}]/[HCO_3^-] = pH - 10.32$$

Carbonate ion-induced SCC, like nitrate ion-induced SCC, is influenced by temperature and potential, the nature of the steel, and the concentrations of inhibitors. These physical and chemical features are evident in the targeted work with simulants of the wastes at the Hanford Site. This work, which focuses on the behavior of the waste solutions in Tanks AY-101 and AY-102, are summarized in this section.

Simulants of the present and aged interstitial liquids in Tanks AY-101 and AY-102 were studied in 2007, 2008, and 2009 (RPP-RPT-35923, *Hanford Tank AY-101: Effect of Chemistry and Other Variable on Corrosion and Stress Corrosion Cracking*, and RPP-RPT-33284, *Hanford Tanks AY-102 and AP101: Effect of Chemistry and Other Variable on Corrosion and Stress Corrosion Cracking*).

The importance of chemical inhibitors was observed in the Tank AY-101 interstitial liquid simulants, which were virtually saturated solutions of sodium carbonate. The high nitrite ion (0.85 M) strongly inhibited carbonate ion-induced SCC. This simulant failed to cause intergranular cracking at 50 or 77°C, even at low potentials in the range for carbonate ion-induced SCC.

The tests with Tank AY-102, which had a very low concentration of nitrate ion of <0.01M, gave more diverse results. Work with these simulants affirmed the importance of chemical inhibitors and the roles of pH, potential, and temperature. Although cracking did not occur at the open circuit potential at 50 or 77°C at pH 10, 10.5, or 11, the steel specimens cracked in tests that were conducted at low potential in the carbonate ion cracking range near -800 millivolts (mV) standard calomel electrode (SCE) and at a high potential of 0 mV (SCE). These tests at the lower potential also showed that the severity of the cracking was greater at low pH than at high pH and also more severe at 77°C than at 50°C.

The corrosion testing to determine the chemistry limits for prevention of SCC were done using quality steel coupons. Therefore, corrosion propensity judgments for AY-102 were developed upon the notion that the welds were properly made as well as on the notion that the heat treatment removed stress. Work at the Savannah River Site (SRS) site, WSRC-MS-2005-00078, *Stress Corrosion Cracking of Carbon Steel Weldments* determined that these two matters can increase the propensity for SCC. In a situation where the weld or heat treatments were not adequate, the thresholds for stress induced corrosion would have been lower (i.e., the concentrations of the inhibitors would have to have been higher than those discussed and temperature threshold for corrosion would be lower). While there were initial issues with the welding and stress relieving of Tank AY-102 during construction, all welds passed the radiograph test prior to stress relieving (see Sections 3.2.3 and 3.2.4).

A structural investigation (BNWL-B-475, *Computer-Based Structural Investigation of the SY-103 Waste Storage Tank which Contains an Out-of-Tolerance Bottom Bump*) in 1976 of the bottom liner 'bump' in Tank SY-103 that exceeded the bottom liner tolerance concluded that increased local tensile stresses would exist in the bottom liner. The document, BNWL-B-475, concluded that the increased localized stresses would not increase the concern for the initiation of SCC to occur. A recent review of this document by members of the DST Expert Panel on Corrosion concluded that, based on current information, the presence of bumps in the bottom liner will increase the tensile stresses and could contribute to SCC initiation, especially if the bumps occurred near a weld defect or from stress concentration at the T-joint of the weld. The bottom liner in Tank AY-102 experienced bulging and wrinkling during construction, which would have induced similar stresses to the bottom liner as experienced by the bulge in Tank SY-103.

The propensity for SCC in the waste layers of Tank AY-102 with significant concentrations of inorganic carbon is continued in Section 4.1.4.4.1.

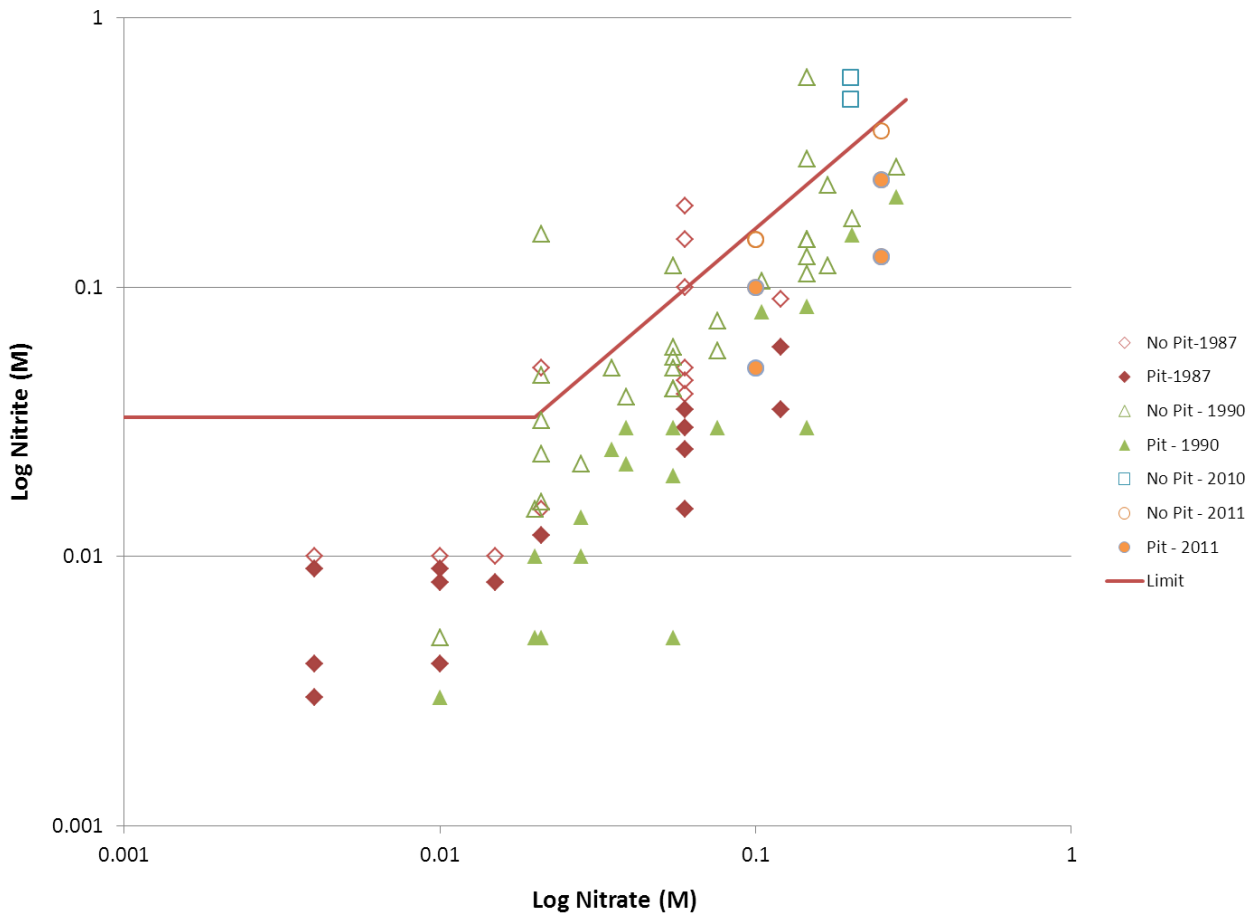
4.1.4.2.2 Localized Corrosion: Pitting and Liquid-Air Interface Corrosion

Dilute solutions of waste that have the potential to cause pitting have been present in Tank AY-102, and the compositional factors that govern pitting by nitrate ion, chloride ion, and sulfate ion are examined in this subsection.

Pitting corrosion has been studied at the Hanford Site and SRS, and minimum concentrations for the inhibitory hydroxide and nitrite ions, which depend on the nitrate ion concentration and the temperature, have been established for Tank AY-102. The chemical compositions required for prevention of pitting corrosion can also be applied as limits for prevention of liquid-air interface corrosion at the surface of the supernatant.

The SRS technical standards for pitting control with nitrate ion concentrations less than 1 M are especially relevant. These standards were created because of the need to wash and store sludge slurries in preparation for feed to their vitrification facility to reduce the amount of material vitrified. The results of their study for low concentrations of nitrate ion are shown in Figure 4-8 (WSRC-TR-94-0250, *Recommended Nitrite Limits for Chloride and Sulfate in ESP Slurries*, and SRNL-STI-2011-00479, *Effect of Chloride and Sulfate Concentration on Probability Based Corrosion Control for Liquid Waste Tanks – Part IV*).

Nitrate ion was determined to be the usual controlling aggressive species when its concentrations ranged between 0.01 M and 1 M (WSRC-TR-90-512, *Effect of Temperature on the Nitrite Requirement to Inhibit Washed Sludge*). The work led to the recommendation that the concentration of nitrite ion be greater than 0.033 M (red line at the left of Figure 4-8) for the avoidance of pitting in dilute solutions of nitrate ion at pH 10 and 40°C. This is a conservative specification inasmuch as the observations imply that pitting can be avoided when the nitrite ion concentration is 0.01 M.



Open symbol indicates no pitting, while closed symbol indicates either occasional pitting or pitting on duplicate samples. The red line represents the corrosion control limits for pitting. The pitting chemistry control limits at the SRS Site are based on these parameters.

Figure 4-8. Pitting Data for Nitrate Ion Concentrations in the Range of 0.004 M to 0.28 M at pH 10 and 40°C

At sufficiently low nitrate ion concentrations, it had been previously observed that other aggressive anions (e.g., chloride and sulfate) controlled the corrosion reaction and therefore the level of nitrite ion needed to inhibit corrosion was greater (Congdon and Lozier 1987). The minimum nitrite ion concentration was set above the amount that would be required to inhibit the other aggressive ions and the nitrate ion.

Pitting corrosion studies, WSRC-TR-94-0250 and SRNL-STI-2011-00479, determined that the chloride ion becomes the controlling corrosive ion if its concentration is greater than 3 percent of the nitrate ion concentration, while sulfate becomes controlling if its concentration is greater than 30 percent of the nitrate concentration. Equation 4-1 and Equation 4-2 were developed for these situations.

If the chloride ratio is exceeded, the following equation is used at 40°C and pH 10.

$$[NO_2^-] = 6.11 * 10^{[1.64+1.34*\log[Cl^-]]}$$

Equation 4-1

If the sulfate ratio is exceeded, the following equation is used at 40°C and pH 10.

$$[NO_2^-] = 0.04 * 10^{[1.64+0.84*\log[SO_4^{-2}]]}$$

Equation 4-2

Tank AY-102 currently has nitrate ion concentrations below 0.01 M in the interstitial liquids in the solids region of the tank, and historically in the supernatant. The sulfate ion concentration is below the level of pitting concern, but the chloride ion content may have been high enough at times to become the controlling aggressive ion for pitting corrosion.

The propensity for pitting corrosion is examined for each Tank AY-102 time interval in Section 4.1.4.4.

4.1.4.3 Chemistry Specifications

The corrosion testing programs that have been underway for many years under the general sponsorship of DOE and other agencies provide a technical basis for the assessment of the propensity for general, pitting, and cracking corrosion. The original specifications for liquid in the AY Farm required the pH to be between 8 and 10 (ARH-205, *Design Criteria PUREX AY Tank Farm*). The first major change in chemistry specifications occurred in 1983, with the publication of OSD-T-151-00017, *Operating Specifications for the Aging Waste Operations in Tank Farms 241-AY and 241-AZ*. The current specifications improved the 1983 specifications over time as more testing was completed and are contained in OSD-T-151-00007. Table 4-3 and Table 4-4 are the specifications currently used for all DSTs.

Table 4-3. Current Waste Chemistry Limits for Tanks AN-102, AN-106, AN-107, AY-101, and AY-102 Interstitial Liquid

Temperature	Variable	Limit
≤122°F	$[NO_2^-]/[NO_3^-]$[a]	≥0.32
	pH	≥10
>122°F	Limits in Table 4-4 apply[b]	

[a] The $[NO_2^-]/[NO_3^-]$ limit > 0.32 does not apply to Tank AY-102.

[b] Tank AY-102 chemistry limits apply for temperatures not in excess of 170°F.

Source: OSD-T-151-00007, 2012, *Operating Specifications for the Double-Shell Storage Tanks*, Rev. 10, Washington River Protection Solutions, LLC., Richland, Washington.

Table 4-4. Current Waste Chemistry Limits for All Double-Shell Tank Wastes Except Tank AN-102, AN-106, AN-107, AY-101, and AY-102 Interstitial Liquid

For $[NO_3^-]$ Range	Variable	For Waste Temperature (T) Range		
		T <167 °F	167 °F < T < 212 °F	T > 212 °F
$[NO_3^-] \leq$ 1.0 M	[OH-]	0.010M ≤ $[OH^-]$ ≤ 8.0 M	0.010 M ≤ $[OH^-]$ ≤ 5.0 M	0.010M ≤ $[OH^-]$ < 4.0 M
	$[NO_2^-]$	0.011M ≤ $[NO_2^-]$ ≤ 5.5 M	0.011 M ≤ $[NO_2^-]$ ≤ 5.5 M	0.011M< $[NO_2^-]$ ≤ 5.5 M
	$[NO_3^-]/([OH^-] + [NO_2^-])$	< 2.5	< 2.5	< 2.5
1.0M< $[NO_3^-]$ ≤ 3.0 M	$[OH^-]$	0.1 ($[NO3^-]$) ≤ $[OH^-]$ < 10 M	0.1 ($[NO_3^-]$) ≤ $[OH^-]$ < 10 M	0.1 ($[NO_3$-]) ≤ $[OH^-]$ < 4.0 M
	$[OH^-] + [NO_2^-]$	≥ 0.4 ($[NO3^-]$)	≥ 0.4 ($[NO_3$-])	≥ 0.4 ($[NO_3^-]$)
$[NO_3^-]$ > 3.0 M	$[OH^-]$	0.3M ≤ $[OH^-]$ < 10 M	0.3M ≤ $[OH^-]$ < 10 M	0.3M ≤ $[OH^-]$ < 4M
	$[OH^-] + [NO_2^-]$	≥ 1.2 M	≥ 1.2 M	≥ 1.2 M
	$[NO_3^-]$	≤ 5.5 M	≤ 5.5 M	≤ 5.5 M

Source: OSD-T-151-00007, 2012, *Operating Specifications for the Double-Shell Storage Tanks*, Rev. 10, Washington River Protection Solutions, LLC., Richland, Washington.

4.1.4.4 Chemical Composition and Corrosion

The changes in the chemical composition of the tank waste layers can be conveniently grouped into five time intervals since waste was first placed in Tank AY-102 in 1971 as shown in Figure 4-9. The analytical measurements and testing programs provide a technical basis for the assessment of the propensity of the different waste compositions for pitting and for the initiation of SCC in these five intervals.

It is necessary to point out that the analysis is adversely affected by the uncertainties associated with the numerous waste transfers, the infrequency of sampling, especially before 1990, and the uncertainties in the operating conditions. The numerous waste transfers and the variations in the volumes of the solid and supernatant layers are also shown in Figure 4-9.

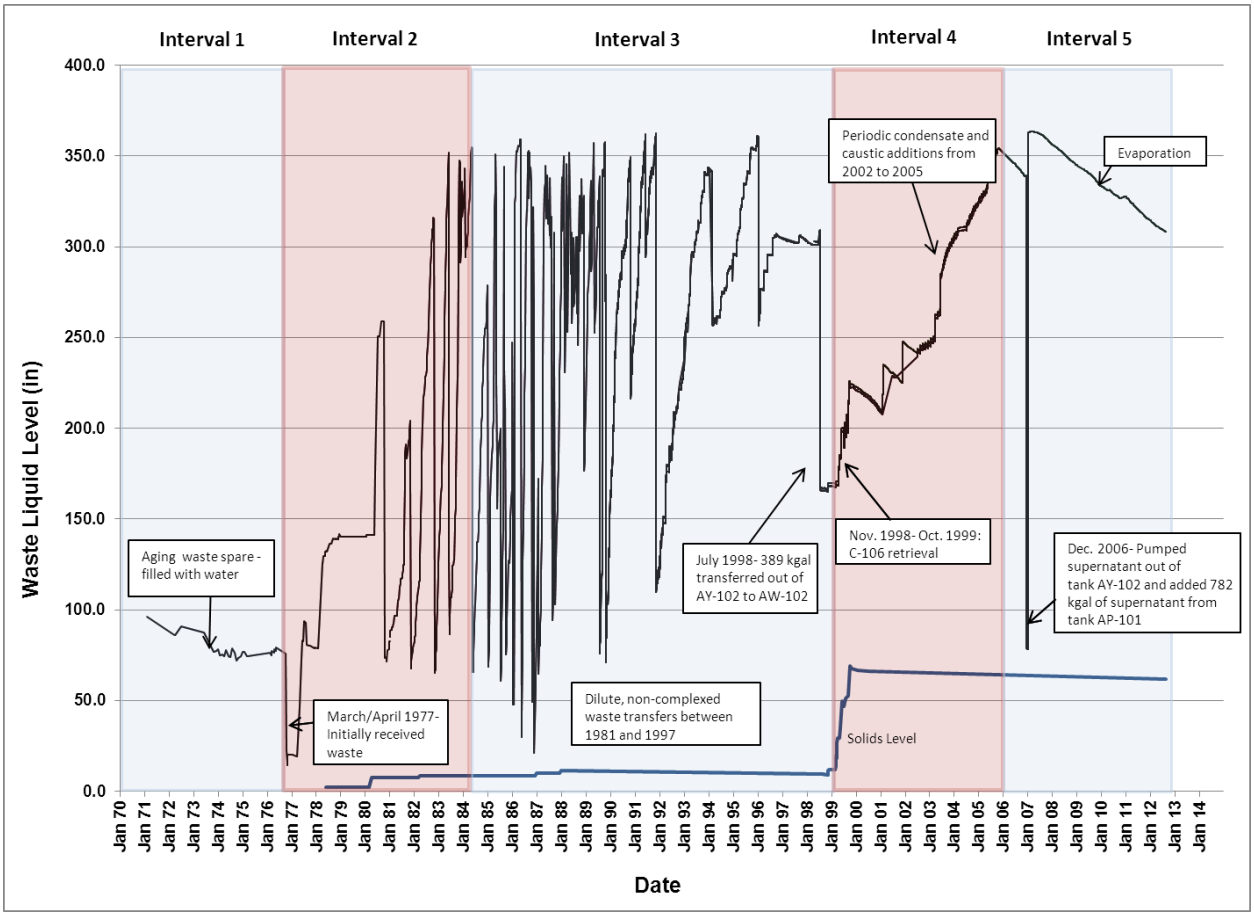


Figure 4-9. Tank AY-102 Primary Tank Liquid Levels and Solids Levels Showing Five Chemistry Intervals

4.1.4.4.1 The Supernatant Layer

Interval 1: 1971 to 1976

Water was added to the tank in February 1971 prior to the transfer of warm wastes from A farm in 1972, and a small quantity of B Plant waste in 1975 (see Section 4.1.1 for transfer information). Only two waste samples were collected during this interval. The results imply the pH was between 10 and 11 with very low concentrations of nitrate ion (< 0.01 M) and nitrite ion (<0.01 M) (Wheeler 1974 and Analytical Services 1976). The tank was operated between 50 and 70°C to evaporate water during this time (see Section 4.1.3 for temperature data).

The solid layer, if any, was small during Interval 1, and the tank bottom and the first 6 ft of the wall were apparently in contact with dilute aqueous solutions. The liquid was incompletely inhibited (pH 10 to 11, nitrite ion <0.01 M), but it contained equally low concentrations of aggressive ions such as nitrate ion. Stress corrosion cracking would not be expected under these conditions. However, these dilute uninhibited solutions at a low pH of 10 to 11 and temperatures near 70°C might have caused pitting corrosion and corrosion at the liquid-air interface during this interval.

Interval 2: 1977 to 1984

The waste level was decreased to about 15 inches in October 1976 during the initial years of Interval 2. Wastes from numerous other tanks were transferred to Tank AY-102 along with vitrification test wastes from Battelle Northwest Laboratory, which were routed through B Plant. These wastes introduced the corrosively aggressive nitrate ion. The liquids apparently contained 0.02 M nitrite ion and 0.30 M nitrate ion at pH 10.3 in 1978 (Analytical Services 1978). Subsequent waste additions from 1979 to 1981 increased the hydroxide and nitrite ion concentrations to about 2 M and the nitrate ion concentration to about 3 M nitrate ion (Jansky 1981). Later transfers in 1983 and 1984 reduced these concentrations to form a liquid with a pH above 12.5 and 0.05 to 0.15 M nitrite ion and 0.2 to 0.7 M nitrate ion (Mauss 1984 and Jansky 1984).

The temperature of these wastes is not generally available except for a few reported values. Towards the end of the interval, recorded temperatures were identified. The wastes were stored at 20-35°C in 1983 and 1984.

As discussed subsequently, a solid layer formed at this time. The high pH and the high nitrite ion/nitrate ion concentration ratio that apparently existed from September 1979 to May 1984 (i.e., during most of Interval 2) presumably minimized the risk of SCC. However, the supernatant liquids, which existed at the beginning and end of Interval 2, were insufficiently inhibited. The hydroxide and nitrite ion concentrations (pH 10.3, nitrite ion 0.026 M, nitrite ion/nitrate ion concentration ratio 0.09) were low in 1978, and the nitrite ion concentration (0.05 M) and the concentration ratio (0.05) were low at the end of 1984.

Although the propensity of SCC is minimized by the low concentration of nitrate ion, the low concentrations of nitrite ion and the low ratios raise concerns. Pitting, for the same reasons, was a definite threat during these times.

Interval 3: 1985 to 1998

The composition of the supernatant layer changed again in 1985. The tank was virtually emptied in May 1986 to leave only 30 inches of waste. Many waste transfers were performed between 1985 and 1998 and not all of these solutions were analyzed. However, the wastes were relatively dilute solutions with nitrate ion concentration generally less than 0.01 M. The nitrite ion concentration ranged from 0.014 to 0.064 M in Interval 3 (Peterson 1990, WHC-SD-WM-DP-150, *60-Day Waste Compatibility Safety Issue and Final Results for Tank 241-AY-102, Grab Samples 2AY-95-1, 2AY-95-2, 2-AY-95-3, and 2-AY-95-4*, and TWINS). The hydroxide ion concentration also decreased during this interval and sodium hydroxide was added to correct the deficiency (Blaak 2000). The temperature of the supernatant layer during this interval varied from about 25 to 30°C.

Stress corrosion cracking corrosion was unlikely because the solutions were dilute and the temperatures were low. The propensity for pitting on the steel walls and corrosion at the liquid air interface is more difficult to assess. As discussed in Section 4.1.4.2.2, it has been recommended that the nitrite ion concentration exceed 0.033 M, when the nitrate ion concentration is less than 0.02 M for solutions at pH 10 at 40°C to control pitting. The lowest measured nitrite ion concentration was 0.017 M. The supernatant layer was not ideally inhibited, but the fact that it contained about 0.02 M nitrite ion at higher pH and a lower temperature than

existed in the tests implies that there was a small risk for pitting corrosion from the supernatant layer during Interval 3.

When the concentration of nitrate ion is low, the concentrations of chloride and sulfate ions need to be considered. A similar analysis for chloride ion-induced pitting was applied because its concentration was about 0.04 M chloride ion during part of Interval 3 (Peterson 1990). As in the case of nitrate ion, the concentration of nitrite ion was less than formally required for the inhibition of pitting by chloride ion, for solutions at pH 10 and 40°C, but the actual pH was somewhat higher and the temperature was somewhat lower than these test conditions, and the pitting threat was small.

Interval 4: 1999 to 2006

Waste from Tank C-106 was transferred into the tank in December 1998 by using the supernatant layer of the receiver tank as the transfer medium (RPP-RPT-42920). Later dilute condensate was added to the tank and a new liquid layer formed on top of the supernatant layer.

The waste transfer raised the temperature of the supernatant layer to between 35 and 50°C. The hydroxide ion concentration in the principal supernatant layer was initially about 0.1 M with about 0.15 M nitrite ion and a low concentration of nitrate ion (TWINS). However, these concentrations both decreased to below the chemistry corrosion limits and sodium hydroxide and sodium nitrite were added to bring the composition of the layer back into compliance (Aromi 2005). The concentrations of nitrate and chloride ion in the supernatant layer were very low during Interval 4.

The composition of the surface layer, which formed as condensate was transferred to the tank, was initially acceptable. However, the further dilution and the introduction of carbon dioxide decreased the pH, and sodium hydroxide was added to compensate for the change in alkalinity. Mixing and the addition of sodium hydroxide addressed this deficiency.

Both supernatant layers can be accurately described as alkaline solutions of sodium carbonate with low concentrations of chloride, nitrite, nitrate, phosphate, and sulfate ions. The very low concentrations of nitrate ion and other aggressive ions forestall cracking as already discussed for the wastes in other intervals.

Pitting, as discussed in Section 4.1.4.2.2, is improbable for solutions with very low concentrations of both nitrate and chloride ions when the solution contains more than 0.033 M nitrite ion and the solution is maintained at a pH greater than 10 and at temperatures less than 40°C. Inasmuch as the nitrite content is greater than 0.033 M, the pH was greater than 10 and the temperature was less than 40°C, there is a negligible propensity for pitting or corrosion at the liquid-air interface.

Interval 5: 2007 to 2012

The supernatant layer was removed in late 2006 and replaced with a new supernatant layer from Tank AP-101. The approximate concentrations were 2.3 M hydroxide ion, 0.90 M nitrite ion, and 1.8 M nitrate ion. The nitrite ion/nitrate ion concentration ratio was about 0.5 (RPP-RPT-42920). The temperature in the supernatant layer remained between 35 and 50°C.

Tests of simulants of Interval 5 waste have shown that neither SCC nor pitting occur at 50 and 77°C. These findings are compatible with the results of many tests of other nitrate ion-rich Hanford Site wastes. The supernatant layer has little propensity for pitting or cracking corrosion.

4.1.4.4.2 The Solid Layer and Interstitial Liquid

Interval 1: 1971-1976

There is no evidence that there was a solid layer during this interval. The supernatant layer was in contact with the bottom of the tank during this time. The propensity for corrosion at the bottom of the tank was the same as at the walls as discussed for the supernatant layer in Interval 1.

Interval 2: 1977-1984

A 22 kL solid layer was reported in June 1978 which increased to 80 kL of solids by April 1980. No samples were obtained from the solid layer at this time, but most, if not all of the layer was produced from solids that were introduced in the first three years of Interval 2 shown in Figure 4-8. Since the tank had been virtually emptied in 1976, the solids that deposited at this time were passed through nitrate ion-rich liquids and presumably acquired interstitial liquids with the same composition as the supernatant layer through which they passed. The supernatant layer that existed when most of the solids were deposited contained 0.02 M nitrite ion and 0.30 M nitrate ion at pH 10.3. The solids that deposited later in this interval passed through at least two different solutions. One contained liquids with about 2 M hydroxide and nitrite ions and about 3 M nitrate ion concentration and the other had less nitrite ion (0.05 to 0.15 M) and less nitrate ion (0.2 to 0.7 M) at pH 12.5.

The adoption of this view, for which, unfortunately, there is no independent analytical evidence, implies that solids with different interstitial liquids were sequentially deposited on the floor of the tank. As already discussed for the supernatant layer in Interval 2, the supernatant liquid that existed at the beginning of Interval 2, and which would have provided the interstitial liquid in the depositing solids, was insufficiently inhibited (pH 10.3, nitrite ion 0.026 M, nitrite ion/nitrate ion concentration ratio 0.09).

The propensity for cracking corrosion by this liquid was small because of the low nitrate content, but a liquid of this composition may have caused pitting. Presumably, the initial interstitial liquid from 1978 mixed with the interstitial liquids in the solids that deposited to form other interstitial liquids with different compositions, but all of which contained nitrate ion. Temperatures in the solids level during this time are unknown, but are assumed to be in the 20-35°C range. Inasmuch as some of these liquids contained more than 2 M hydroxide ion, the initial deficiency in the concentration of this important pitting inhibitor may have been relieved through the slow mixing of these liquids. Nevertheless, pitting corrosion may have occurred on the bottom of the tank during this interval.

Interval 3: 1985-1998

The continuing slow growth of the solid layer during this interval has been attributed to the ongoing addition of low level B Plant waste, which continued until 1990. Numerous waste transfers were made in this interval (see Figure 4-8), but frequent analyses indicate the

supernatant layer was carbonate ion-rich with low concentrations of nitrate ion (0.005 to 0.04 M). The temperature of the waste during Interval 3 was 25 to 35°C.

The first sample was taken from the solid layer in 1987, when it held approximately 95 kL of solids. Several other cores were obtained from the solid layer following the transfer of solid waste from Tank C-106 in 1999. The solids that were deposited between 1985 and 1999 passed through carbonate ion-rich liquids with low concentrations of nitrate ion. The interstitial liquid from the 1987 core and the interstitial liquids from the lowest segments of the later cores (i.e., samples from the solid layer that already existed in 1987), indicate uniformly that the interstitial liquid is a carbonate ion-rich solution with a low concentration of nitrate ion.

Although there are discrepancies regarding the chloride and nitrite ion concentrations, the interstitial liquid from the 1987 core had a high concentration of carbonate ion with 0.03 M nitrate ion at pH 12.1 (Peterson 1990). The pH and nitrate ion concentrations for the interstitial liquids from the supernatant and the solid layers in 1987 are similar and in accord with the notion that the portion of the interstitial liquid, which was sampled, had acquired the composition of the new supernatant layer[5].

It is unknown whether the core samples obtained an accurate representation the first layers of solids deposited in the tank or only retrieved upper layers. Dynamic mixing of the various waste compositions from multiple transfers is also difficult to assess.

The fact that rates of migration of ions through the interstitial liquids are very slow implies that the nitrate ion-rich interstitial liquid that was presumably near the bottom of the tank at the end of Interval 2 in 1984 may not have equilibrated with the carbonate ion-rich liquid in the other portions of the solid layer in the short time between the end of Interval 2 and the coring event in 1987.

Consequently, the propensities for corrosion of a nitrate ion-rich interstitial liquid and a carbonate ion-rich interstitial liquid will both be considered for Intervals 3, 4 and 5.

Nitrate ion-rich liquid: The propensity for cracking and pitting corrosion by the nitrate ion-rich interstitial liquid was discussed in the previous section, where it was concluded that there was a small propensity for pitting corrosion because the concentration of nitrite ion in the liquid was sufficient to inhibit pitting at the pH and temperature of the waste.

Carbonate ion-rich liquid: Cracking corrosion was unlikely because the solutions were dilute and the temperatures were low during Interval 3. The propensity for pitting is more difficult to assess because of the uncertainties in the nitrite and chloride ion contents of the interstitial liquid. The reported nitrite ion concentration (0.17 M) greatly exceeds the amount needed to control pitting at the low nitrate ion concentration. Even if the concentration were 0.017 M, there would only be a small risk for pitting corrosion at the relatively high pH and the relatively low temperature during Interval 3.

[5] Duplicate analyses yielded diverse results for chloride ion (0.04 and 0.41 M), and the concentration of nitrite ion reported for the interstitial liquid, 0.17 M, is significantly higher than reported for the supernatant layer or for other samples from the solid layer. The results may simply be anomalous because of the long delays in the analytical work or they may reflect the heterogeneity of the liquids in the solid layer.

The differences in the chloride ion measurements in the 1987 core (0.04 and 0.40 M) complicate the assessment of the potential for pitting. These concentrations are much higher than other chloride ion measurements for later cores and, as already mentioned may be anomalous. If the chloride concentrations were actually this high, there would have been a significant propensity for pitting corrosion, as discussed in Section 4.1.4.2.2.

Interval 4: 1998-2006 and Interval 5: 2007-Present

The addition of the solid waste from Tank C-106 in late 1998 submerged the previous solid layer (105 kL) beneath a large new solid layer (476 kL). The previous supernatant layer in Tank AY-102 was used as the transfer medium and it became the interstitial liquid of the large new solid layer. The previous solid layer retained the same interstitial fluid it had in Interval 3. The immediate consequence of the transfer was the rapid increase in temperature of the two solid layers and the supernatant layer. The temperature reached 50°C after one year following the completion of the Tank C-106 solids addition. The temperature reached over 60°C on multiple occasions since 1999, but was generally maintained around 50°C.

The supernatant layer in Tank AY-102 was replaced in 2007 with a new supernatant layer from Tank AP-101. This change in the supernatant layer may have changed the composition of the interstitial liquid at the top of the large solid layer that originated from Tank C-106, but this change of the supernatant layer did not change the composition of the interstitial liquid in the fully submerged lower solid layer. The composition and propensity for corrosion by the interstitial liquids in the large upper solid layer and the small lower solid layer will be discussed separately.

Large upper solid layer from Tank C-106: Several cores were taken from the solid layer after the transfer of the solids from Tank C-106 from 1999 to 2005. Carbonate ion is the most abundant anion in the interstitial liquid in the large solid layer, which has a very low concentration of nitrate ion with low concentrations of aluminate, chloride, fluoride, oxalate, sulfate, and phosphate ions. The concentrations of hydroxide ion and nitrite ion are somewhat larger in the segments from the top of the layer as a consequence of the relatively high concentrations of these ions in the supernatant layer as illustrated by the average nitrite ion contents of the top (0.33 M), center (0.13 M) and bottom (0.01 M) segments of Core 319 (Ritenour 2005).

The temperature of this layer of waste increased to approximately 50°C after the completion of the transfer in 1999 achieved a maximum of 87°C in 2002. The solids level temperatures are recently in the range of 35-55°C.

The migration of the inhibited supernatant liquid into the interstitial liquid of the solid layer, which is slow, would lessen the propensity for corrosion. However, a conservative approach was used in the testing programs and simulants of the least inhibited interstitial liquid in the lower segment were examined at pH below the pH of the actual waste. Three carbonate ion-rich simulants, which contained less than 0.01 M nitrite ion at pH 10, 10.5 and 11, did not cause pitting or cracking of heat treated carbon steel at either 50 or 77°C. Other results of the testing program and information from the literature strongly suggest that the high carbonate ion concentrations inhibit pitting and SCC at the open circuit potential.

Radiolytic and chemical reactions generate hydrogen and hydrogen peroxide and oxygen in the carbonate ion-rich waste. The estimated rate of hydrogen generation, 2.71×10^{-5} mole/kg/day is especially high in this Hanford Site waste because of the low nitrate ion content. It is much more difficult to estimate the rates of hydrogen peroxide and oxygen formation because the reactive intermediates that are involved in their formation are consumed in competitive reactions with organic compounds in the waste. The maximum rate of hydrogen peroxide formation is estimated to be about twice the rate of hydrogen generation from radiolytic and chemical reactions. It is not clear whether such low concentrations of hydrogen peroxide would cause corrosion, but the fact that hydrogen peroxide is known to be a corrosive agent in nuclear power facilities prompted corrosion tests with simulants in 100% oxygen atmospheres. Corrosion did not occur in these tests.

Lastly, the tests of the simulants also showed that carbonate ion-induced cracking can occur at low potential near -800 mV (SCE). This finding prompted the installation of electrode systems into Tank AY-102 as discussed in Section 4.1.6. Data collected to date indicate that the tank and properly functioning tank material electrodes are not at corrosion potentials shown to cause SCC by the referenced Expert Panel Oversight Committee (EPOC) laboratory test program results.

In summary, these lines of evidence led the EPOC to conclude that carbonate ion-induced SCC and pitting were not credible corrosion threats for the interstitial liquid in this layer of the tank to the tank under the present storage conditions (RPP-RPT-43115, *Summary and Recommendations of the Expert Panel Oversight Committee Meeting on Double-Shell Tank Corrosion Monitoring and Testing Held June 1-3, 2009*).

Small lower solid layer: The addition of the solid waste from Tank C-106 in Interval 4 and the replacement of the supernatant layer in Interval 5 would not have altered the chemical composition of the waste in the bottom solid layer. The complex nature of the waste in the lower solid layer was described in Solid Interval 3 where it was pointed out that the layer may have been heterogeneous with a nitrate ion-rich interstitial liquid at the bottom of the layer and a carbonate ion-rich interstitial liquid at the top of the layer. The elevated temperatures introduced during Tank C-106 addition would have increased the possibility for pitting and SCC to occur in the lower solids layer.

The composition of the carbonate ion-rich interstitial liquid in this layer can be judged from the compositions of the lowest segments of the lowest cores. As already mentioned, simulants with this composition do not cause pitting or cracking corrosion at low pH (10) or high temperature (77°C).

4.1.4.5 Summary

Although there were opportunities for corrosion in the early operation of the tank, there are no definite indications of a high propensity for corrosion in Tank AY-102 because of its operating history. One scenario that should be considered is that remnants of incompletely inhibited nitrate-rich interstitial liquids that were present in the low temperature solids layer in Interval 2 remained at the bottom of the tank after 20 years of storage. It is conceivable that pitting and SCC occurred on the bottom of the tank when the tank temperature increased significantly after the addition of solid waste from Tank C-106 in 1999.

However, the concern remains that the cores have not sampled the waste at the actual bottom of the tank or detected elements of its lateral heterogeneity. As discussed above, the interstitial liquid at the bottom of the tank may have retained interstitial liquids with nitrate ion that was deposited in Interval 2. The solids that deposited in Interval 2 traversed at least three different supernatant layers. The first and third supernatant layers, through which the solids traveled, had low concentrations of nitrite ion and a low nitrite ion/nitrate ion concentration. The supernatant layer that was present for the most of Interval 2 had about 2 M hydroxide ion and nitrite ion with about 3 M nitrate ion. It is very difficult to judge the composition of the interstitial liquid that existed at the bottom of the tank 15 years later in 1999 when it experienced the large increase in temperature. However, it is well established that pitting and SCC occur much more readily at higher temperatures, and the possibility that pitting and SCC occurred as a consequence of the addition of the hot waste cannot be dismissed on the basis of the information that is now available. Any remaining tensile stresses from bulging in the Tank AY-102 bottom liner following stress relieving during construction would have also increased the propensity for SCC initiation.

4.1.5 Primary Ventilation

The primary ventilation system ventilates the headspace of the primary tank. It provides multiple functions including the prevention of flammable gas accumulation in the headspace, partial cooling of the tank contents, and confinement of radioactive material.

The Tank AY-102 primary tank headspace is connected to the 702-AZ ventilation system, which provides primary tank ventilation for both the AY and AZ Farms as shown in Figure 4-10. The 702-AZ primary ventilation train draws a slight negative pressure on the tank headspace. This ensures that airflow through a tank penetration is drawn into the tank headspace. The 702-AZ system is connected directly to the tank headspace via risers that penetrate the tank dome.

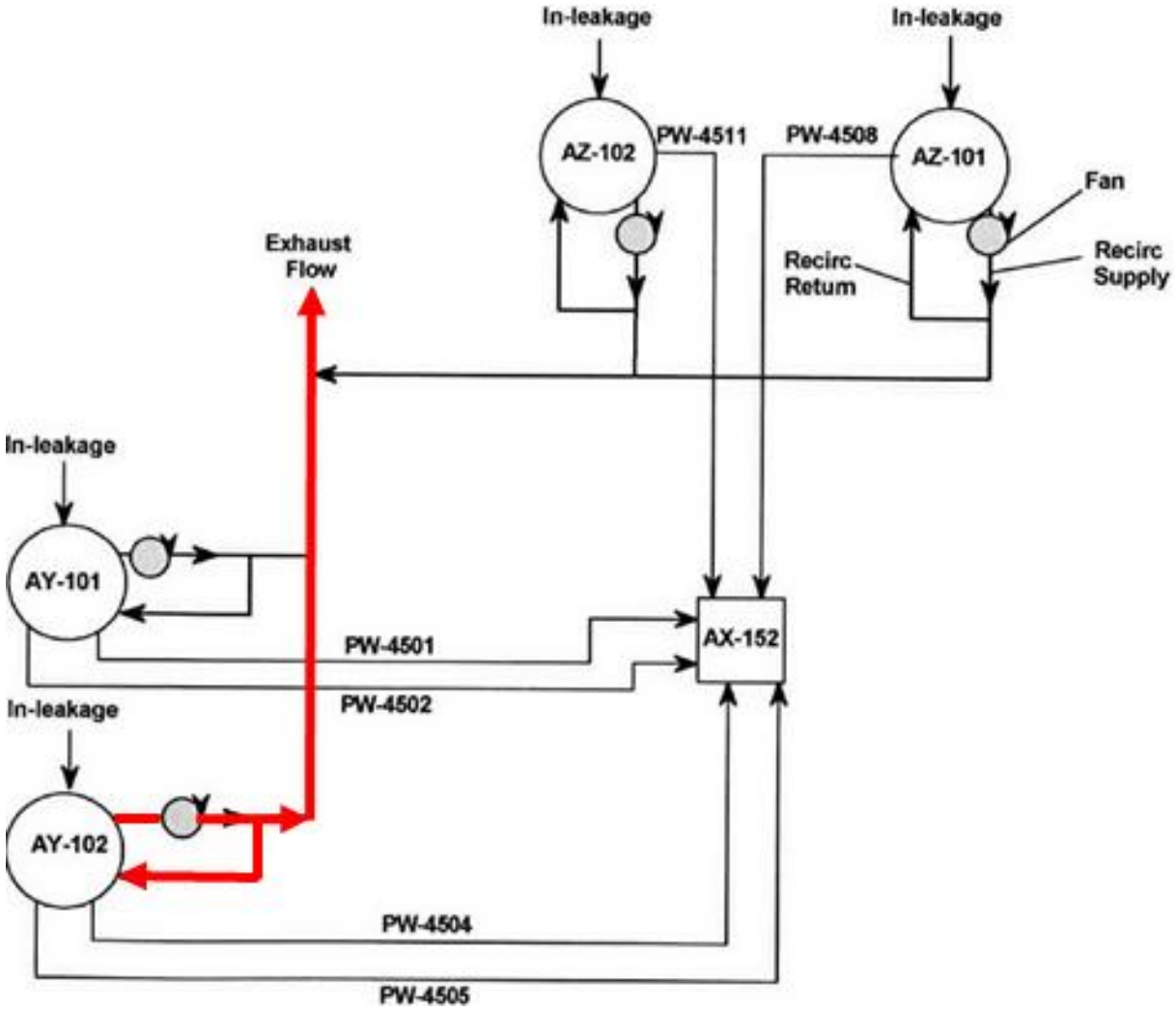


Figure 4-10. 702-AZ Primary Ventilation System

The ventilation exhaust train pulls from Riser 27 through a recirculation loop and into ventilation building 702-AZ. From the exhaust duct, a record sampler and a CAM monitor the exhaust emissions for radioactivity downstream of the high efficiency particulate air (HEPA) exhaust filters. The configuration is shown in Figure 4-11 (RPP-15127, *System Design Description for AY/AZ Tank Farm Primary Ventilation System [DSA Based]).*

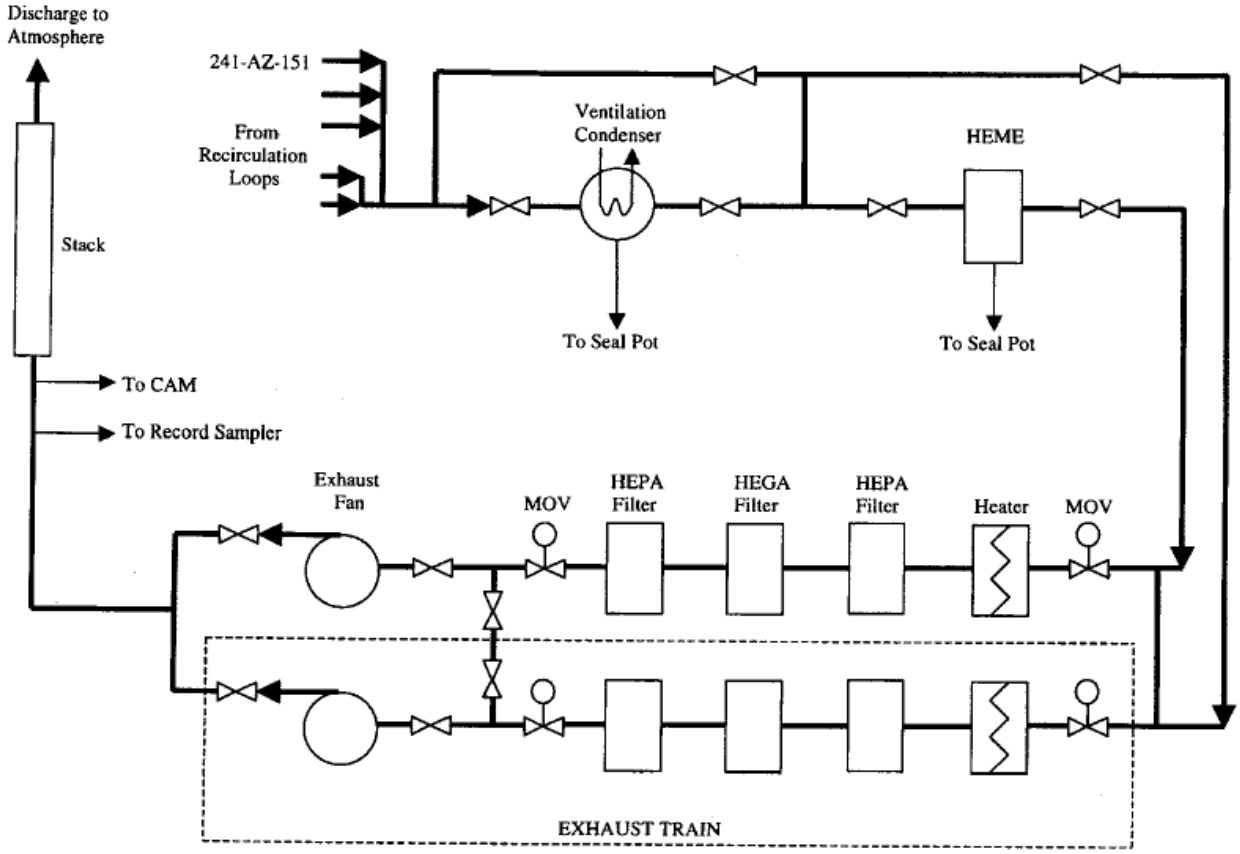


Figure 4-11. 702-AZ Primary Ventilation System Flow Diagram

The 702-AZ primary ventilation system typically maintains Tank AY-102 pressure at -1-2-in. wg negative pressure with documented flow rates from 200-500 ft^3/min (RPP-42658, *AZ-702 Ventilation System Bypass Flow Evaluation*).

4.1.5.1 Primary Ventilation Outages

The 702-AZ primary ventilation outages were retrieved from system log books, scanned in IDMS, and outages greater than one day are reported in Table 4-5. The 702-AZ primary ventilation outages prior to 2003 could not be recovered.

The longest outage of the 702-AZ primary ventilation system since 2003 was 108 days from March to June 2004. The next longest outage of 79 days occurred from October 2010 to January 2011. Typically primary ventilation outages were less than six days.

Table 4-5. 702-AZ Primary Ventilation Outages (2003 to Present)

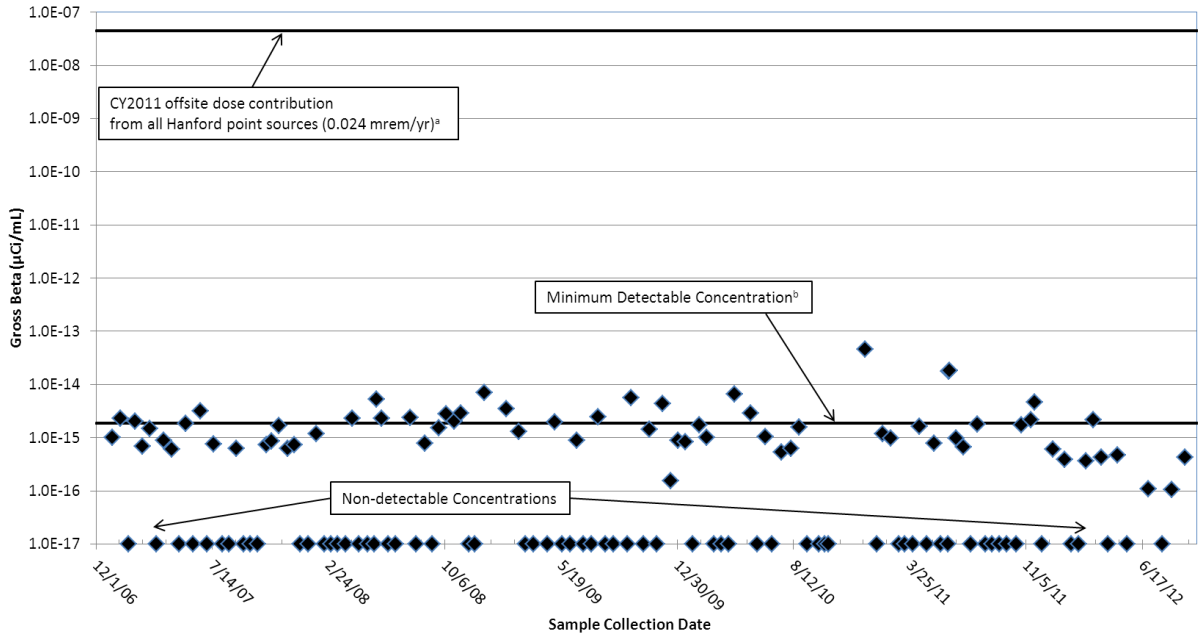
Start	End	Days	Start	End	Days
06/23/2003	07/07/2003	14.0	01/13/2009 02:47	01/13/2009 20:40	0.7
03/09/2004	06/25/2004	108.1	01/31/2009 22:05	02/04/2009 13:35	3.6
07/05/2004	07/07/2004	1.9	04/06/2009 10:18	04/16/2009 15:25	10.2
08/12/2004	08/18/2004	5.9	07/16/2009 09:05	07/19/2009 19:30	3.4
01/05/2005 17:30	01/07/2005 04:13	1.4	04/10/2010 21:05	05/13/2010 10:15	32.5
04/01/2005 08:20	04/04/2005 10:17	3.1	07/19/2010 12:50	07/20/2010 09:42	0.9
06/29/2005 11:00	06/30/2005 07:40	0.9	07/20/2010 09:50	07/22/2010 14:49	2.2
09/26/2005 16:54	09/28/2005 10:00	1.7	08/17/2010 17:20	08/18/2010 13:50	0.9
09/30/2005 15:47	10/06/2005 07:56	5.7	09/12/2010 21:50	09/15/2010 15:40	2.7
10/16/2005 15:52	10/29/2005 14:53	13.0	10/08/2010 08:40	10/12/2010 09:20	4.0
10/29/2005 17:55	11/01/2005 04:17	2.4	10/19/2010 10:18	01/06/2011 17:55	79.3
11/01/2005 05:20	11/02/2005 10:00	1.2	01/19/2011 18:04	01/21/2011 19:55	2.1
11/07/2005 04:05	11/12/2005 16:01	5.5	01/27/2011 17:18	01/28/2011 08:46	0.6
06/03/2006 03:20	06/04/2006 20:12	1.7	01/28/2011 18:00	01/29/2011 07:30	0.6
06/06/2006 19:15	06/20/2006 14:10	13.8	01/29/2010 15:18	01/31/2010 09:20	1.8
05/07/2007 00:30	05/10/2007 14:30	3.6	01/31/2011 16:13	02/01/2011 16:50	1.0
01/20/2008 20:15	01/21/2008 15:20	0.8	02/15/2011 00:02	02/17/2011 11:47	2.5
09/20/2008 12:20	09/23/2008 15:34	3.1	04/02/2011 07:53	04/07/2011 10:10	5.1
11/04/2008 09:15	11/05/2008 09:48	1.0	04/14/2011 16:10	04/18/2011 15:15	4.0
11/18/2008 00:36	11/21/2008 11:10	3.4	11/18/2011 20:00	11/21/2011 12:35	2.7

Compared to the annulus ventilation system, the primary ventilation system has relatively little effect on tank temperature. This can be seen in the figures in Section 3.5.3. It is therefore unlikely that the operating status of the primary ventilation system has affected the integrity of the tank.

4.1.5.2 AY Farm Record Sampler

The 702-AZ primary exhaust system (stack #296-A-42) is sampled for radionuclide particulate matter prior to release to the ambient environment. The stack samples are collected using a sample extraction probe permanently installed at a fixed location on the vertical portion of the stack downstream from the HEPA exhaust filters. Stack samples are collected every 2 to 4 weeks with the samples subsequently shipped to the Waste Sample Characterization Facility for analyses. The 702-AZ stack sample is analyzed for gross alpha and gross beta radioactivity, and individual radioisotopes. All Waste Sample Characterization Facility analytical data and calculated concentrations are uploaded into ABCASH (Automated Bar Coding of All Samples at Hanford) and available for end users.

Figure 4-12 presents five years of ABCASH gross beta sample concentrations for the 702-AZ systems. No adverse trends or areas of concern have been identified from the graphs.



[a] 4.5E-08 µCi/mL, DOE/RL-2012-19, "Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2011," 1,000 ft^3/min. and ^{90}Sr assumed.

[b] 1.9E-15 µCi/mL, HNF-EP-085-17, "Statement of Work for Services Provided by the Waste Sampling and Characterization Facility for the Effluent and Environmental Monitoring Program during Calendar Year 2011."

Figure 4-12. 296-A-42 702-AZ Primary Exhauster Record Sample Results

4.1.6 Corrosion Probe

In FY2008, the design requirements for a new multi-probe corrosion monitoring system (MPCMS) were developed and issued in RPP-SPEC-35429, *Procurement Specification for the AY-102 Corrosion Probe Assembly*. Based on these requirements and lessons learned from previous DST corrosion monitoring systems, the probe was designed, fabricated, and installed in Tank AY-102 on March 26, 2009. A 12 in. spool piece was installed on the riser after it was found that the probe came in contact with the bottom of the tank 4-6 times as the probe was being installed. A recent dimensional analysis indicated the riser and bottom of the tank elevations were incorrect resulting in an approximate 8-in. discrepancy. However, there was limited potential for damage due to controlled installation speed. After installation, the probe was monitored daily through the first month, on a weekly basis for the next six months, and then on a monthly basis.

The MPCMS consists of a fixed probe and four removal probes. The fixed probe of the Tank AY-102 MPCMS was fabricated from 2-in. diameter schedule 80 ASTM A106 Grade B carbon steel pipe with mounting bracket guide plate assemblies to house four removable probes. The primary function of the fixed probe is to house electrodes and sensors dedicated to monitoring tank corrosion potential and general corrosion rates in the vapor space, supernatant, and solids/sludge layer. The assembly contains mounting brackets and guide plates, which are designed to house four removable probes, holding them in place during system installation and

operation. The fixed probe is fitted with sets of custom-made radiation-resistant primary reference electrodes, metallic secondary reference electrodes (for making corrosion potential measurements upon the failure of the primary reference electrodes), surrogate tank steel electrodes (for corrosion potential measurements), electrical resistance (ER) sensors, and stressed C-ring and unstressed corrosion coupons (made of steel similar to that used in tank construction) (see Table 4-6).

Table 4-6. Tank AY-102 Multi-Probe Corrosion Monitoring System Sensing Elements

Probe Type	Passive Elements	Active Elements	
Removable probes	Bar	None	
	C-Ring		
	Round		
Fixed probe	Bar	Primary reference electrodes	Silver/Silver-Chloride (Ag/AgCl)
			Copper/Copper-Sulfate ($Cu/CuSO_4$)
	C-Ring		Saturated Calomel (SCE, Hg/HgCl)
		Secondary reference electrodes	Nickel (Ni)
	Round		Copper (Cu)
			Silver (Ag)
		Surrogate tank steel	AAR 128TC Grade B
		Electrical resistance sensors	

The electrodes, sensors, and coupons are installed along the fixed probe at specific elevations to facilitate corrosion monitoring in the vapor space, supernatant, and solids/sludge regions. Only the corrosion coupons are installed on the removable probes. Electrodes and sensors are isolated from the probe body with commercially-available glass-lined feed through capability. Individual radiation-resistant shielded data cables, running through the interior of the fixed probe body, connect the in-tank electrodes and sensors to measurement test points located in a weather-tight terminal box at probe top.

No electrically powered corrosion monitoring hardware is installed in the Tank AY-102 MPCMS field cabinet. Likewise, the system does not provide for automated data collection. Instead, measurement and test equipment is periodically carried out to the cabinet by tank farm operations personnel and used to gather data from the in-tank electrodes. The frequency at which data are collected and the type and amount of data collected have varied by length of operation. Data was collected once per day at the beginning of operation, and have since been reduced to once every two weeks.

Corrosion potential data collected from the Tank AY-102 MPCMS are periodically collected and compared with the range of corrosion potential shown to induce SCC in the EPOC-guided laboratory test program. Prior to January 1, 2012, data and system performance was periodically summarized for the MPCMS in a standalone report. In January 2012, this format was changed to combine data from the five MPCMSs located in different DSTs into a single quarterly operational summary report (RPP-RPT-51766, *Multi-Probe Corrosion Monitoring Systems: Quarterly Report*). The tanks with MPCMSs are Tanks AY-101, AY-102, AN-102, AN-107, and AW-104.

4.1.6.1 Operability

As of the end of June 2012, 11 of the 19 electrodes and ER sensors on the fixed probe of the Tank AY-102 MPCMS were considered to have failed. Electrode failures, troubleshooting, and maintenance activities prior to August 2011 are summarized in RPP-RPT-40661, *241-AY-102 Multi-Probe Corrosion Monitoring System: May, June & July 2011 Quarterly Report*, Rev. 29.

The operating status of each electrode and ER sensor as of June 30, 2012, for the Tank AY-102 MPCMS is summarized in Table 4-7. For clarity, electrode names in the figures presented in this section have been slightly modified from those shown on the Tank AY-102 MPCMS drawings. Data from failed electrodes and ER sensors are not presented in this report. Corrosion potential data were not collected from the Tank AY-102 MPCMS during the month of May due to construction activities in the area. Normal data collection operations are expected to resume at the conclusion of construction activities.

Table 4-7. Tank AY-102 Multi-Probe Corrosion Monitoring System Electrode and Electrical Resistance Sensor Status as of June 2012

Electrode/Sensor	Status	Electrode/Sensor	Status	Legend
VS-ER	Operational	SS-ER	Failed	AG: Silver Secondary Reference Electrode
SP-NI	Operational	SS-CUSO4	Failed	AGCL: Silver/Silver-Chloride Primary Reference Electrode
SP-CU	Operational	SS-TNKMAT2	Failed	CALOMEL: SCE
SP-AG	Operational	SS-AGCL	Failed	CU: Copper Secondary Reference Electrode
SP-TNKMAT1	Operational	SS-AG	Failed	CUSO4: Copper-Sulfate Primary Reference Electrode
SP-TNKMAT2	Operational	SS-NI	Failed	ER: Electrical Resistance
SP-CALOMEL	Failed	SS-CU	Failed	NI: Nickel Secondary Reference Electrode
SP-AGCL	Failed	SS-CALOMEL	Failed	SP: Supernatant
SP-CUSO4	Operational	SS-TNKMAT1	Failed	SS: Solids/Sludge
SP-ER	Operational			TNKMAT: Tank Material Reference Electrode
				VS: Vapor Space

4.1.6.2 Corrosion Potential

Table 4-8 and Table 4-9 show the average tank potential and average tank material electrode potential data for the current reporting period with respect to functional primary reference electrodes (as

Table 4-8. Average Tank AY-102 Tank Potential (March 2009 through August 2012)

Average Tank Potential (mV) (As Measured)	Average Tank Potential (mV) (Converted to SCE)
-235 vs. SP-$CuSO_4$	-163 vs. SCE

SCE = saturated calomel electrode.

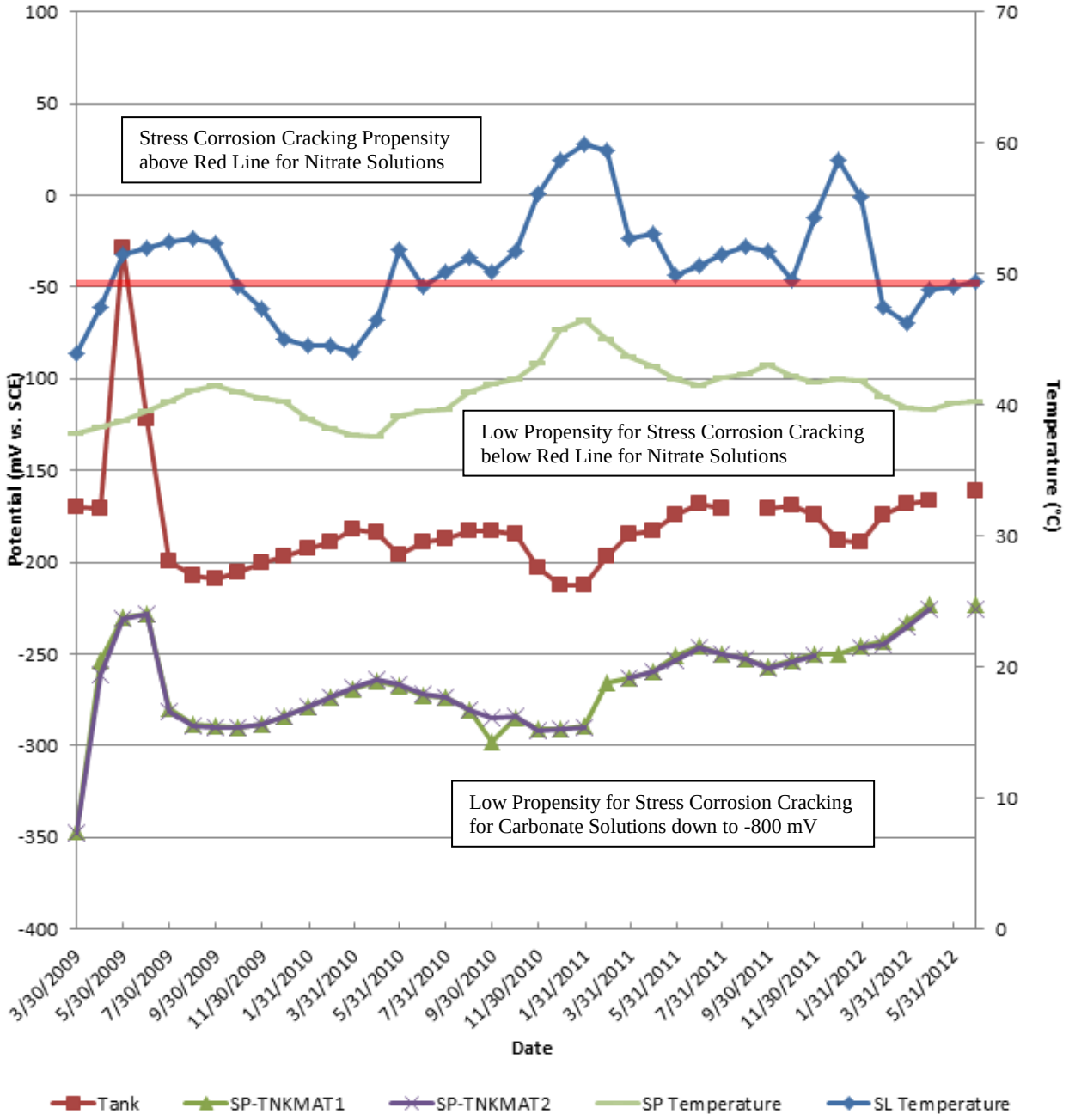
converted to the SCE scale) for the Tank AY-102 MPCMS.

Table 4-9. Average Tank AY-102 MPCMS Tank Material Electrode Potentials (March 2009 through August 2012)

Average SP-TNKMAT1 Potential (mV) (As Measured)	Average SP-TNKMAT1 Potential (mV) (Converted to SCE)		Average SP-TNKMAT2 Potential (mV) (As Measured)	Average SP-TNKMAT2 Potential (mV) (Converted to SCE)
-295 vs. SP-$CuSO_4$	-223 vs. SCE		-297 vs. SP-$CuSO_4$	-225 vs. SCE

SCE = saturated calomel electrode.

Figure 4-13 shows the average monthly corrosion potential data for the tank and tank material electrodes on the Tank AY-102 MPCMS. Both recent and historical data are presented to show trends over the life of the system.



Note: Temperature data is plotted as available.

Figure 4-13. Tank AY-102 Multi-Probe Corrosion Monitoring System Average Monthly Tank and Supernatant Tank Material Electrode Potentials

4.1.6.3 Corrosion Rate

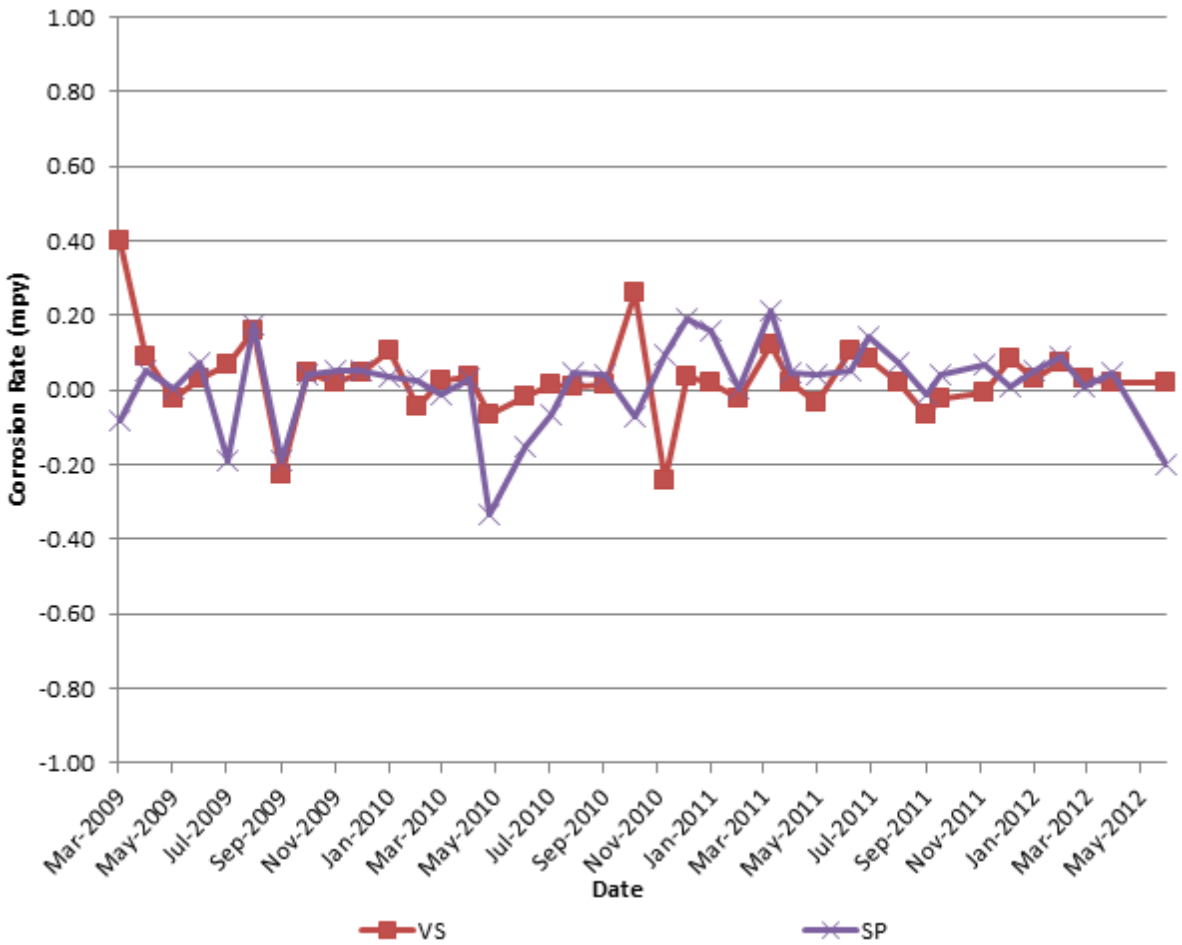
Table 4-10 shows average steel corrosion rates as measured by the ER sensors on the Tank AY-102 MPCMS. Note that data shown in Table 4-10 are overall averages for the life of the system.

Figure 4-14 shows average monthly corrosion rates as determined from ER sensor data. Both recent and historical data are presented to show trends over the life of the system.

Table 4-10. Average Corrosion Rates from the Tank AY-102 Multi-Probe Corrosion Monitoring System Electrical Resistance Sensors (March 2009 through August 2012)

Electrical Resistance Sensor	Overall Corrosion Rate (mpy)
VS	0.020
SP	0.044

VS = vapor space.
SP = supernatant.



VS = vapor space SP = supernatant

Figure 4-14. Tank AY-102 ER Sensor Average Monthly Corrosion Rates

4.1.6.4 Summary

Corrosion Potential

RPP-RPT-33284, *Hanford Tanks AY102 and AP101: Effect of Chemistry and Other Variables on Corrosion and Stress Corrosion Cracking*, presents the results of waste simulant evaluations for Tank AY-102. The laboratory work documented in RPP-RPT-33284 showed the following.

- The onset of SCC is unlikely at corrosion potentials more negative than approximately 50 mV (vs. SCE) for nitrate solutions.
- The onset of SCC is likely to occur in a narrow range of corrosion potentials around -800 mV (vs. SCE) carbonate solutions.

Data collected to date indicate that the tank and properly functioning tank material electrodes are not at corrosion potentials shown to cause SCC by the referenced EPOC laboratory test program results.

Corrosion Rate

During the reporting period from April through June 2012, the operational Tank AY-102 MPCMS ER sensors in the supernatant have indicated corrosion rates near 0 mpy. Data from the immersed ER sensor are consistent with what would be expected for carbon steel in a passive, high-pH environment. Similarly, data from the ER sensor located in the vapor space are consistent with what would be expected for carbon steel in relatively dry air even though the vapor space contained significant amounts of moisture, which hindered the most recent visual inspection.

4.1.7 Primary Tank Visual Inspection

The Tank AY-102 primary tank was first visually inspected in FY2001. The inspection showed very little detail due to a high volume of moisture content in the primary tank headspace (RPP-RPT-34311, *Double-Shell Tank Integrity Inspection Report for 241-AY Tank Farm*). The second in-tank video inspection was performed in FY2006. It showed light to moderate corrosion product accumulation on the tank dome. It is difficult to compare the FY2006 inspection to the first inspection in FY2001 due to the poor conditions during the FY2001 inspection. The most recent in-tank video inspection was performed in FY2012, showing light to moderate corrosion product accumulation on the tank dome (RPP-RPT-34311). When compared to the FY2001 and FY2006 inspection, little to no change was noted.

On April 15, 2005 during the process of removing a steel core drill string from Riser 58 in Tank AY-102, the lower half of the drill string (approximately 33 ft long and 125 lb) fell approximately 27 ft into the tank after disconnecting from the upper section (PER-2005-1582, “Lower Half of Drill String Fell into AY-102 When It Was Disconnected from the Upper Section”).

During the FY 2012 inspection, a portion of the core drill string was visible above the tank waste surface (Figure 4-15). The shaft remains in the vertical position even after the tank waste was pumped down in December 2006 to approximately 80 in., and then refilled in January 2007. The core drill string is being held in place by the approximate 5 ft of solids at the bottom of the tank. Whether or not the drill string damaged the tank bottom when it fell into the tank cannot be determined.

Figure 4-15. Tank AY-Core Drill String (July 26, 2012) In-Tank Photo ID# AY-102-163

4.1.8 Tank AY-102 Ultrasonic Testing

Tank AY-102 has had two ultrasonic testing (UT) examinations, which occurred in FY1999 and FY2007. These examinations were part of the ongoing DST Integrity Project, which examines the DSTs on an eight- to ten-year cycle. Figure 4-16 shows the Tank Integrity Inspection Guide (TIIG) for Tank AY-102. The TIIG indicates the locations of the UT examinations and areas of interest from visual inspection described in Section 4.2.6. Riser 89 was examined in FY1999 and Risers 88 and 89 were examined in FY2007.

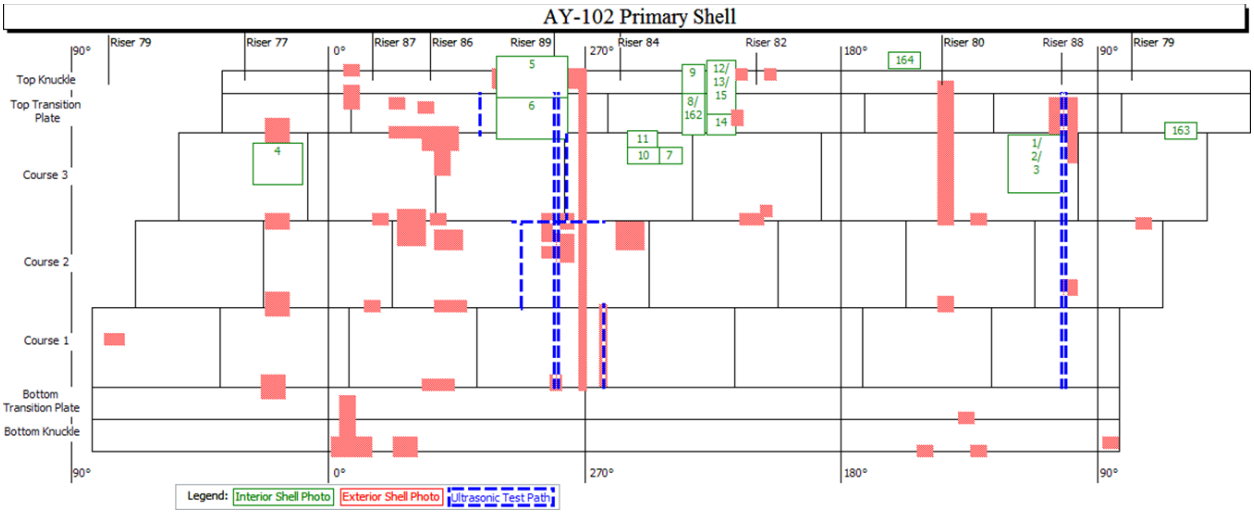


Figure 4-16. Tank Integrity Inspection Guide for Tank AY-102

The guidance for these examinations comes from BNL-52527, *Guidelines for Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks*. These guidelines came from the Tank Structural Integrity Panel, which DOE commissioned to provide criteria for HLW tank integrity (shown in Table 4-11). The integrity project has selected values below the guidelines to serve as reportable values in the corrosion evaluation. The methods used to inspect the tanks are found in RPP-7574, *Double-Shell Tank Integrity Program Plan*.

Table 4-11. Ultrasonic Testing Evaluation Guidelines and Reportable Values

Parameter	Acceptance Criteria Based on Tank Structural Integrity Panel's Evaluation Guidelines (BNL-52527)	Double-Shell Tank Integrity Program Reportable Value (RPP-7574)
Thinning	<20% thickness	<10% thickness
Pitting	<50% thickness	<25% thickness
Cracking	>12 in. 20% of thickness <12 in. 50% of thickness	Any linear indication greater than 6 in. in length and 0.1 in. in depth.

[a] BNL-52527, 1997, *Guidelines for Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks*, Brookhaven National Laboratory, Upton, New York.
[b] RPP-7574, 2007, *Double-Shell Tank Integrity Program Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

As shown in Figure 4-16, the UT system examines a small fraction of the sidewall area (about 2 percent), which translates to a smaller fraction of the overall surface exposed to the waste. Though differences in corrosion rate may occur over the height of the tank, it is assumed the corrosion within the tank occurs in a uniform fashion circumferentially around the tank. Thus, the examination on opposite sides of the tank provides sufficient coverage to assess the integrity of the tank.

To provide accurate measurement, the UT transducer must have good contact with the sidewall. As such, the standard UT measurements are generally limited to the side walls of the tanks so that the crawler can hold the transducer assembly against the wall. The dome, top knuckle, and bottom knuckle aren't routinely examined during UT examinations because of the tank curvature. A Y-arm can be added to the crawler examine these areas on a special needs basis.

The bottom of the primary tank can't be examined because of the limited access. A special device call the Remote Ultrasonic Test Inspection (RUTI) was developed to perform UT in the air channels, but the device was limited to just the metal exposed in the air channels. When deployed in Tank AZ-102 the device couldn't move freely along the channel because of debris and other obstructions.

4.1.8.1 Initial Ultrasonic Inspection (FY1999)

In FY1999, UT scans were performed through Riser 89 and results reported in HNF-4818, *Final Results of Double-Shell Tank 241-AY-102 Ultrasonic Inspection*. The scans included two side-by-side vertical scans, vertical weld scans, a horizontal weld scan, and a knuckle weld scan. The UT crew did not perform any tank wall cleaning prior to UT scans and the steel surface conditions created a difficult UT scanning environment.

The measurements were made with the Force Industries, Inc. P-Scan Model PSP-3 ultrasonic analog flaw detector and the Force Industries AWS-5D remote, digitally controlled, magnetic-wheel mechanical crawler. The scans were 12 in. long (in the vertical) by 15 in. wide (in the horizontal) with 0.100 in. resolution in the horizontal and 0.125 in. resolution in the vertical. Thus for each reported area there were 14,400 pixels.

The inspection found no indication of reportable thinning or pitting and no cracks were identified. Though Scan 1 showed a higher average wall thickness than Scan 2, there was no rescan of the data as would be performed today to ensure consistency between the two scans. In general, the rescan of the thicker set measurements brings the two measurements in line because setup errors incurred in the initial measurement are eliminated. Figure 4-17 depicts this offset between the two scans. Table 4-12 shows the measured averages for the four plates. On Plate 3 for Scan 1 and Scan 2, the inspector noted that there were "Laminations detected throughout plate." This callout wasn't made for any of the other plates.

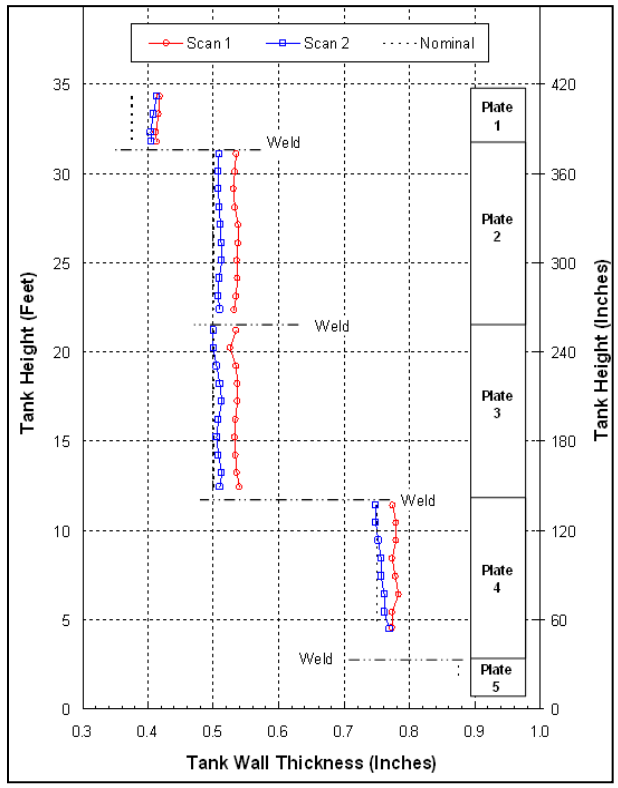


Figure 4-17. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 1 and Scan 2 Tank AY-in Riser 89 for FY1999

Table 4-12. Ultrasonic Testing Wall Thickness Measurements FY1999

Plate	Nominal Wall Thickness (in.)	Scan 1 Wall Thickness (in.)	Scan 2 Wall Thickness (in.)
One	0.375	0.415	0.408
Two	0.500	0.535	0.509
Three	0.500	0.535	0.507
Four	0.750	0.776	0.756

4.1.8.2 Second Ultrasonic Inspection (FY2007)

In FY2007, UT scans were performed through Risers 88 and 89 and results reported in RPP-RPT-32137, *Ultrasonic Inspection Results for Double-Shell Tank 241-AY-102 – FY 2007*. The FY1999 inspections in Riser 89 were repeated in FY2007 along with the addition of wall thickness measurements in the portion of the plate above the lower haunch. Two side-by-side vertical wall scans from Riser 88 were included in the FY2007 inspection.

The measurements were made with the Force Industries, Inc. P-Scan Model PSP-4 Plus ultrasonic flaw detector system and the Force Industries AWS-5D remote, digitally controlled, magnetic-wheel mechanical crawler. The scans were 12 in. long (in the vertical) by 15 in. wide (in the horizontal) with 0.035 in. resolution in the horizontal and 0.035 in. resolution in the vertical. Thus for each reported area there were about 146,400 pixels (or a ten-fold increase over the FY1999 examination). This increased resolution is helpful in the determination of pits rather than wall thickness. Another change between the two examinations is that the FY2007 inspection required extensive cleaning before a noise-free signal could be established.

Examination results of the vertical wall plates and welds revealed twenty-three areas of wall thinning that exceeded the minimum thinning reportable level of 10 percent of the nominal thickness. Twelve areas of greater than 10 percent thinning were found at the Plate 3 level, eight areas at the Plate 4 level (one was in a weld), and three areas at the Plate 5 level. However, the UT Level III inspector determined that eighteen of the twenty-three areas were considered to be pit-like and did not exceed the reportable pitting level of 25 percent of the nominal thickness.

Three reportable thinning areas were discovered at the Plate 4 level (pages A-31 and A-45 of RPP-RPT-32137); one at the 7.9-ft tank elevation level, one at the 7.8-ft tank elevation level, and one at the 4.3-ft tank elevation level. These thinned regions covered a surface area of 0.024 in^2, 0.031 in^2, and 2.55 in^2, respectively. The minimum thickness reported in these areas was 0.648 in., 86.4 percent of the nominal plate thickness. The fourth reportable thinning area was discovered at the Plate 5 level (page A-43 of RPP-RPT-32137), at the 2.3-ft tank elevation level. This thinned region covered a surface area of 0.08 in^2. The minimum thickness reported in this area was 0.775 in., 88.6 percent of the nominal plate thickness.

There were neither crack-like indications nor reportable pit-like indications detected in any of the vertical wall plates or the bottom knuckle.

4.1.8.3 Comparison

The two UT examinations of the Tank AY-102 sidewalls show few signs of corrosion over more than 40 years of service. Neither report shows reportable pits or cracking in the tank sidewall. Reportable thinning was recorded in the FY2007 report in five areas.

There were significant changes between the two examinations as the UT inspection matured from a demonstration program to a routine inspection of the tanks. The FY1999 UT used the PSP-3 UT system, which had lower resolution than the equipment used in FY2007. Lower resolution of the PSP-3 (0.100 in. x 0.125 in.) versus PSP-4 (0.035 in. x 0.035 in) hindered ability to accurately classify indications. Comments from Level III NDE inspectors involved in the Tank AY-102 UT examination focused on the steel surface conditions and the level of experience of the UT program during the FY1999 inspection.

Direct comparison of the wall thickness measurements between the two inspections is difficult because of the changes in equipment and methodology (e.g., the lack of cleaning of the tank surfaces prior to the FY1999 inspection). However, since Scan 2 from the FY1999 inspection of Riser 89 and the four scans from FY2007 show similar wall thickness, only the Scan 1 results from Riser 89 seemed to have been noticeably impacted by these differences. The Scan 1 results showed about 30-mil more wall thickness than the Scan 2 results. If similar offset measurements

occurred today, current UT protocol by the Level III Inspector would require a rescan of the plates to address the offset.

Table 4-13 summarizes the minimum and average wall thicknesses for the primary tank and bottom knuckle measured in FY 1999 and FY 2007. It also shows the changes between FY1999 and FY2007 measurements in Riser 89.

Table 4-13. Comparison of Tank Ultrasonic Testing Wall Thickness Measurements FY1999-FY2007

Plate	Design Nominal (in)	Riser and Year of Scan[a]	Measured Minimum (in)	Average Minimum (in)	Avg. Min. % Nominal	Measured Average (in)	Average % Nominal
Plate 1	0.375	R-088 2007	0.359	0.3671	97.9	0.3773	100.6
		R-089 2007	0.347	0.3741	99.8	0.3873	103.3
		R-089 1999	0.383	0.3958	105.5	0.4111	109.6
		Change[b]	-0.036	-0.0217	-5.7	-0.0238	-6.3
Plate 2	0.500	R-088 2007	0.457	0.4705	94.1	0.4862	97.2
		R-089 2007	0.470	0.4813	96.3	0.4928	98.6
		R-089 1999	0.485	0.5001	100.0	0.5222	104.4
		Change[b]	-0.015	-0.0188	-3.7	-0.0294	-5.8
Plate 3	0.500	R-088 2007	0.403	0.4610	92.2	0.4870	97.4
		R-089 2007	0.441	0.4544	90.9	0.4988	99.8
		R-089 1999	0.485	0.4981	99.6	0.5210	104.2
		Change[b]	-0.044	-0.0437	-8.7	-0.0222	-4.4
Plate 4	0.750	R-088 2007	0.646	0.7053	94.0	0.7475	99.7
		R-089 2007	0.672	0.6976	93.0	0.7367	98.2
		R-089 1999	0.734	0.7423	99.0	0.7664	102.2
		Change[b]	-0.062	-0.0447	-6.0	-0.0297	-4.0
Plate 5	0.875	R-088 2007	0.783	0.8018	91.6	0.8863	101.3
		R-089 2007	0.775	0.7968	91.1	0.8817	100.8
		N/A[c]	-	-	-	-	-
		Change[b]	-	-	-	-	-
Bottom Knuckle	0.875	R-089 2007	0.792	0.815	93.1	0.863	98.6

[a] Data from both Scan 1 and Scan 2 combined.
[b] Difference between Riser 89 FY1999 and FY2007 data.
[c] Plate 5 was not scanned in FY1999.

Figure 4-18 shows the measured wall thickness between Scan 1 and Scan 2 in Riser 89 in the FY1999 inspections. Figure 4-19 shows the measured wall thicknesses for Scan 2 in Riser 89 for the FY1999 and FY2007 inspections. Figure 4-20 and Figure 4-21 show the Scan 1 and Scan 2 measurements for Riser 88 and 89, respectively, in FY2007.

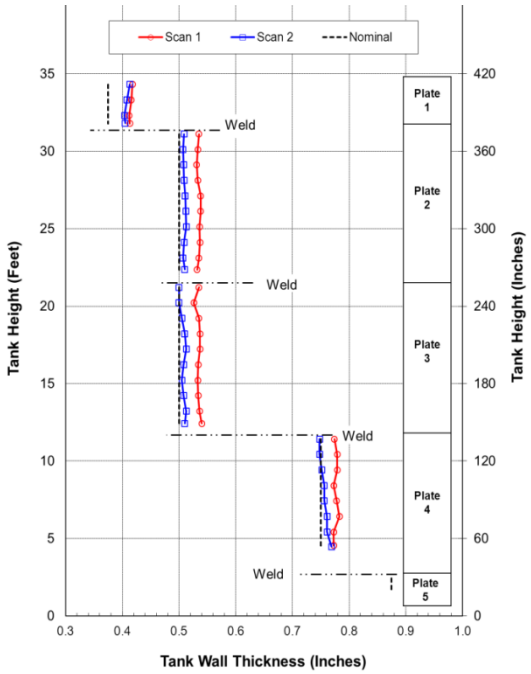


Figure 4-18. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 1 and Scan 2 in Riser 89 for FY1999

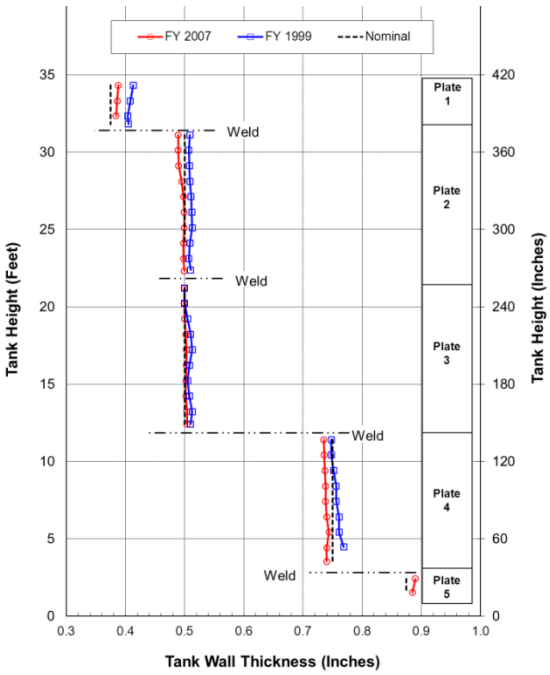


Figure 4-19. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 2 in Riser 89 between FY1999 and FY2007

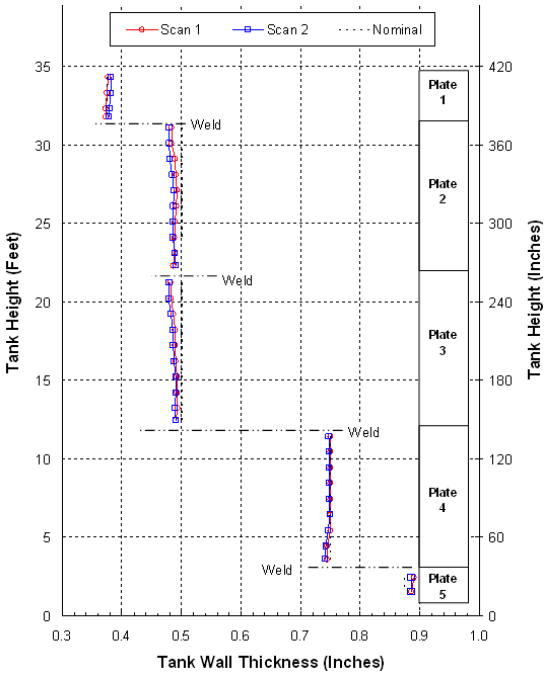


Figure 4-20. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 1 and Scan 2 in Riser 88 for FY2007

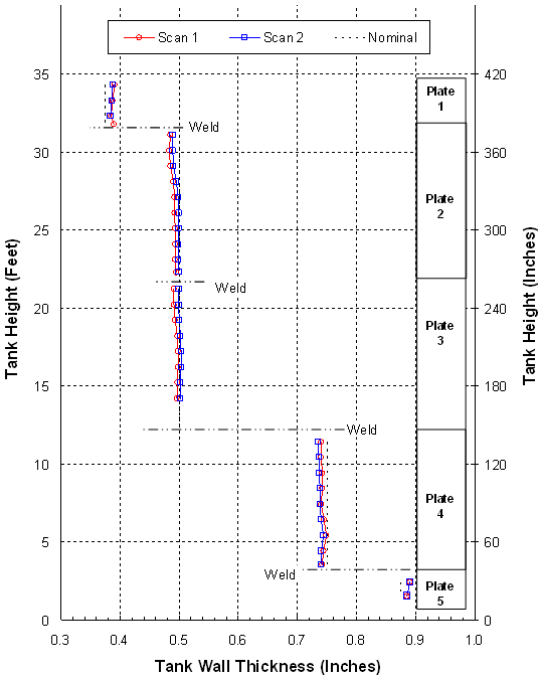


Figure 4-21. Comparison of Tank AY-102 Ultrasonic Measurements for Scan 1 and Scan 2 in Riser 89 for FY2007

Of the 23 areas of greater than ten percent wall reduction found in FY2007, 18 were identified as non-reportable pits. In the FY2007 inspection, the Level III NDE inspector reported pitting on plates 3, 4, and 5 whereas the FY1999 inspector did not. In FY1999, Level III NDE inspector reported "laminations detected throughout plate" for Plate 3 with inspector's notes suggesting potential existence of pitting. The distinction between laminations and the presence of pitting could be attributed to equipment resolution and wall contact of the UT system. In FY2007, the Level III NDE only reported non-reportable pits as plate minima, but his notes indicated the presence of other non-reportable pits.

4.1.8.4 Conclusion

The reportable wall thinning does not exceed the acceptance criteria of 20 percent wall thinning other than in the five small areas identified. During the next inspection cycle, when equivalent equipment and techniques have been employed a consistent understanding of the wall thickness can be made and the extent of pitting determined. Not all of the pits detected were reported because of the ten percent criterion. To further explore the pitting potential, a preliminary analysis of all of the pits detected was conducted and it showed no trend with respect to the height on the tank wall.

4.1.9 Occurrence Reports

Twenty-two ORs and PERs were found that relate to the Tank AY-102 primary tank (see Table 4-14). Six of the ORs were related to misrouting of small (~2,000 gal) portions of a transfer and did not appreciably affect the Tank AY-102 waste composition. Two of the ORs deal with liquid levels: a liquid level decrease and a liquid level below minimum level specification. One of the PERs (PER-2005-1582) addressed the disconnection of the lower half of a core sampler drill string that dropped down into the waste as the drill string was being removed from the tank (see Section 4.1.7). The other thirteen, a combination of ORs and PERs, addressed various aspects of controlling tank waste chemistry including control of caustic additions, mixing, and sample results.

Table 4-14. Tank AY-102 Primary Tank Occurrence Reports and Problem Evaluation Requests (3 pages)

Tank	OR/PER	Origin	Initial	Description	Final
241-AY-012	Occurrence Report 75-127	M	11/9/1975	Misrouting of process solution	2/9/1976
241-AY-102	Occurrence Report 76-138	LL	10/4/1976	Liquid level decrease exceeding criteria	1/3/1977
241-AY-102	Occurrence Report 76-148	LL	10/28/1976	Possible specification violation: liquid level decrease to below a minimum level	1/28/1977
241-AY-102	RL-WHC-TANKFARM-1994-0046	Ch	8/19/1994	Analysis of waste samples results in discovery of out-of-specification levels of hydroxide in 200 East Area waste tanks	6/9/1994
241-AY-102	RL-WHC-TANKFARM-1995-0105	CH	11/15/1995	Tank AY-102 chemistry analysis reveals low hydroxide content	2/9/1996
241-AY-102	RL-WHC-TANKFARM-1997-0073	M	9/9/1997	Misrouting Tank AY-101 to Tank AY-102 three-way valve leak through	1/29/1998
241-AY-102	Occurrence Report 80-8	M	1/21/1980	Misrouting Tank A-103 to AY-102	1/30/1980
241-AY-102	Occurrence Report 80-50	M	5/23/1980	Misrouting Tank A-103 three-way valve to AY-02A pit split flow	7/11/1980
241-AY-102	Occurrence Report 80-51	M	6/6/1980	Misrouting 244-A catch tank to Tanks AY-101 and AY-102	6/13/1980
241-AY-102	Occurrence Report 80-52	M	8/17/1981	Misrouting Tank AY-101 to AY-102	8/28/1981
241-AY-102	RP-CHG-TANKFARM-2000-0073	Ch	10/20/2000	Calculated hydroxide and nitrite readings are below specification limits of TSR AC 5.15 limits	5/18/2001
241-AY-102	RP-CHG-TANKFARM-2001-0103	Ch	11/28/2001	One time extension of AC 5.23, “Caustic Transfer Controls” violated (USQ)	11/18/2002
241-AY-102	PER-2002-3409	Ch	6/12/2002	Upon testing the chemistry of Tank AY-102 pre-caustic addition samples in February 2001, it was unexpectedly found that the nitrite content was out-of specification (depleted)	1/23/2003
241-AY-102	PER-2002-5680	Ch	10/17/2002	The condensate added to Tank AY-102 does not appear to be mixing with the supernatant. It cannot be determined whether the uppermost 20 in. of supernatant meets chemistry control TSR requirements (AC 5.15)	1/6/2003

Table 4-14. Tank AY-102 Primary Tank Occurrence Reports and Problem Evaluation Requests (3 pages)

Tank	OR/PER	Origin	Initial	Description	Final
241-AY-102	RP-CHG-TANKFARM-2003-0033	Ch	7/9/2003	Sample results from Tank AY-102 below required AC 5.15 limits, low pH (see PER-2003-2580)	9/18/2003
241-AY-120	PER-2003-5225	Ch	12/31/2003	An immiscible liquid phase was found in Tank AY-102 sludge samples. Core 312 segment 14 confirmed silicone grease to isolate supernatant. Core 312 segment 15 concluded C-106 source consisted of B Plant solvent residues	4/30/2004
241-AY-102	PER-2004-0204	Ch	1/12/2004	The 222-S Laboratory notified Process Analysis on January 12, 2003 that the preliminary pH, OH, and nitrite analytical result were outside the TSAP notification limits (pH less than 12, OH^- less than 170 µg/mL, nitrite less than 506 µg/mL as specified in the TSAP, RPP-18243,[a] Rev. 0) for the Tank AY-102 core sample interstitial liquid from the sludge segments closest to the bottom of the tank	1/27/2004
214-AY-102	PER-2004-1247	Ch	2/26/2004	The November 2003 core sample results indicated layering of the supernatant in Tank AY-102, the AZ-151 condensate receiver tank. The waste is predicted to exceed the limits as early as October 2004, if condensate transfers are continued	6/7/2005
241-AY-102	PER-2005-1582	DS	4/15/2005	The lower half of drill string fell into Tank AY-102 when it was disconnected from the upper section without a foot clamp	12/6/2005
241-AY-102	PER-2005-3074	Ch	8/22/2005	Preliminary sample results from Tank AY-102, core sample 319, segment 3 upper and lower half interstitial liquid indicate a pH of 11.7 and 11.3, respectively which are below the TSR AC 5.16 indicate that caustic mixing from the supernatant into the sludge interstitial liquid has not penetrated to the lowest depths of the sludge	12/19/2005

Table 4-14. Tank AY-102 Primary Tank Occurrence Reports and Problem Evaluation Requests (3 pages)

Tank	OR/PER	Origin	Initial	Description	Final
241-AY-102	PER-2005-3187	Ch	8/31/2005	Preliminary sample results from Tank AY-102, core sample 319, segment 3 upper and lower half interstitial liquid indicate nitrite concentrations of 446 µg/mL and <81.8, respectively µg/mL which are below the TSR AC 5.16 and indicate nitrite mixing has not penetrated to the lowest depths of the sludge	12/19/2005
241-AY-102	CH2M-PER-2006-1799	Ch	10/16/2006	Tank AY-102 is the only DST where the hydroxide level was allowed to fall below waste chemistry specifications at the same time that the nitrite level was allowed to go essentially to zero	10/19/2006

[a] RPP-18243, 2003, *Tank 241-AY-102 Push-Mode Core Sampling and Analysis Plan for Fiscal Year 2004*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

AC = administrative control.
Ch = chemistry
DS = drill string disconnect.
DST = double-shell tank.
LL = liquid level
M = misrouting.
TSAP = tank sampling and analysis plan
TSR = technical safety requirement.
USQ = unreviewed safety question.

4.2 ANNULUS HISTORY

4.2.1 Annulus Description

The tank annulus is formed by the difference between the 75-ft diameter primary tank and the 80-ft diameter secondary liner, resulting in a nominal 2.5-ft wide annular space wrapping around the entire circumference of the primary tank. Several penetrations, or risers, of various sizes exist at the top of the secondary liner, which allows access into the annulus space. This access is used for a variety of activities, including visual inspection cameras, sampling, ultrasonic testing crawlers, and leak detection instruments. The annulus provides secondary containment if the primary tank fails and also provides the ability to cool the primary tank to reduce thermal stresses, which have been linked to failures of several single-shell tanks (SST). Figure 4-22 is a diagram of the tank cross-section showing the annulus that surrounds the primary tank.

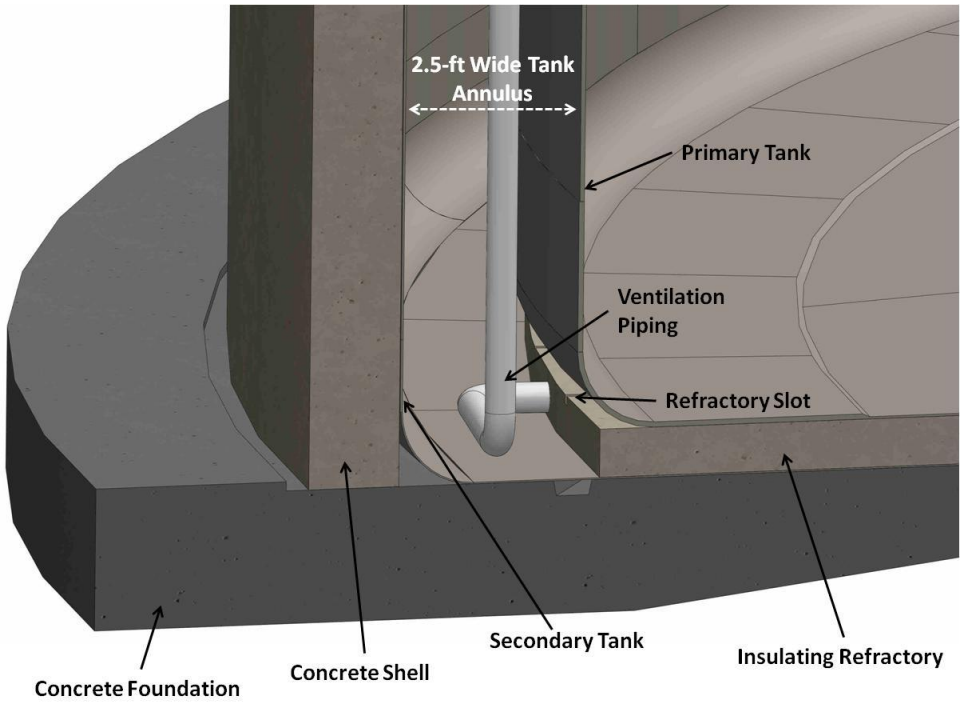


Figure 4-22. Double-Shell Tank Annulus Diagram

Leak Detection

There are two leak detection systems monitoring the annular space to detect a primary tank leak. These include three annulus ENRAF leak detectors and a CAM on the annulus ventilation exhaust upstream of the HEPA filters.

As of August 7, 2012, the three annulus ENRAFs were located in Riser 88 (AY102-WSTA-LDT-151), Riser 90 (AY102-WSTA-LDT-152), and Riser 91 (AY102-WSTA-LDT-153). The purpose of the annulus ENRAFs is to detect liquid in the annulus with a minimum depth of approximately 0.25 in. above the annulus floor (see Section 4.2.4 for additional information). The ENRAFs can be installed in any of four annulus risers (88, 89, 90, and 91).

Primary tank leak detection also is accomplished by sensing airborne radioactive contamination levels in the annulus ventilation exhaust airstream. A CAM samples the exhaust air from the tank annulus, and if contamination is present above 2,000 cpm, an alarm is activated (see Section 4.2.5).

Thermocouples

Thermocouple conduit enters the annulus via six dome risers and traverses the secondary liner wall until reaching the annulus floor. The thermocouple conduit then branches out into the refractory towards the termination point, where it is in contact with the primary tank bottom (see H-2-64372 for locations and details of construction). The purpose of the thermocouples is to monitor the temperature of the primary tank bottom. Figure 4-23 shows the thermocouple conduit in Tank AY-102 reaching the annulus floor and penetrating the refractory.

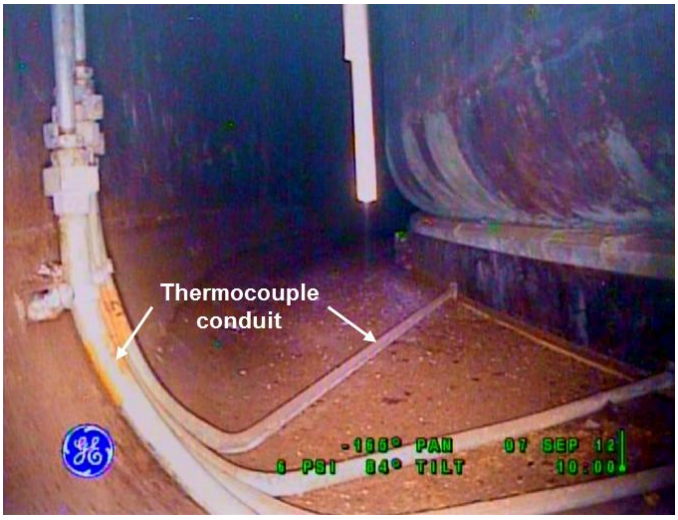


Figure 4-23. Thermocouple Conduit Orientation in Tank Annulus

The following subsections provide further background information on the annulus leak detection systems and describe recent and historical events pertaining to the Tank AY-102 annulus.

4.2.2 Annulus Ventilation

The primary function of the annulus ventilation system is to remove heat from the primary tank. A record sampler collects a sample of the exhaust stream prior to discharge to ensure radioactive emissions comply with permit conditions. A CAM monitors for increased contamination in the exhaust stream. The configuration is shown in Figure 4-24 (RPP-15127, *System Design Description for AY/AZ Tank Farm Primary Ventilation System [DSA Based]*).

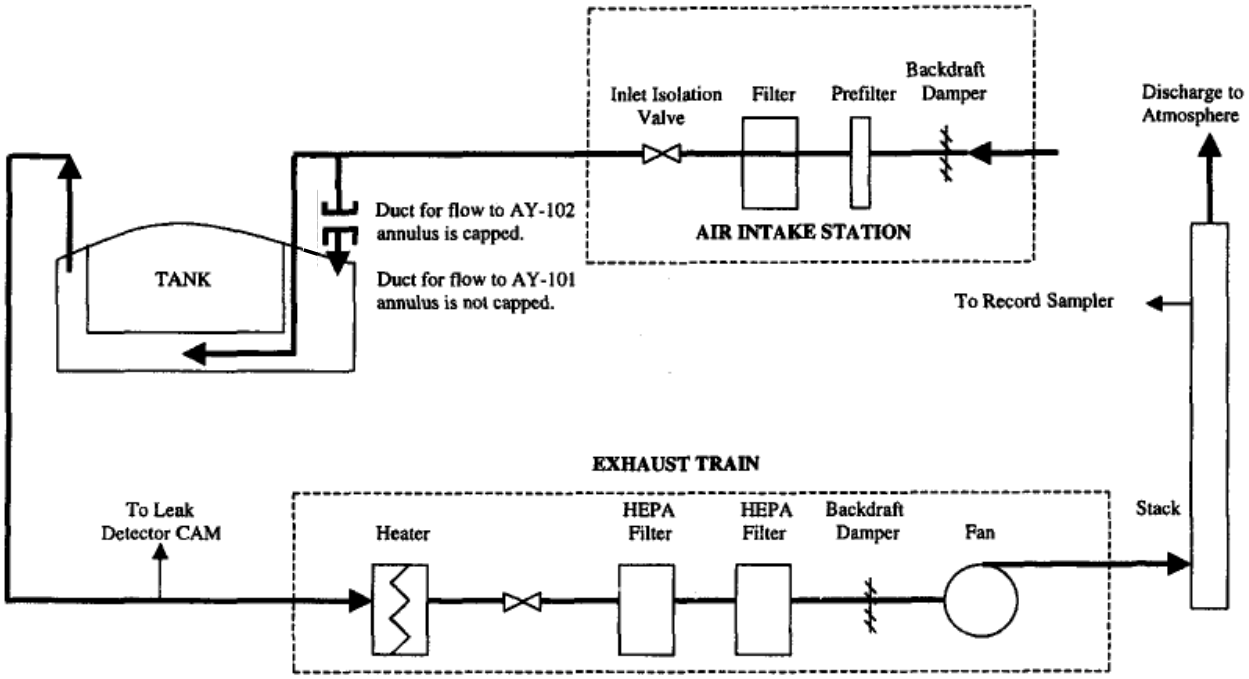


Figure 4-24. Simplified Annulus Ventilation Flow Diagram

4.2.2.1 Annulus Ventilation System Modifications

The annulus ventilation system for the AY Farm was completed under Project IAP-614 from 1968 to 1971. The original configuration provided a separate system for each tank. The system included a supply fan, an exhaust fan, and an air supply dehumidifier. A portion of the air was routed to an air distribution chamber located directly beneath the bottom center of the primary tank, and the remainder was routed to the annulus (ARH-MA-102, *241-AY Tank Farm Information Manual*).

The capacity of the original annulus ventilation system was approximately 2,000 scfm flow rate over a range of -1-in. to +1-in. wg pressure (Tardiff 2001). The operating specification in 1974 allowed a pressure range between -6-in. to +9-in. wg (ARH-1601).

In 1981, the dehumidifier was eliminated, and the inlet was modified to allow outside air as the supply air to the annulus (RPP-7695, *Double-Shell Tank Annulus Ventilation Engineering Study*). In 1983, another modification eliminated the supply fan creating a situation where the annulus could no longer be operated under positive pressure relative to atmosphere.

In 1989, the Tank AY-102 annulus ventilation piping was replaced by Project B-672 (see Section 3.6). Replacements included new cathodically protected piping tied into the original ductwork. The old ducts were cut and sealed with plugs (7G410-JKE-MJR-007-005).

In preparation for receiving the high-heat sludge from Tank C-106, Project W-320 modified the Tank AY-102 annulus ventilation system in 1998 to route all of the airflow to the air distribution chamber, and exhaust it through the radial channels present in the surface of the refractory concrete beneath the primary tank. To achieve sufficient cooling airflow, the annulus vacuum had to be significantly increased (i.e., the pressure further reduced). Project W-320 evaluated the

structural design and concluded that the primary tank could withstand a -20-in. wg pressure in the annulus.

This modification involved excavating and capping the four annulus air supply pipes that terminated in the annulus space (Figure 4-25 provides the configuration of the original air supply pipes during AY Farm construction). The four remaining air supply pipes that terminated in the air distribution chamber then provided 100 percent of the annulus airflow directly to the bottom of the primary tank to achieve maximum air cooling (RPP-RPT-25731) (See Figure 4-26). The annulus vacuum had to be increased to approximately -15-in. wg to achieve the desired airflow and vacuum. Since the modification, the ventilation rate has ranged between about 850 scfm and 1,075 scfm, or about one-half of the rate provided by the original system equipped with a supply fan (RPP-25731).

Figure 4-25. Annulus Ventilation Inlet Piping During Construction

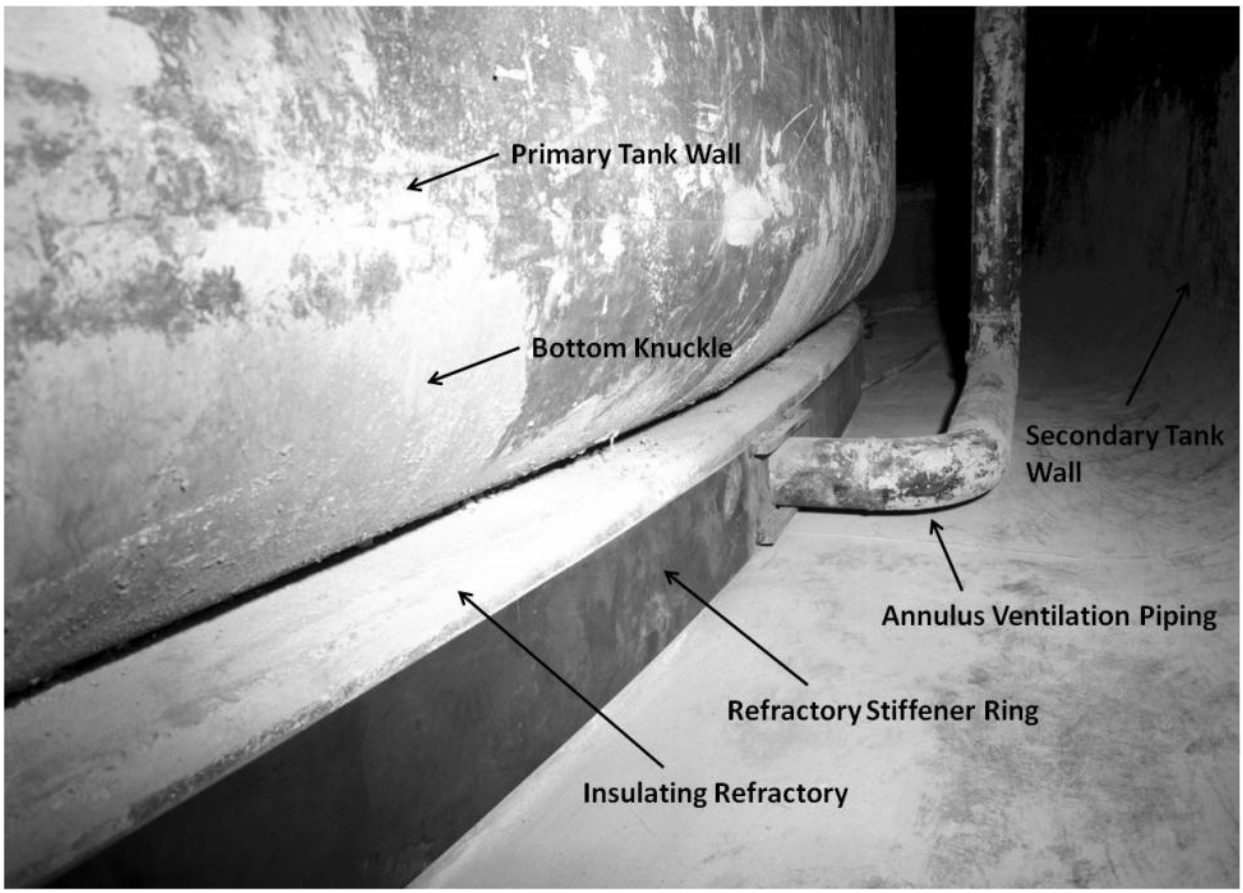


Figure 4-26. Annulus Ventilation Supply Piping Penetrating Refractory

4.2.2.2 Annulus Ventilation Outages

The annulus ventilation operating status between 1980 and 2000 is from RPP-7695, and reported in Table 4-15. Outages from 2003 to present are from system log books. Records for the Tank AY-102 annulus ventilation outages from 2001 to 2003 are not available. Annulus ventilation outages greater than one day are summarized in Table 4-15 and Table 4-16. The impact of annulus ventilation system operation on refractory and concrete foundation temperatures is discussed in Section 3.5.

Table 4-15. Tank AY-102 Annulus Ventilation Outages 1980-2000

Annulus System Outage	Days	Annulus System Outage	Days
04/03/1980	1	05/12/1997 - 05/26/1997	14
04/05/1980 - 04/09/1980	4	11/15/1997 - 01/22/1998	68
05/20/1980 - 05/21/1980	1	02/02/1998 - 02/03/1998	1
06/11/1980 - 06/12/1980	1	02/11/1998 - 08/11/1998	181
10/09/1980 - 10/13/1980	4	09/03/1998 - 09/14/1998	11
05/27/1982 - 06/01/1982	5	12/18/1998 - 12/22/1998	4
09/30/1982 - 10/20/1984	20	08/12/1999 - 08/13/1999	1
01/17/1986 - 01/27/1986	10	08/25/1999 - 08/26/1999	1
05/02/1987 - 01/27/1988	70	09/01/1999 - 10/03/1999	32
06/29/1988 - 08/02/1988	34	10/14/1999	1
12/24/1989 - 02/14/1990	52	11/12/1999 - 11/16/1999	4
06/23/1990 - 08/02/1990	40	01/20/2000 - 01/27/2000	7
06/10/1991 - 03/09/1997	2099	09/22/2000 - 09/27/2000	5
03/25/1997 - 03/27/1997	2	10/12/2000 - 11/11/2000	30

Table 4-16. Tank AY-102 Annulus Ventilation Outages 2003-Present

Start	End	Days	Start	End	Days
05/06/2003	05/30/2003	24	12/19/2006	12/22/2006	3
12/01/2003	12/23/2003	22	04/26/2007	05/11/2007	15
01/06/2004	01/17/2004	11	07/08/2007	07/17/2007	9
02/20/2004	03/05/2004	14	01/13/2008	04/09/2008	87
03/08/2004	04/06/2004	29	04/03/2009	04/16/2009	13
05/10/2004	05/13/2004	3	05/04/2009	05/27/2009	23
09/01/2004	09/08/2004	7	04/16/2010	05/13/2010	27
12/12/2004	12/23/2004	11	07/19/2010	07/23/2010	4
11/07/2005	11/11/2005	4	10/17/2010	02/23/2011	129
03/07/2006	03/22/2006	15	11/08/2011	01/14/2012	67
11/12/2006	11/21/2006	9	04/12/2012	04/25/2012	13
11/25/2006	12/05/2006	10			

4.2.2.3 Pathways for Possible Contamination in the Tank AY-102 Annulus

There are three possible pathways that exist for contamination to enter the annulus region from the primary tank other than a tank leak:

- Tank AY-102 was originally designed with a valved cross-tie to ventilate both the primary and annulus headspaces from either system. However, this was never used and the cross-tie was removed by Project W-030 (Tardiff 2001).
- The second pathway exists when the waste liquid level is below 60 in., exposing the inlet of the annulus pump pit drain leg. This event has occurred several times, the first recorded in 1976 and then again in the 1985-1986 time frame. This has resulted in low-level contamination in the annulus pump pit and probably the annulus itself (see Section 4.2.5 for details).
- The third pathway is via the exposed leak detection pump pit drain leg that also exists when the waste liquid level is below 60 in.

The annulus was sampled extensively in 1999 for smearable contamination. Swabs of the primary tank surface and floor and of all annulus risers resulted in no contamination found. The annulus pump pit smears resulted in 2,000-3,000 dpm/100 cm^2, which were reduced after reseating a drain plug. Generally, equipment removed from annulus risers has been contamination free.

4.2.2.4 Presence of Water in the Annulus

Annulus water ingress and corrosion of ventilation piping have been observed in Tank AY-102, as documented in memorandum 7G41-JKE/MJR-007-005 (Engeman and Rodgers 2007). A number of actions performed in 2006-2008, and discussed in Section 4.2.3, were believed to have eliminated previous water intrusions.

Water can be introduced to the annulus when the ENRAF leak detection probes are flushed during recalibration. Water is also introduced as couplant used during UT examinations of the primary tank wall.

Several studies have examined the possibility that a seasonal moisture accumulation and evaporation cycle occurs within the annulus, but the possibility of a net water accumulation cycle has not been demonstrated (RPP-32420, *Tank 241-AY-101 Annulus Ventilation System Psychrometric Data Evaluation*).

4.2.2.5 Annulus Ventilation Summary

The Tank AY-102 annulus ventilation system currently operates at -15-in. wg pressure and about 850 ft^3/min airflow. The system has experienced multiple prolonged outages, with the longest outage of approximately 6 years from 1991 to 1997 during ventilation upgrades. Since 2003, the longest outage of 129 days occurred from October 2010 to February 2011.

The cross-connections between the primary tank headspace and the annulus system present a contamination backflow pathway. Historical records indicate cross-contamination has occurred several times since first recorded in 1976. In 1999, contamination surveys of the annulus determined the surfaces were contamination-free; the annulus pump pit contamination ranged up to 3,000 dpm/100 cm^2.

Water intentionally is introduced during ENRAF leak detector flushing and UT examinations. Seasonal humidity variations have been studied to determine whether or not a chronic humidity-driven water accumulation in the annulus is possible; the results were inconclusive.

4.2.3 Water Intrusion

On March 31, 1986, an annulus exhaust ventilation pipe for Tank AY-102 was punctured while performing air lift circulator upgrades and the pipe was found to be severely corroded (Rockwell International internal letter, 65950-86-328). A follow-on investigation indicated both Tank AY-101 and Tank AY-102 annulus ventilation systems were severely corroded while the primary ventilation system was not (Rockwell International internal letter, 65950-86-396). It was determined that the annulus ductwork was corroded only where it directly contacted the soil. A review of the construction specifications along with visual and ultrasound inspection indicated the annulus ventilation ductwork was wrapped in the AZ Farm.

In 2001, significant corrosion was identified in the annulus on the outside of the primary tank of Tank AY-102 during tank video inspection (Occurrence Report RP-CHG-TANKFARM-2001-0106; RPP-9497, *Year 2001 Visual Examinations of Tank Annuli at Tanks 241-AY-102 and 241-AZ-101*). It was concluded that the corrosion had occurred since the previous 1992 visual inspection. Increased corrosion was attributed to water intrusion from external sources, coupled with shutdown of the annulus ventilation system for an extended period. The corrosion was similar to that previously documented in Occurrence Report, RP-CHG-TANKFARM-2001-0004, *Corrosion Observed in Double-Shell Tank 241-AY-101 during Video Inspection and Ultrasonic Testing*, for Tank AY-101. There it was reported that, “Water infiltration due to leakage from raw water lines located above the tank dome and natural storm run-on and run-off together with the inoperability of the tank ventilation system appear to be the cause” (RPP-9497).

In September 2001, a leak evaluation of the AY Farm raw water system over the tank structures was performed (RPP-8887, *Evaluation of Potential Water Intrusion Sources*). It was concluded that raw water supply valves were leaking into the raw water valve pits, which are open-bottomed and filled with gravel and vermiculite. The raw water supply valves for Tanks AY-101 and AY-102 were replaced with blind flanges. Inspection of the raw water piping excavated for the leak evaluation noted that the nearby abandoned 1 ½-in. carbon steel steam condensate piping was heavily corroded, as documented in the 1980s. The corrosion appeared to be typical for the 200 Areas caused by carbon pipe in contact with soil and accelerated by the increased temperature of the steam condensate (Rockwell International internal letter 65950-81-466). The condensate lines were removed from service and capped at the valve pits. Inspection of the 4-in. coated raw water supply line showed no signs of degradation. In June 2006, the raw water header was cut and capped outside of AY Farm (RPP-RPT-37440; ECN-723915).

Corrosion product was collected from the annulus side of the primary tank wall of Tank AY-102 through Riser 80 in February 2003 (RPP-15758, *Analysis of Corrosion Product Retrieved From The Primary Tank Wall in the Annulus of Tank 241-AY-102*). The sample was scanned by Operational Health Physics and found to contain no radioactivity. Three types of analyses were performed: energy dispersive X-ray spectrometry (EDS), XRD, and wet chemical analysis. The analyses indicated that the steel was wetted with water resulting in aqueous corrosion. The likely cause was ingress of water from an external source combined with the shutdown of the annulus ventilation system for an extended period of time as reported previously (RPP-15758).

During the FY2006 annulus visual inspections of Tanks AY-101 and AY-102, rust streaks and mineralization were observed on the outside surface of the primary tank walls. During this time, annulus video examinations were expanded from four to eight risers in the Tank AY-102 annulus. For Tank AY-102, comparisons of the FY2006 videos with those taken in FY2001 showed that the size of the rust areas had increased, and were concentrated on the primary tank top knuckle region. The rust appeared most significant in areas where the primary and secondary liner walls converged, appearing to originate at the flashing-covered convergence between the primary and secondary liner walls. White and the yellow mineralization was reported in this location (Engeman and Rodgers 2007; CH2M-PER-2007-0086).

It is likely that soil channels created by the now isolated raw water supply leaks or the annulus ductwork may provide a path for rainfall and snowmelt seepage onto the concrete dome of the tank where it eventually finds its way to the metal dome of the primary tank. Ingress through the abandoned annulus ventilation piping (ductwork) could provide additional pathways. The water ingress once it penetrates through the concrete could travel under the 18 gauge metal flashing covering the gap where the primary and secondary liner walls converge and present itself as primary tank dome mineralization.

If the annulus ventilation system is turned off, it is possible for condensation to accumulate whenever the dew point of the incoming air is higher than the tank wall temperature. The condensate generated during these periods would also contribute to the rust.

Operating specification OSD-T-151-00007 requires that upon detection of water ingress into a DST annulus, either the water ingress be stopped within 30 days or a recovery plan be prepared and the intrusion stopped in accordance with the recovery plan.

The 2006 visual inspections of the Tank AY-102 annuli identified significant additional annulus-side corrosion after taking actions in 2001 that were believed to stop the water ingress from the raw water supply. In 2006, water intrusion mitigation requirements were specified in HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*, Administrative Control, (AC) 5.16, "Corrosion Mitigation Controls." The Tanks AY-101 and AY-102 Annulus Corrosion Recovery Plan was submitted to the U.S. Department of Energy on March 6, 2007 (Ferrera 2007).

As a result of the Tank AY-102 Annulus Corrosion Recovery Plan, a number of evaluations were performed in 2007. Table 4-17 provides a summary of events and actions in response to the water intrusion into Tank AY-102 annulus.

Table 4-17. Summary of Events in Response to the Tank AY-102 Water Intrusion (2 pages)

Date	Event	Reference
06/1991	Tank AY-102 annulus ventilation system shut down	7G410-JKE/MJR-007-005, "Evidence of Annulus Moisture Accumulation in Tanks 241-AY-101 and 241-AY-102" (Engeman and Rodgers 2007)
03/1997	AY-102 annulus ventilation system comes back online after being off for approximately 6 years. The AY-102 annulus ventilation system operates for ~ 8 months until Project W-320 required the system to be shut down	RPP-7695, *Double-Shell Tank Annulus Ventilation Engineering Study*
01/2001	Water intrusion detected in annulus of Tank AY-102	RPP-7764, *Year 2001 Visual Examination of Tank Annuli at Tanks 241-AY-101 and 241-AZ-102*
09/2001	Raw water supply valves, V-110 and -138, to Tanks AY-101 and -102 were cut and capped and pressure tested	RPP-8887, *Evaluation of Potential Water Intrusion Sources*
12/2001	Corrosion observed in AY-102 during video inspection of the annulus section attributed to water intrusion from external sources, coupled with shutdown of the annulus ventilation system for an extended period	Occurrence Report RP—CHG-TANKFARM-2001-0106, *Corrosion Observed in Double-Shell Tank 241-AY-102 During Video Inspection of the Annulus Section*
02/2003	Corrosion product sampled from annulus side of primary tank and found no radioactivity	RPP-15758, *Analysis of Corrosion Product Retrieved From The Primary Tank Wall in the Annulus of Tank 241-AY-102*
06/2006	Raw water header cut and capped outside of AY Farm	ECN-723915, "DST Isolation Project: Isolate Raw Water to AY0152 and AY-501"
12/2006	Continuing water intrusion detected in annulus of Tank AY-102	7G410-JKE/MJR-007-005 (Engeman and Rodgers 2007)
03/2007	Tanks AY-101 and AY-102 Annulus Corrosion Recovery Plan submitted to DOE	CH2M-0700558 (Ferrera 2007)

Table 4-17. Summary of Events in Response to the Tank AY-102 Water Intrusion (2 pages)

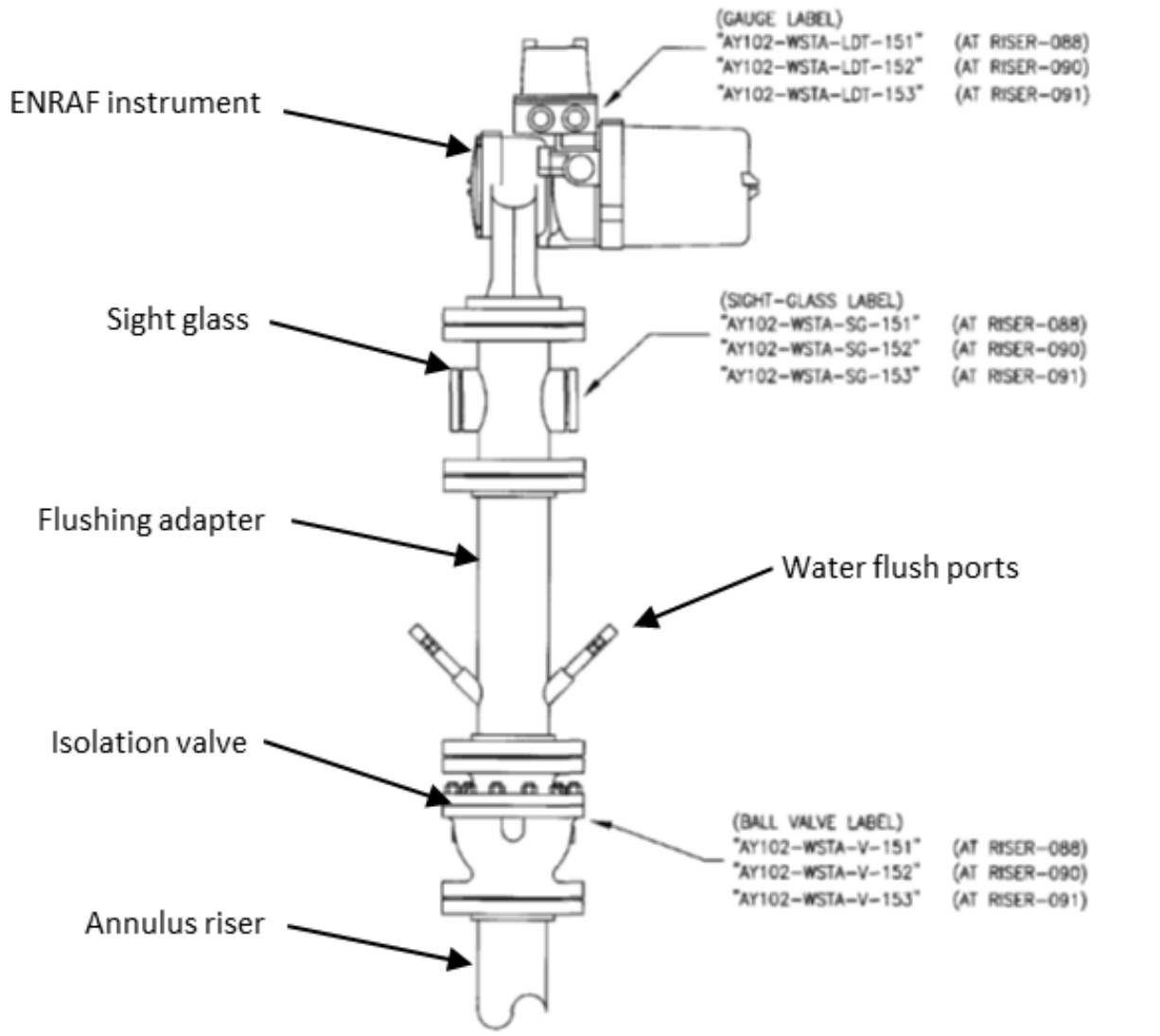
Date	Event	Reference
05/2007	Moisture intrusion analysis indicates that natural precipitation is the likely source of water intruding into annulus of Tanks AY-101 and AY-102. Tanks AY-101 and AY-102 settlement surveys completed to check for dome deflection	RPP-RPT-37440, *Tank 241-AY-101 Interim Surface Barrier Feasibility Study* RPP-ASMT-34090, *Hanford Double-Shell Tank Thermal and Seismic Project-Effects of Dome Rebar and Concrete Degradation* RPP-RPT-33273, *241-AY-101/AY-102 Annulus Moisture Intrusion Analysis*
07/2007	Report issued documenting all visible corrosion in the annulus of Tanks AY-101 and AY-102	RPP-RPT-34311, *Double-Shell Tank Integrity Inspection Report for 241-AY Tank Farm*
08/2007	Analysis of neutron probe data indicated no buildup of water in the soil above the AY tanks indicative of preferential or collection areas.	7G410-JKE/MJR-007-005 (Engeman and Rodgers 2007) CH2M-0700558 R4 (Fulton 2007a)
09/2007	Closed check valves downstream of valve V-141 to isolate raw water supply to AX, AY, and AZ Farms	RPP-RPT-37440
10/25/2007	The Tank AY-101 and AY-102 Annulus Corrosion Recovery Plan included a requirement to complete collection of the AY-101 annulus psychrometric data and make recommendations for future data collected needed to identify the ingress of water to the annulus. It was concluded that psychrometric data are not a reliable detection method for the onset of water ingress.	CH2M-0700558 R5 (Fulton 2007b) RPP-35008, *AC-5.16 Engineering Evaluation Methodology and Sampling Strategy*
11/08/2007	The Tank AY-101 and AY-102 Annulus Corrosion Recovery Plan included assessing the technical feasibility of performing a Fluorescein dye tracer test for potential leakage. It was determined the dye tracer test was not a feasible water ingress pathway detection method.	CH2M-0700558 R6 (Fulton 2007c)
12/21/2007	Safety Evaluation Report replacing the annulus psychrometric data with periodic annulus video inspections as a result of the closure of the Tanks AY-101 and AY-102 Annulus Corrosion Recovery Plan.	DOE-ORP: 07-TED-055, *Approval of Safety Basis Ammendment-042 to Revise Requirements for Evaluating Annulus Ventilation System Effectiveness in Administrative Control 5.16*
02/2008	Raw water header cut and capped west of AN Farm to isolate all raw water supplies to the AX, AY, and AZ Farms.	RPP-RPT-37440

In December 2007, operating specification OSD-T-151-00007 requirements were changed as the result of the Tank AY-102 Annulus Corrosion Recovery Plan (Ferrera 2007) to require at least one DST in each tank farm to be video-examined every two years. Each video examination would require an engineering evaluation of new or changed water intrusion areas and any significant corrosion. Every tank in each tank farm would be video examined and evaluated every seven years. The recovery plan was closed out per Johnson (2009).

4.2.4 ENRAF Leak Detector Liquid Level

4.2.4.1 Background

ENRAFs were first installed in the annulus of Tank AY-102 for leak detection in 2004 (ECN-720173 R2, *241-AY-102 Annulus Leak Detection using Three ENRAF Level Gauges*) replacing conductivity probes (see Figure 4-27 for installation arrangement). For Tank AY-102, the annulus ENRAFs currently were located in Riser 88 (AY102-WSTA-LDT-151), Riser 90 (AY102-WSTA-LDT-152), and Riser 91 (AY102-WSTA-LDT-153) in early August 2012. The ENRAF level gauge measurement principal is based on detection of a change in weight of a displacer suspended in a fluid. The displacer is connected to a wire wound on a precision measuring drum. A level change causes a change in weight of the displacer that is detected by the instrument and converted to tank level. The ENRAF gauges were qualified for use in the annulus for leak detection and shown to be able to accurately detect 0.25 in. of water accumulation (HNF-4328, *Test Report for ENRAF Annulus Leak Detector Development*).



Source: ECN-720173, 2003, "241-AY-102 Annulus Leak Detection using Three ENRAF Level Gauge," Rev. 2, Lockheed Martin Hanford, Inc., Richland, Washington.

Figure 4-27. Annulus ENRAF Leak Detection Installation on Tank AY-102 August 2012

The ENRAF levels are monitored continuously since July 2004 using the TMACS. The alarm level is specified at 0.25 in. in OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection.*

4.2.4.2 Data

The annulus ENRAF liquid level data, from 2004 to present, obtained from Surveillance Data Display System (SDDS) and PCSACS was reviewed (see Appendix C). There were no unexplained increases in liquid level data from 2004 until October 2011.

Beginning on October 9, 2011, ENRAF 152 levels began to slowly increase from 0.26 in. to a maximum value of 0.51 in. on October 13, 2011. Levels then gradually declined to less than 0.25 in. by October 27, 2011. Figure 4-28 shows SDDS data for the October 4, 2011 to November 8, 2011 time period.

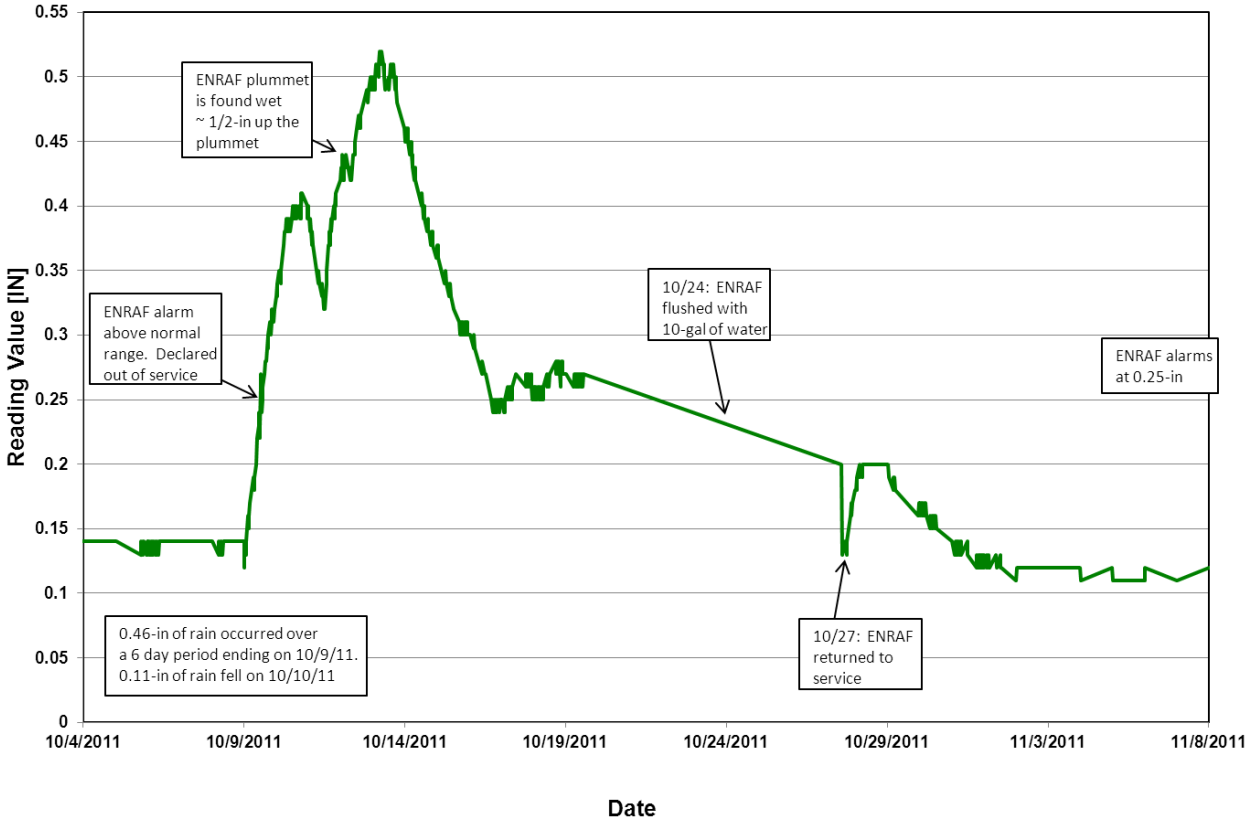


Figure 4-28. Tank AY-102 Riser 90 Annulus ENRAF 152 Liquid Levels October 2011

Prior to October 9, 2011, 0.46 in of rain occurred over a 6 day period and an additional 0.11 in. of rain fell on October 10, 2011 (Hanford Meteorological Station, October 2011 Monthly Summary). An increase in liquid level and high-level alarm at TMACS occurred on October 9, 2011 for ENRAF 152 (WRPS-PER-2011-2120). On October 12, 2011 it was determined ENRAF 152 was working properly and the plummet was found wet approximately ½ in. up the plummet with a radiation dose rate of 2 – 4 mrem/hr through the sight glass enclosure (see Figure 4-27). Rainwater intrusion was thought to be the cause of the wetness (TOC-ENV-NOT-2011-0012). On October 24, 2011 the ENRAF was again flushed with water. The dose rate on the plummet was 5 mrem/hr before flushing and 1.5 mrem/hr afterwards. As a result of these events, it was recommended that a camera be inserted into the annulus to see if the suspected water intrusion could be pinpointed (WRPS-PER-2011-2120). However, a camera was not inserted into the annulus space until August 2012 (see Sections 4.1.7 and 4.2.6). Table 4-18 provides the chronology of events between the alarm on October 9, 2011 and the ENRAF 152 return to service on October 27, 2011.

Table 4-18. Tank AY-102 Annulus ENRAF 152 (Riser 90) October 2011 Events

Date	Event	Reference
10-09-2011 to 10-10-2011	0.46 in. of rain occurred over a 6 day period with suspected rainwater intrusion at Riser 90 on 10-9-2011. An additional 0.11 in. of rain fell on 10-10-2011	Hanford Meteorological Station – October 2011 Month Summary
10-09-2011	ENRAF alarm above normal range; declared out of service	PER-2011-2120
10-12-2011	ENRAF plummet is found wet ~ ½ in. up the plummet; some dose rate 2-4 mr/hr in enclosure. Rainwater intrusion is thought to be the cause of the wetness. It was recommended to insert a camera into the annulus to pinpoint water intrusion at this time. However, it was determined that it would take several days to plan the work package and would most likely not be completed in time to determine the source of the water intrusion	TFC-WO-11-5469, "241-AY Annulus Enraf Cals and Functional Tests" TOC-ENV-NOT-2011-0012, "AY-102 Annulus ENRAF" WRPS-PER-2011-2120, "Create Pre-Planned Work Package to Investigate Annulus Water Intrusion.
10-13-2011	Ecology notified; Ecology visits	
10-13-2011	Bolts were reported to be missing on the AY-102 Riser 78 (in the same annulus quadrant as Riser 90) 3-in. shield plug and it was only being held in place by some black tape. Bolts could have been missing as early as 2006. The flange was not very secure on the riser and could have been a source of water intrusion into the annulus. Gasket and bolts were installed to reduce any in-leakage	WRPS-PER-2011-2099, "Water Intrusion into the AY-102 Annulus" Riser 78 Photo 1 Riser 78 Photo 2
10-17-2011	Ecology questions answered	
10-24-2011	ENRAF flushed with 10-gal of water and allowed to dry; dose 5 mr/hr before flush then 1.5 mr/hr after flush	TFC-WO-11-5545 RSR WTO-022533
10-27-2011	ENRAF recalibrated and returned to service	TFC-WO-11-5469

Figure 4-29 shows the liquid level for the three annulus ENRAFs from January through August 2012. All three liquid level readings of the annulus ENRAFs were below the 0.25-in. specification except for two readings. Two readings were reported to be above 0.25 in. which occurred on July 24, 2012 and August 29, 2012 for ENRAF 152. It is assumed these were erroneous data points as levels returned to normal within hours.

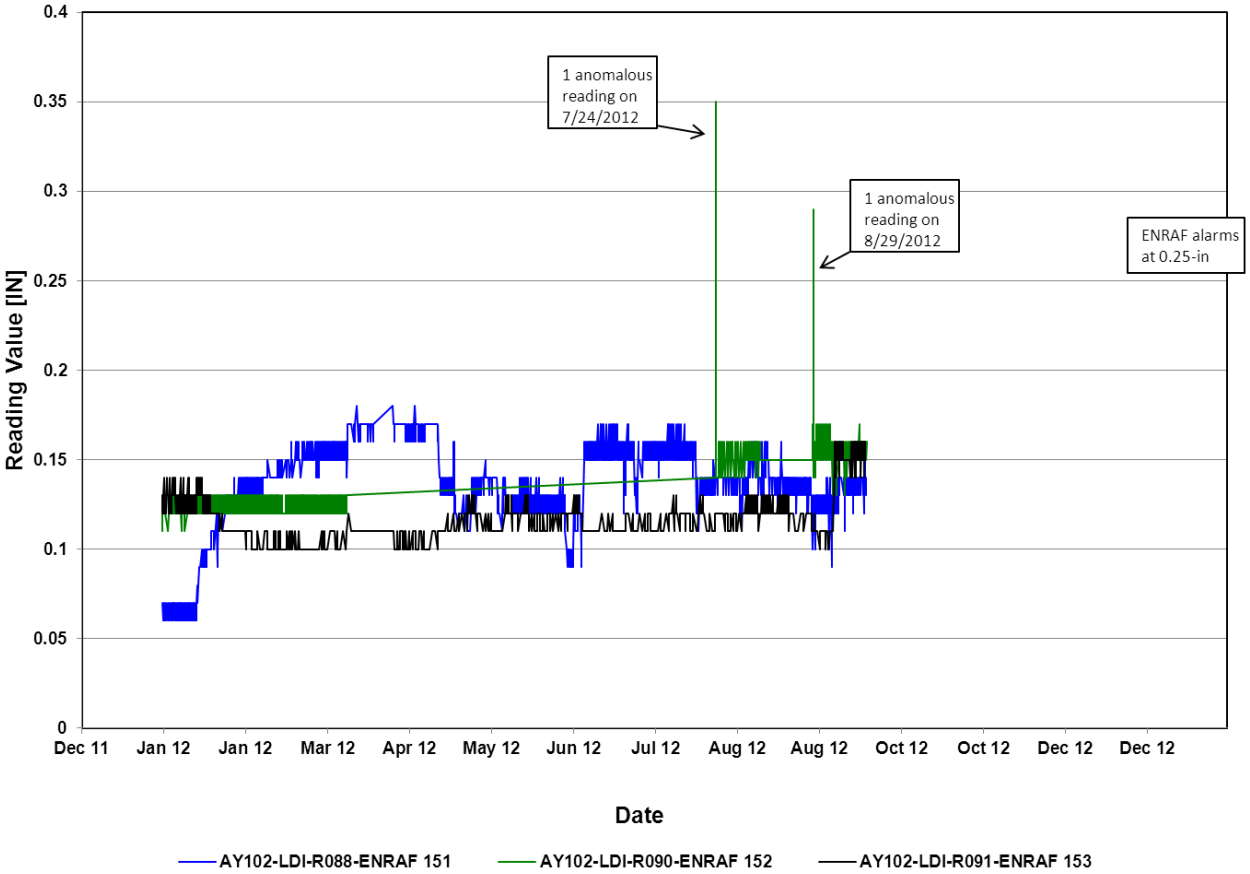


Figure 4-29. Tank AY-102 Annulus ENRAFs Liquid Levels 2012

4.2.4.3 Summary

The liquid level readings for the Tank AY-102 annulus ENRAFs were reviewed from 2004, when the ENRAFs were first installed, to present. There were no unexplained increases in liquid level data from 2004 until October 2011. In October 2011, ENRAF 152 alarmed as liquid levels gradually increased to a maximum level of 0.51 in. and then slowly declined to less than 0.25 in. by November 2011. Water intrusion from rainfall was the suspected cause; however, this explanation seems problematic because of the plummet radiation readings where none would be predicted.

4.2.4.4 Broken/Sticking ENRAF

On March 10, 2012, the Riser 90 ENRAF 152 was declared out of service. During planned repairs on May 24, 2012, the ENRAF displacer wire broke while attempting to retrieve the displacer and fell into the annulus of Tank AY-102 (see Section 4.4). A bullet camera was deployed into the annulus on June 4, 2012 which identified that the displacer was in a location

that would interfere with the performance of a replacement ENRAF. During this time, it was reported the drum and reel contamination readings were 20,000 dpm/100 cm^2. On June 5, 2012 attempts to retrieve the stuck ENRAF displacer were unsuccessful; thus, the displacer remains in the annulus floor debris as shown in Figure 4-30 (see Section 1.2.1).

Figure 4-30. Video of Tank AY-102 Annulus through Riser 87 Showing Broken ENRAF Displacer (August 30, 2012)

On July 24, 2012, the upper flange of the riser was rotated to avoid the displacer and debris on the annulus floor and a replacement ENRAF 152 drum and displacer were installed on Riser 90. The ENRAF was functionally tested and returned to service (TFC-WO-12-2156).

4.2.5 Continuous Air Monitor (Alarms and Decay Count)

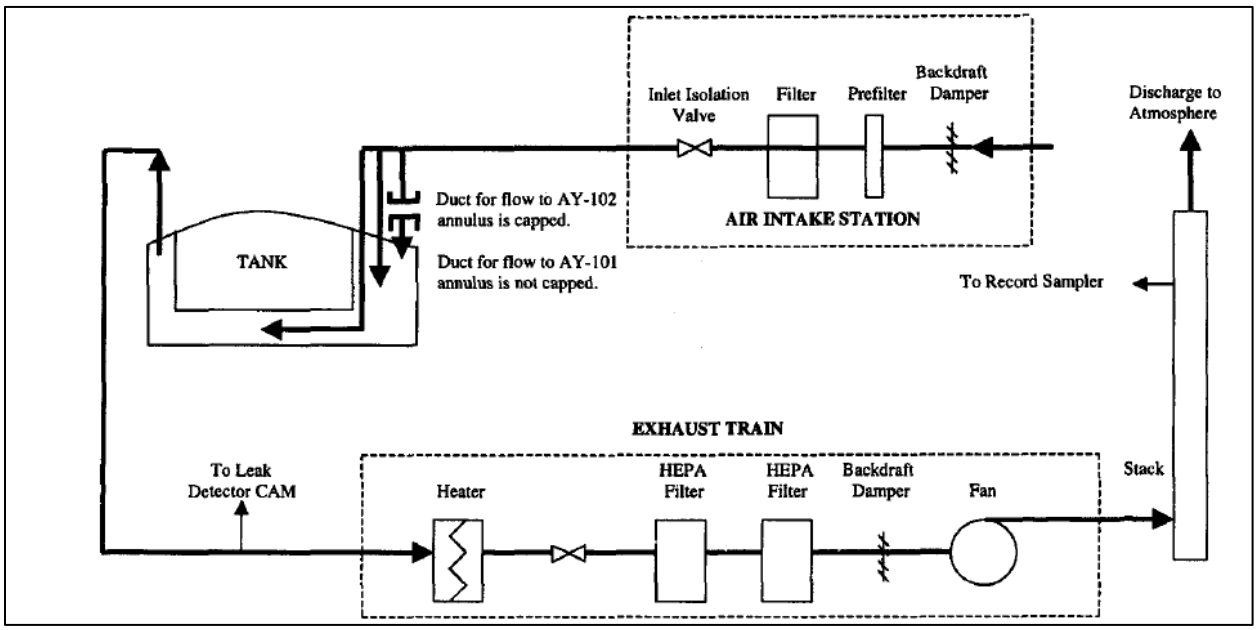
4.2.5.1 Background

A new CAM airborne radioactivity monitoring and sampling system was installed on Tank AY-102 annulus exhaust in August 1975 (ARH-LD-208 B, *Atlantic Richfield Hanford Company Monthly Report August 1975*, page 11). The CAM system pulls a sample from the annulus exhaust duct through a filter paper. A radiation probe monitors the filter paper.

Each CAM instrument enclosure includes a basic stack sampler monitor cabinet, a beta/gamma CAM module, a vacuum pump, a vacuum regulator, a plug assembly which connects the CAM electronics to the auxiliary relay box, a local alarm panel with exterior alarm light, electrical power distribution panel, and cabinet ventilation fan and heater with thermostat (RPP-15135, *System Design Description for AY/AZ Tank Farm Double-Shell Tank Waste Storage System [DSA-Based]*). Continuous air monitor high radiation alarms are sent to the monitor control system computer located in 241-AZ-271 control room.

The Tank AY-102 annulus ventilation system's exhaust fan draws outside air into an intake consisting of a damper and two pre-filters configured in series as shown in Figure 4-31 (RPP-15128, *System Design Description for AY/AZ Tank Farm Annulus Ventilation System [DSA-Based]*). The air is routed to the air distribution ring centered under the primary tank floor. The air flows from the air distribution ring through the air distribution slots in the refractory to the annulus. Exhaust air from the tank annulus is drawn out through six risers and into the exhaust header.

A vacuum pump extracts an air sample from the exhaust header and feeds it to the CAM. The tank exhaust air continues through a heater and two steps of HEPA filters. Filtered air exits the annulus through an exhaust fan and exhaust stack (296-A-19) where it is released to the environment. The stacks are fitted with a record sampler system (see Section 4.2.5.4) that samples the air stream for radioactive particulates. The maximum flow capacity of the annulus exhaust fan is 850 ft^3/min at 15 in. wg.



Source: RPP-15128, 2007, *System Design Description for AY/AZ Tank Farm Annulus Ventilation System (DSA-Based)*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

Note: Tanks AY-101 and AY-102 have separate annulus ventilation systems. The configuration of both systems is identical except as shown

Figure 4-31. AY Farm Ventilation Tank Annulus System Flow Diagram

The filter efficiency is tested annually. The minimum efficiency for a new filter is 99.97% for particles greater than 0.3 µm and 99.95% for installed filters (ASME AG-1, *Code on Nuclear Air and Gas Treatment* [RPP-15128]).

The alarm set point for the CAM is 2,000 cpm (RPP-15128).

4.2.5.2 Potential Contamination of Annulus

The Tank AY-102 annulus has been subjected to numerous cross-contamination events over the years (see Section 4.2.2). The first event occurred in October 1976 when a transfer of waste lowered the Tank AY-102 primary tank level to below 60 in. At this level, the leak detection pit drain, the central pump pit drain, the annulus pump pit drain, and the sluice pit drains were uncovered, exposing the pits to the primary tank vapor space. When the annulus is operated at a lower pressure than the primary ventilation, airborne contamination can be drawn into the annulus via the annulus pump pit or the leak detection pump pit. The primary tank liquid level was below 60 in. on multiple occasions during the tank's operation (see Section 4.1.1).

Several historical incidents of contamination of central pump and sluice pits have been documented. In October 1994, one of the Tank AY-102 sluice pits, 241-AY-102 O2D (O2D) became contaminated from a failed transfer line, SL-503 (Occurrence Report RL—WHC-TANKFARM-1994-0059). This line failed in the wall of the O2D pit and sprayed waste into the O2D pit, and set off the leak detector. At that time, there was an open wall nozzle in the O2D pit. This wall nozzle is part of a transfer line system connected to the annulus pump pit. However, a PUREX blank was installed on the annulus pump pit side, so no contamination entered the annulus pump pit.

4.2.5.3 History of Elevated AY-102 Annulus Continuous Air Monitor Readings

Tank AY-102 CAM alarms have historically corresponded to changes in the annulus exhaust system operating status or occurred when the tank waste level was below the 60 in. level required to seal the annulus pump pit drain. After each annulus ventilation startup, the annulus CAM count rate has been in the range of 600 to 2,800 cpm. For example, the annulus ventilation system was on line from late 1984 until mid-1987. In late 1986 and early 1987, the CAM count rate showed several peaks between 5,000 cpm and 20,000 cpm; these peaks typically corresponded to periods when the tank waste level was too low to seal the annulus pump pit drain (Tardiff 2001).

The annulus ventilation system was offline from mid-1987 to early 1988. The system was restarted and remained on line from early 1988 to mid-1991. The CAM count rate during this period was nominally 1,000 to 2,000 cpm with many peaks in excess of 2,000 cpm. The highest peak was 10,000 cpm. The annulus ventilation system was shutdown in mid-1991 and remained offline until early 1997.

The annulus ventilation system was next operated for a short period between early 1997 and early 1998. The CAM count rates during this period fluctuated between 500 and 1,500 cpm. The system's last shutdown period was early 1998 to mid-1998. In mid-1998, the annulus ventilation system was started and CAM count rates increased upon startup with the count rate being a nominal 1,500 cpm with many peaks between 1,800 cpm and 2,800 cpm; four peaks were recorded at 3,000 cpm or higher.

A Discrepancy Report, 98-857, was issued in December 1998 concerning the higher than normal count rate observed on the tank AY-102 annulus CAM in October 1998 (Occurrence Report RL-PHMC-TANKFARM-1999-0024). Significant changes were made to the airflow through the annulus in 1998. In March 1998, the primary tank headspace exhaust rate was lowered from 800 scfm to 200 scfm (HNF-4798, *Tank 241-AY-102 Annulus Continuous Air Monitor High Readings*). In August 1998, the annulus ventilation rate was raised to 1,000 scfm. This resulted in the headspace vacuum of -1 in. wg and the annulus vacuum of -14 in. wg.

Swabs of the tank annulus were taken on the sides of the primary tank and the annulus floor in 1999 following a steady increase in CAM readings over a two week period. No contamination was found (RL-PHMC-TANKFARM-1999-0024). On February 17, 1999, smears were obtained of the annulus pump pit pump opening, the pit drain area, and the floor of the pit. Smearable contamination was found on all samples with contamination levels ranging from 2,000 to 3,000 dpm/100 cm^2. Laboratory analysis revealed the presence of very low levels of ^{137}Cs and ^{90}Sr. The annulus pump pit drain plug assembly was reseated over the drain in an effort to better seal the primary tank from the annulus pump pit. After sealing the drain, the CAM count rate remained in the range of 200 cpm to 2,500 cpm.

It is not known how long the drain line plug had been removed. With the plug removed, an open contamination pathway existed between the primary tank and the annulus pump pit. During a 1997 remote visual inspection of the pit, a significant amount of moisture was observed. Water could be seen beading off the cover block and pit walls. The pit floor also looked wet. Contaminated water could pass from the pump pit into the annulus when the pump shield plug gasket is deteriorated.

The investigation conducted for HNF-4798 concluded that the increased annulus CAM count rate AY-was related to historical smearable contamination of the annulus pump pit.

The next reportable increase in CAM count rates was in 2001 (Tardiff). It was concluded that these increased readings were the result of the previous contamination of the annulus pump pit and movement into the annulus through deteriorating seals/gaskets in the pump pit. No CAM event reports are available for the period after 2001 until March 2005.

Recent Anomalous Continuous Air Monitor Readings

The CAM sample results were reviewed from March 19, 2005 to present (see Appendix D). There were three alarm periods with samples ranging up to about 2,300 net beta activity counts from March 2005 to October 2011.

On October 26, 2011, two days after the Riser 90 annulus ENRAF was flushed, the CAM alarmed (see Section 4.2.4). The CAM sample collected during this time had a field count of 4,200 cpm. Samples were sent to the 222-S Laboratory and the results are shown in Table 4-19. The ^{137}Cs airborne concentration was 1.46E-11 µCi/mL (Sample CR11-02070). Five days earlier the annulus CAM sample paper was changed as part of regular biweekly monitoring routine and the sample was within normal limits.

Table 4-19. Tank AY-102 Annulus Continuous Air Monitor Sample Results (October 26, 2011)

Sample CR12-02070	α μCi/mL	β μCi/mL	β ncpm
Initial	6.40E-13	4.32E-11	18,840
1 day decay	2.16E-13	4.22E-11	18,400
7 day decay	3.06E-14	4.14E-11	18,270

On August 27, 2012, the annulus CAM alarmed, less than 24 hours after the Riser 83 sampling event (see Section 4.2.7). On August 16 and August 18, 2012, the annulus CAM alarmed, about one day after the Riser 90 sampling event (see Section 4.2.7.3). Results from the CAM sample are presented in Table 4-20.

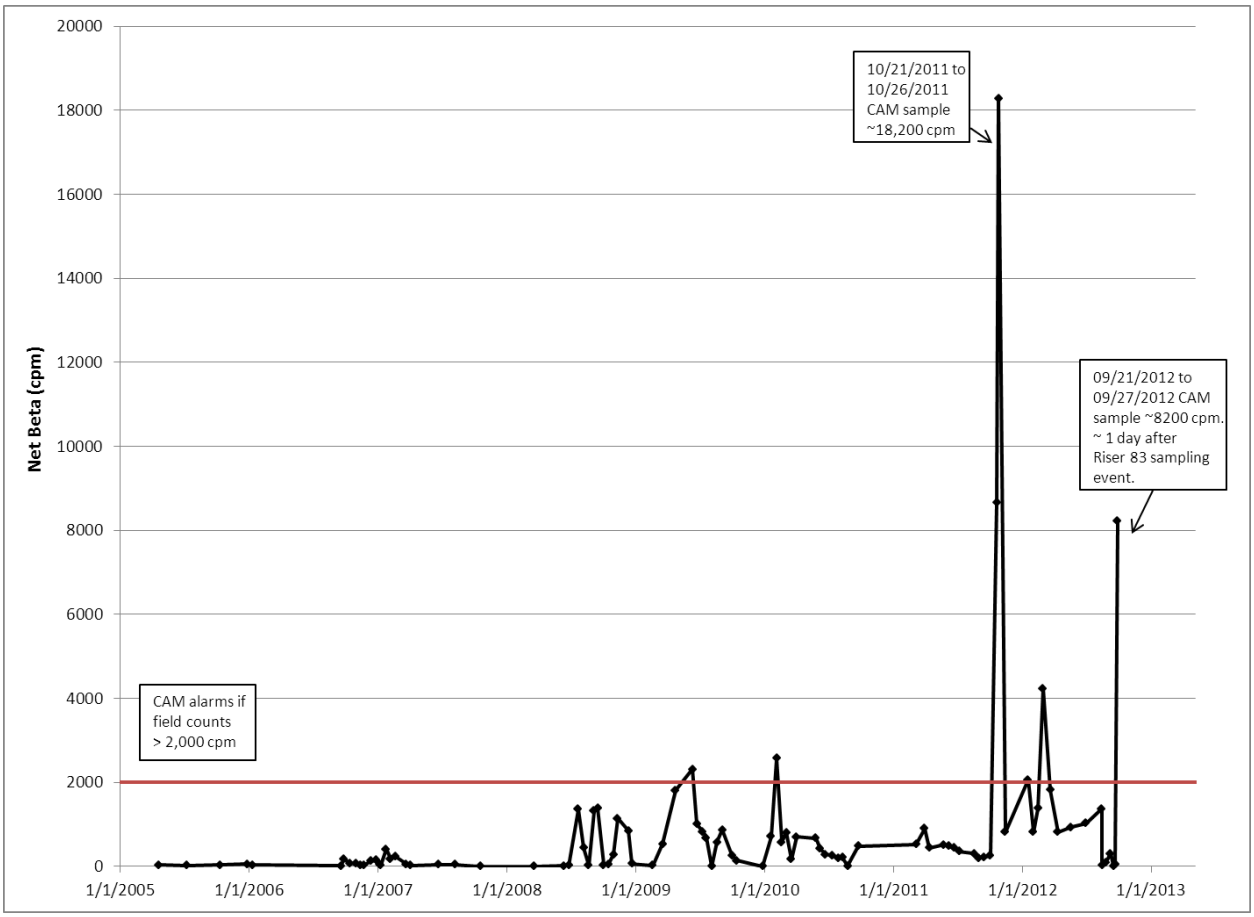
Table 4-20. Elevated Tank AY-102 Annulus Continuous Air Monitor Sample Results for Period October 2011- September 2012

Count Room Sample ID	Sample Number	Sample Collection Period (Date and Time)		Samples Activity (Net Counts)		Rotameter (ft^3/min)			Concentration		
		On	Off	Alpha	Beta	On	Off	Volume (cu. ft)	α (μCi/cc)	α (μCi/cc)	Total DAC
CR11-02077	S875035	10/03/11 09:05	10/21/11 09:24	3	8657	2.2	2.0	53,553.9	2.7E-15	5.7E-12	1.10E-03
CR11-02070	S875083	10/21/11 09:26	10/26/11 13:47	10	18270	2.2	2.0	15,404.0	3.1E-14	4.1E-11	1.03E-02
CR12-00228	S889530	02/15/12 14:18	02/29/12 13:24	6	4233	2.2	2.0	41,609.8	6.9E-15	3.6E-12	1.73E-03
CR12-01194	S904011	06/29/12 13:01	08/13/12 09:15	28	1370	2.3	1.6	124,114.6	1.1E-14	4.0E-13	2.24E-03
CR12-01573	S905886	09/21/12 09:10	09/27/12 12:50	12	7734	2.1	1.8	16,815.4	3.60E-14	1.67E-11	8.87E-03

DAC = derived air concentration.

Note: Net beta counts were higher in October 2012 due to sampling events in the annulus and were not included in this figure. See Appendix D- for additional data.

Figure 4-32 shows the CAM sample net beta counts per minute since March 2005. The spike in beta counts in October 2011 coincides with the Riser 90 ENRAF troubleshooting activities that occurred in this same time frame (see Section 4.2.4).



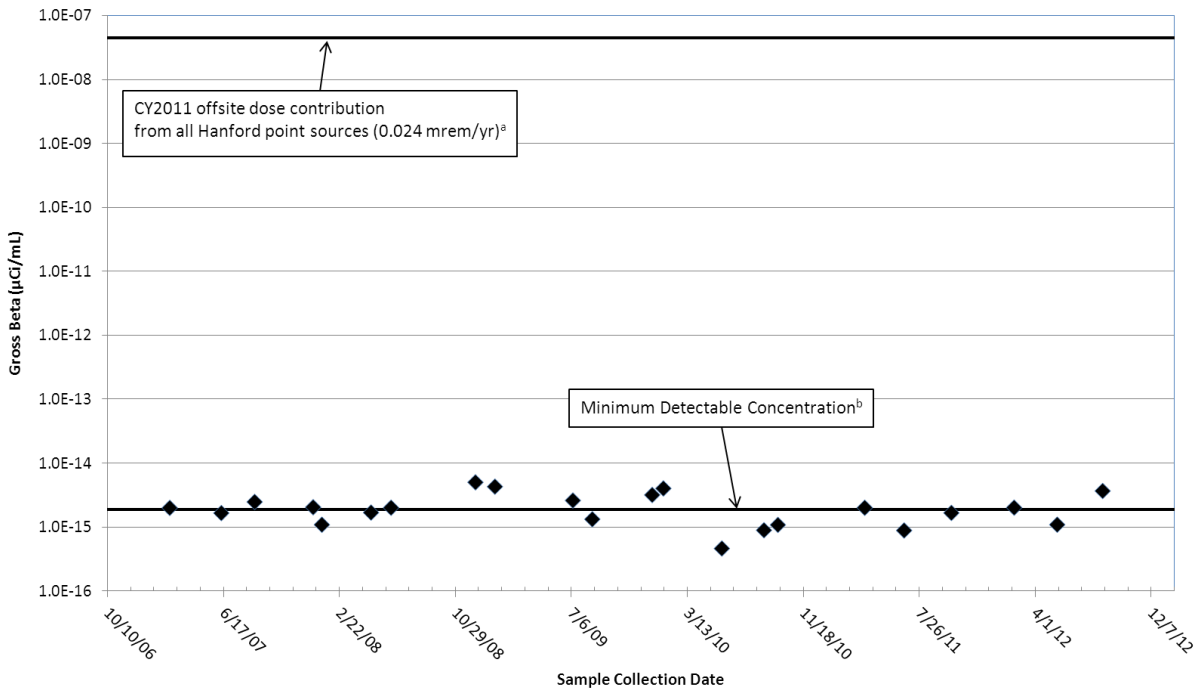
Note: Net beta counts were higher in October 2012 due to sampling events in the annulus and were not included in this figure. See Appendix D- for additional data.

Figure 4-32. Sample Net Beta Counts for the Tank AY-102 Annulus Continuous Air Monitor- March 2005 to September 2012

4.2.5.4 Stack Record Sampler

The Tank AY-102 annulus exhaust system (Stack 296-A-19) is sampled for radionuclide particulate matter prior to release to the ambient environment. The stack samples are collected using a sample extraction probe permanently installed at a fixed location on the vertical portion of the stack downstream from HEPA filtration. Stack samples are collected every two to four weeks and the samples shipped to the Waste Sample Characterization Facility for analyses. The Tank AY-102 annulus stack has four samples selected from various times during the calendar year for gross alpha and gross beta analyses. Analytical data and calculated concentrations are uploaded into ABCASH and available for end users.

Figure 4-33 presents five years of ABCASH gross beta sample concentrations for the Tank AY-102 annulus exhaust systems. The sample analyses show airborne radioactivity in the filtered annulus ventilation airstream is at or below detection levels.



a – 4.5E-08 µCi/mL, DOE/RL-2012-19 "Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2011", 1000ft^3/min. and ^{90}Sr assumed.

b – 1.9E-15 µCi/mL, HNF-EP-085-17 "Statement of Work for Services Provided by the Waste Sampling and Characterization Facility for the Effluent and Environmental Monitoring Program during Calendar Year 2011".

Figure 4-33. 296-A-19 Tank AY-102 Annulus Exhauster Record Sample Results

4.2.6 Video Inspections

The tank annulus is formed by the difference between the 75-ft diameter primary tank and the 80-ft diameter secondary liner resulting in a nominal 2 1/2-ft wide annular space wrapping around the entire circumference of the primary tank. Several penetrations exist in the top of the secondary liner, which allow access into the annulus space. This access is used for a variety of activities, including visual inspection cameras, sampling, ultrasonic testing crawlers, and leak detection instruments. Access into the annulus space provides visibility of the primary tank wall, secondary liner wall, outer perimeter of the refractory, refractory stiffener ring, ventilation piping, refractory slots, and installed equipment. Figure 4-34 and Figure 4-35 identify some of the features and show the condition of the annulus prior to Tank AY-102 being placed into service.

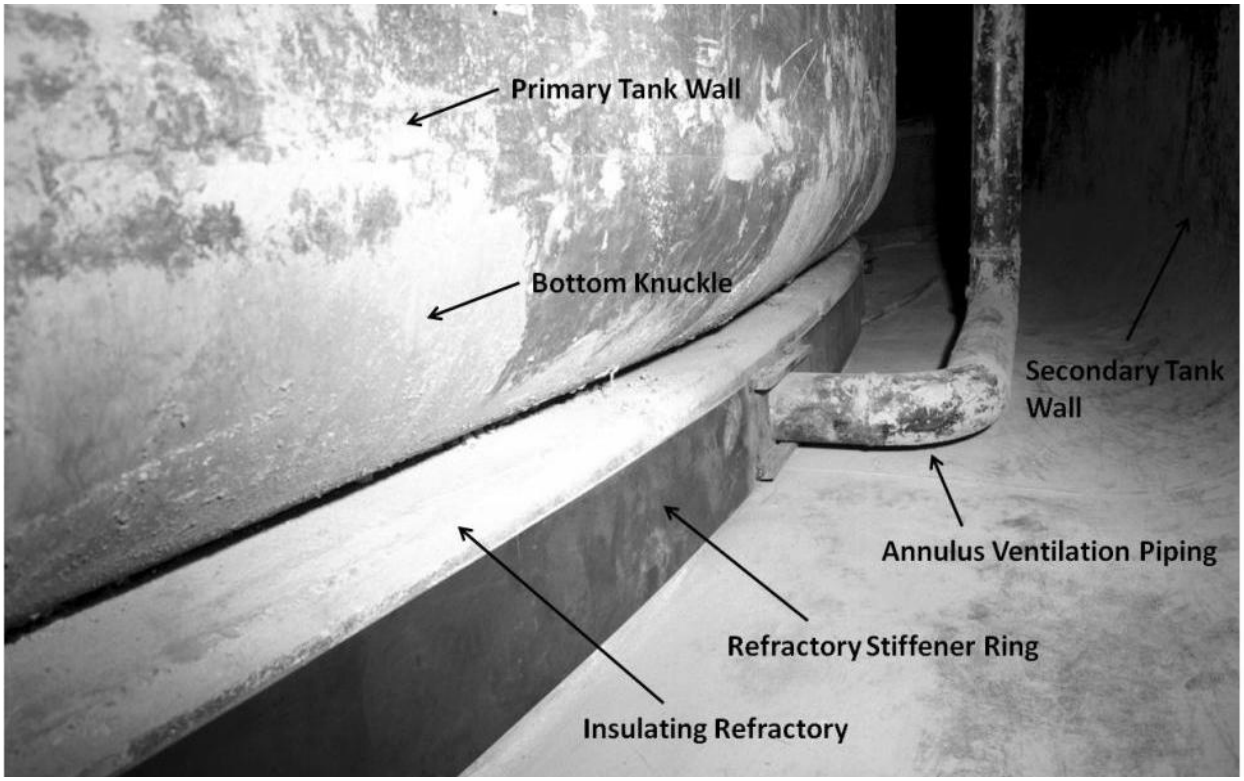


Figure 4-34. Tank AY-102 Annulus Description

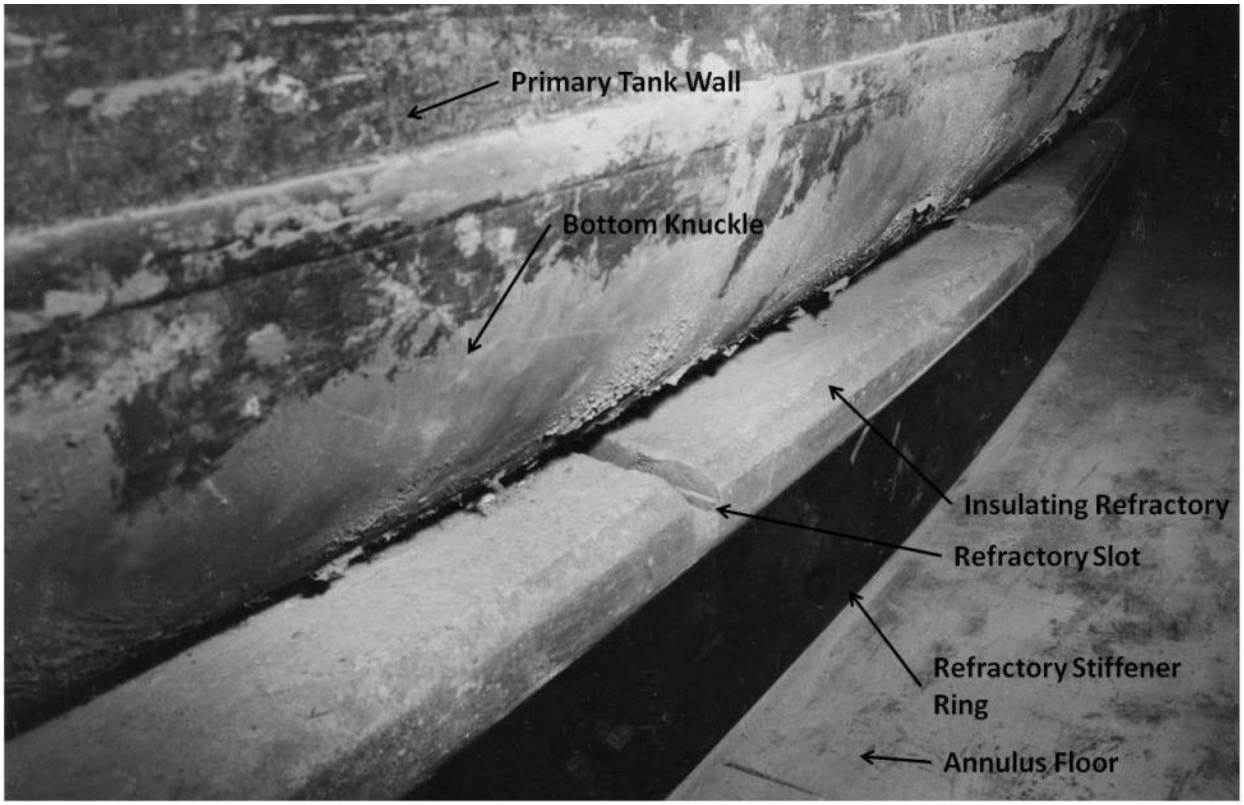


Figure 4-35. AY Farm Tank Annulus Description Showing Refractory Slot

Annulus inspections performed in the Tank AY-102 annulus up to the issue date of this report are as shown in Table 4-21. The first visual inspections in the DST annuluses began in 1992 as part of an integrity assessment to understand the condition of the primary tank and secondary liner. Routine inspections were established in 2001. At the present time each DST annulus is inspected on a five to seven year interval.

Table 4-21. Tank AY-102 Risers Used for Visual Inspection

Year	1992	2001	2006	2012
Riser	79, 84	79, 80, 84, 86	77, 79, 80, 82, 84, 86, 88, 89	77, 79, 80, 83, 86, 87, 88, 89, 90, 91

Results of the previous AY Farm visual inspections are documented in RPP-RPT-34311, *Double-Shell Tank Integrity Inspection Report for 241-AY Tank Farm*. The results in 2001 and 2006 showed a strong indication of corrosion along the primary tank wall due to long outages of the annulus ventilation system and evidence of water intrusion into the annulus space.

In 2006, several recovery actions were conducted and documented in an effort to limit or eliminate the sources of water intrusion. One of these actions was to perform a more widespread inspection of the Tanks AY-101 and AY-102 annuluses. An additional four risers in the Tank AY-102 annulus were selected to gather a more comprehensive understanding of the extent of corrosion and intrusion. The Tanks AY-101 and AY-102 Annulus Corrosion Recovery Plan (Ferrera 2007), and Section 4.2.3 provide details of this effort. In August 2009, the Tanks AY-101 and AY-102 Annulus Corrosion Recovery Plan was closed (Johnson 2009) after completing the actions identified in the plan.

In 2012, the Tank AY-102 annulus was scheduled for its fourth visual inspection. Inspections were performed on August 1 (Risers 87 and 89), and August 5, 2012 (Risers 77 and 80). The selection of these risers was based on a recommendation identified in PER-2011-2120. The PER documented suspected water intrusion into the annulus based on an annulus ENRAF leak detector level increase in Riser 90 following a period of rain in October 2011 (see Section 4.2.2.4). A riser-by riser description of recent visual inspections results, including comparisons to past inspections is presented in the following sections.

Inspections using Risers 77 and 87 identified unexpected material on the annulus floor that was not present in earlier inspections. After these initial observations, additional risers were selected as part of a comprehensive annulus visual inspection with emphasis placed on the annulus floor and refractory. Table 4-21 includes a complete list of risers used in 2012 to support the inspection. Figure 4-36 provides the location of each riser relative to the Tank AY-102 orientation. Eventually ten risers were accessed to complete the inspection.

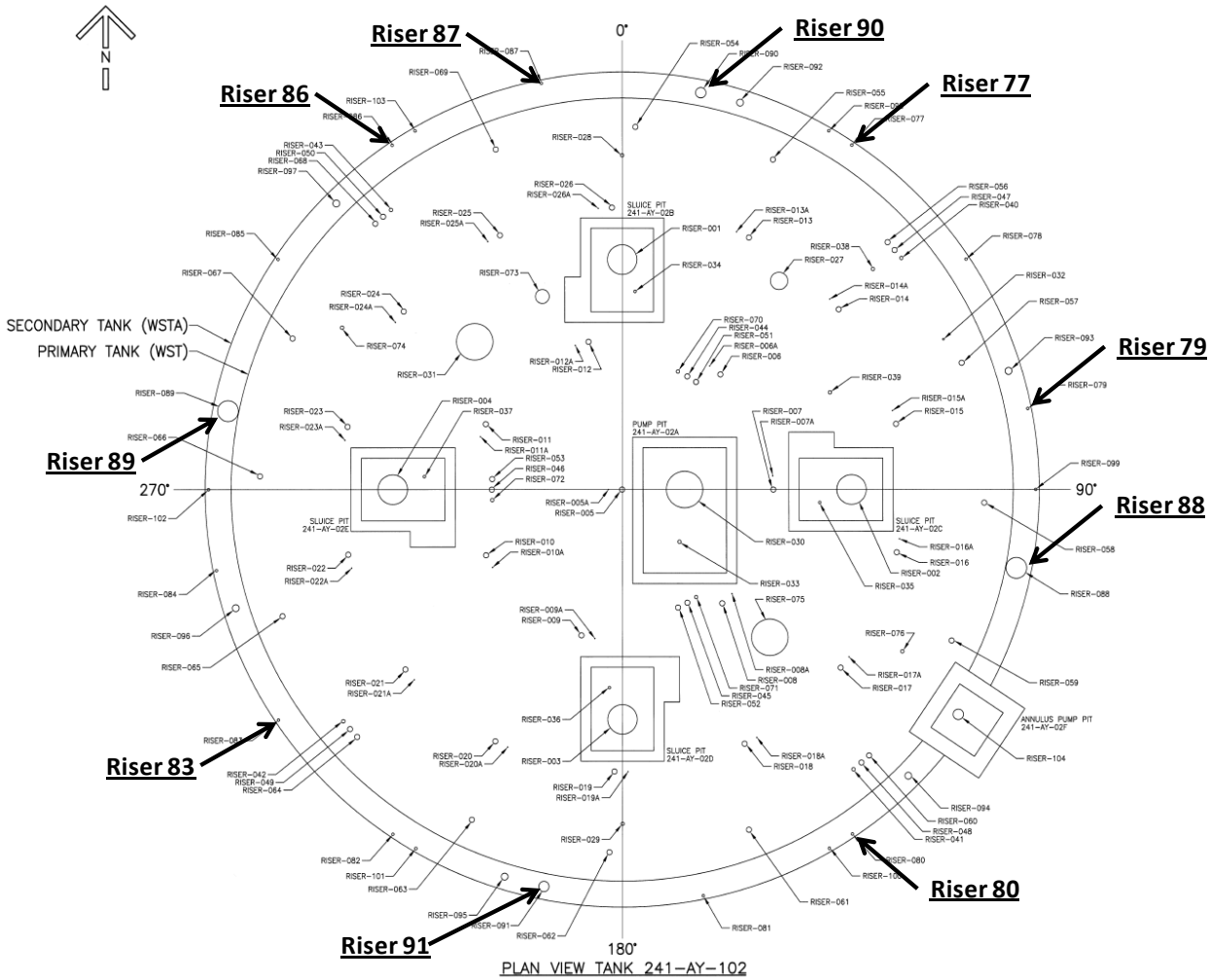


Figure 4-36. 2012 Visual Inspection Riser Selection

Inspections performed in 2012 provided nominal coverage of 90 percent of the primary tank wall and 100 percent of the annulus floor, discounting lighting limitations and obstructions in the annulus (e.g., ventilation piping, conductivity probes, etc.). Figure 4-37 and Figure 4-38 show the annulus coverage area from the 1992 to 2012 inspections.

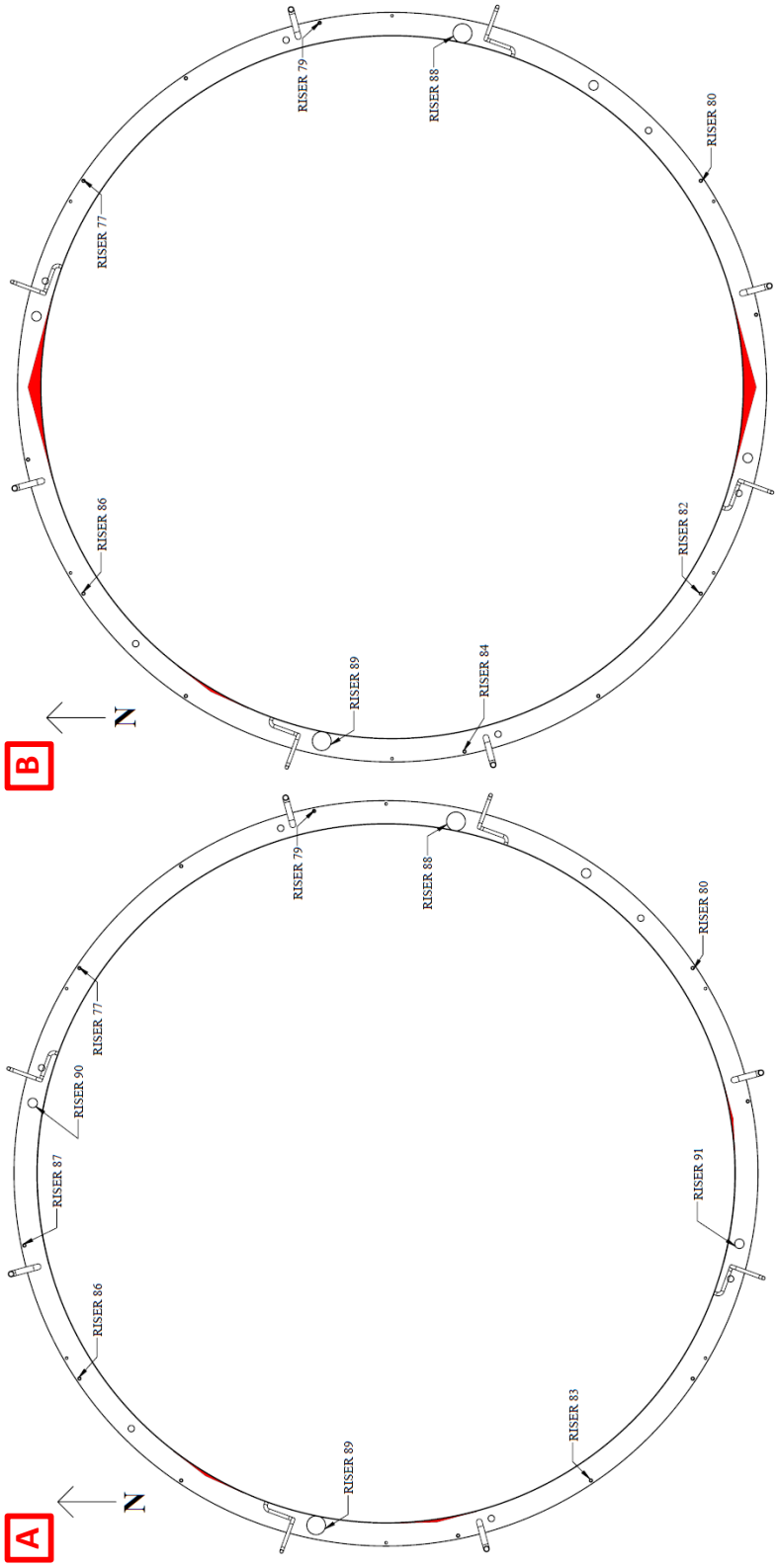


Figure 4-37. 2012 Visual Inspection Coverage (A) 2006 Visual Inspection Coverage (B) - Areas Not Inspected Shown in Red

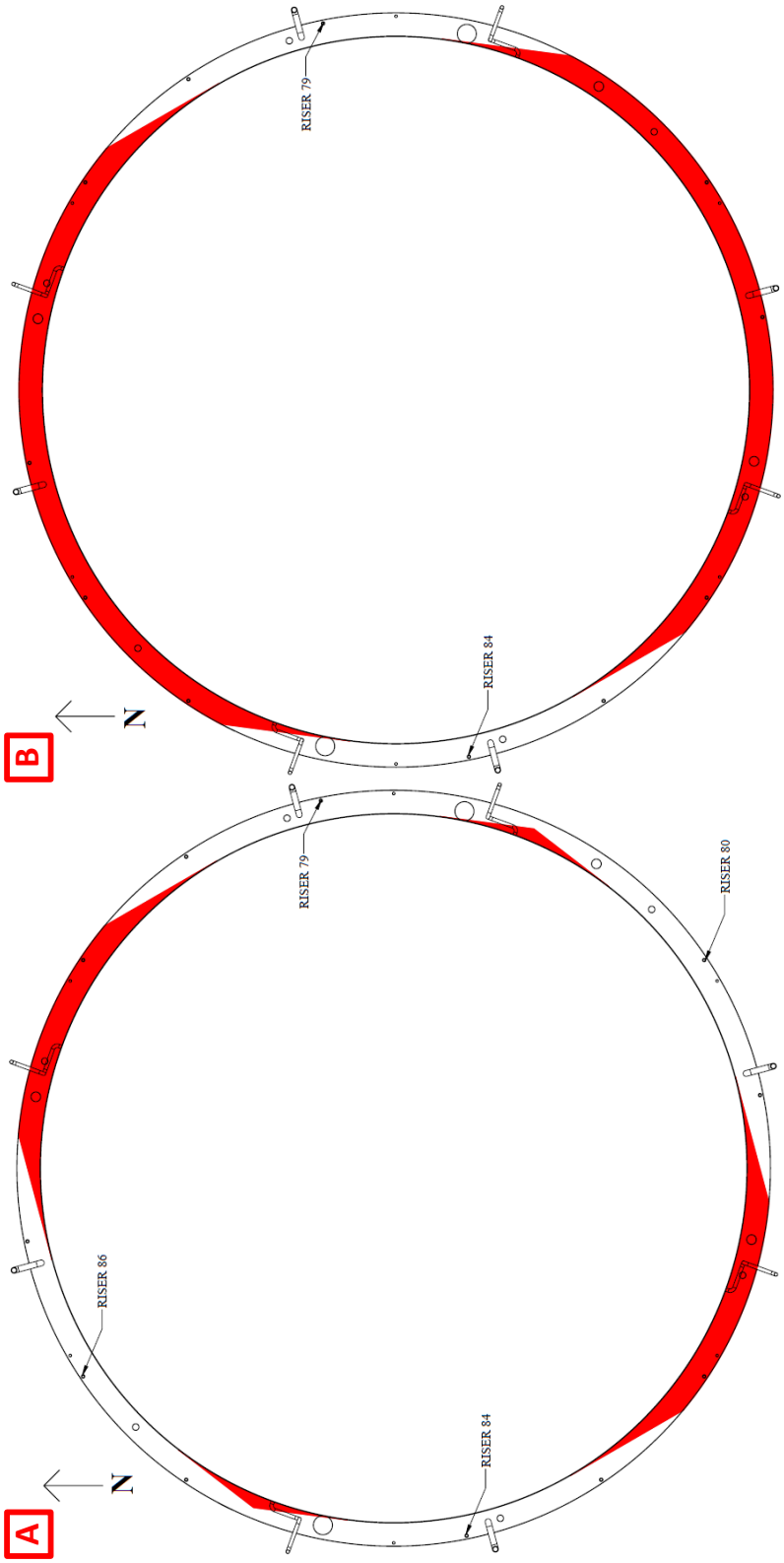


Figure 4-38. 2001 Visual Inspection Coverage (A) 1992 Visual Inspection Coverage (B) - Areas Not Inspected Shown in Red

4.2.6.1 2012 Riser 77 Inspection

The first inspection of Riser 77 took place on August 5, 2012. No anomalies were observed during the inspection except when positioned near the bottom of the annulus. While the camera was directed towards Riser 90, two anomalies were identified. The first was a large mound of material that appeared to have a height in excess of the annulus ventilation piping. The peak of the mound appeared to be in line with the ventilation piping. The second anomaly was found in the same region, but along the primary tank. In this case solid white material appeared to originate from the refractory and flow onto the annulus floor. Figure 4-39 provides a view of the two anomalies.

The second inspection of Riser 77 took place on September 7, 2012. The two areas of interest noted in the previous Riser 77 inspection were the primary focus of the inspection. No additional anomalies were observed during the inspection. The condition of the annulus as seen from Riser 77 was unchanged from the August 5, 2012 inspection. The location of the adjacent conductivity probes as seen in Figure 4-39A did not allow the camera to focus on the anomalies with increase optical zoom for greater detail. Figure 4-39B provides a view of the white material originating from the refractory.

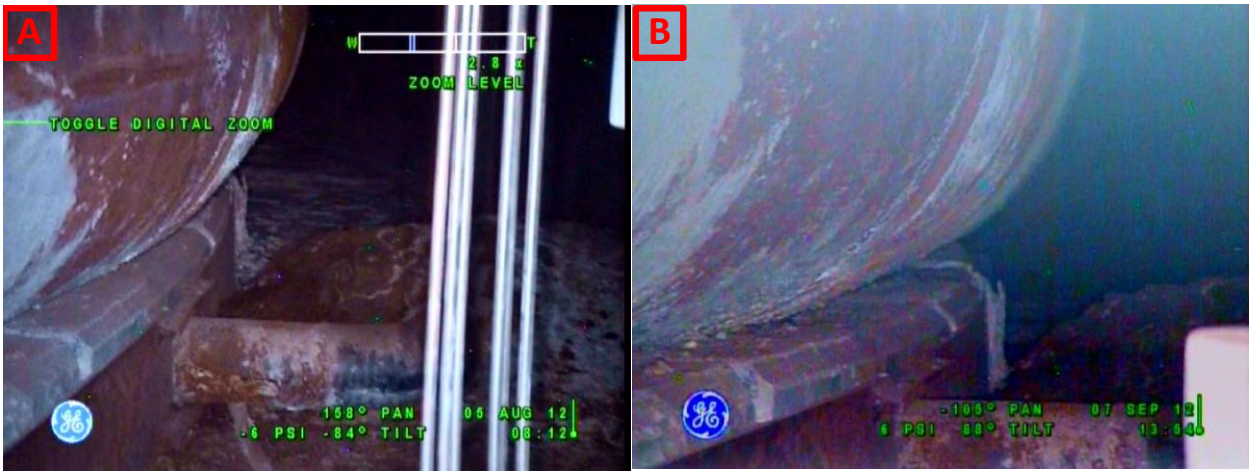


Figure 4-39. Anomalies Noted from Riser 77 Inspection on August 5, 2012 (A) and September 7, 2012 (B)

4.2.6.2 2012 Riser 87 Inspection

The first inspection of Riser 87 took place on August 1, 2012. During the initial entry into the annulus through Riser 87, white material was observed on the annulus floor spanning from Riser 90 to the vicinity of Riser 86, a distance of approximately 25 ft. Based on the concentration of the white material near Riser 86 and the anomalies seen via Riser 77, it was determined that the material most likely originated near the ENRAF leak detector installed in Riser 90. Review of the previous inspections near Riser 87 indicated that the white material that occurred on the annulus floor was not present during the 2006 inspection. Figure 4-40 shows the change between 2006 and 2012 near the thermocouple conduit. Figure 4-40A is from the 2006 inspection via Riser 86 looking towards Riser 87. Figure 4-40B is from the 2012 inspection via Riser 87 looking towards Riser 86. Note that the thermocouple conduit shown in each view is the same piece of equipment.

Figure 4-40. Annulus Floor Comparisons Between Inspections on October 23, 2006 Riser 86 (A) and August 1, 2012 Riser 87 (B)

The second inspection of Riser 87 took place on August 30, 2012. The condition of the white material appeared unchanged from the August 1, 2012 inspection. Figure 4-41 provides a composite/panoramic view of the annulus floor from the Riser 87 centerline towards Riser 90. Figure 4-42 is a composite/panoramic view of the annulus floor from the Riser 87 centerline towards Riser 86.

Figure 4-41. Composite View of Annulus Floor From Riser 87 Centerline Towards Riser 90 on August 30, 2012

Figure 4-42. Composite View of Annulus Floor From Riser 87 Centerline Towards Riser 86 on August 30, 2012

Figure 4-43 provides views of the areas surrounding Riser 87 on August 30, 2012. Figure 4-43B and Figure 4-43D show the condition looking towards Riser 90. The ENRAF plummet is visible, adhered to the annulus floor. The mound identified during the earlier the Riser 77 inspection can be seen near the ventilation piping in the background. The inspection identified no areas of moisture. Some refractory slots showed signs of previous flow patterns onto the annulus floor (see Figure 4-43A). None of the refractory slots showed signs of flow onto the annulus floor as pronounced as that near Riser 90.

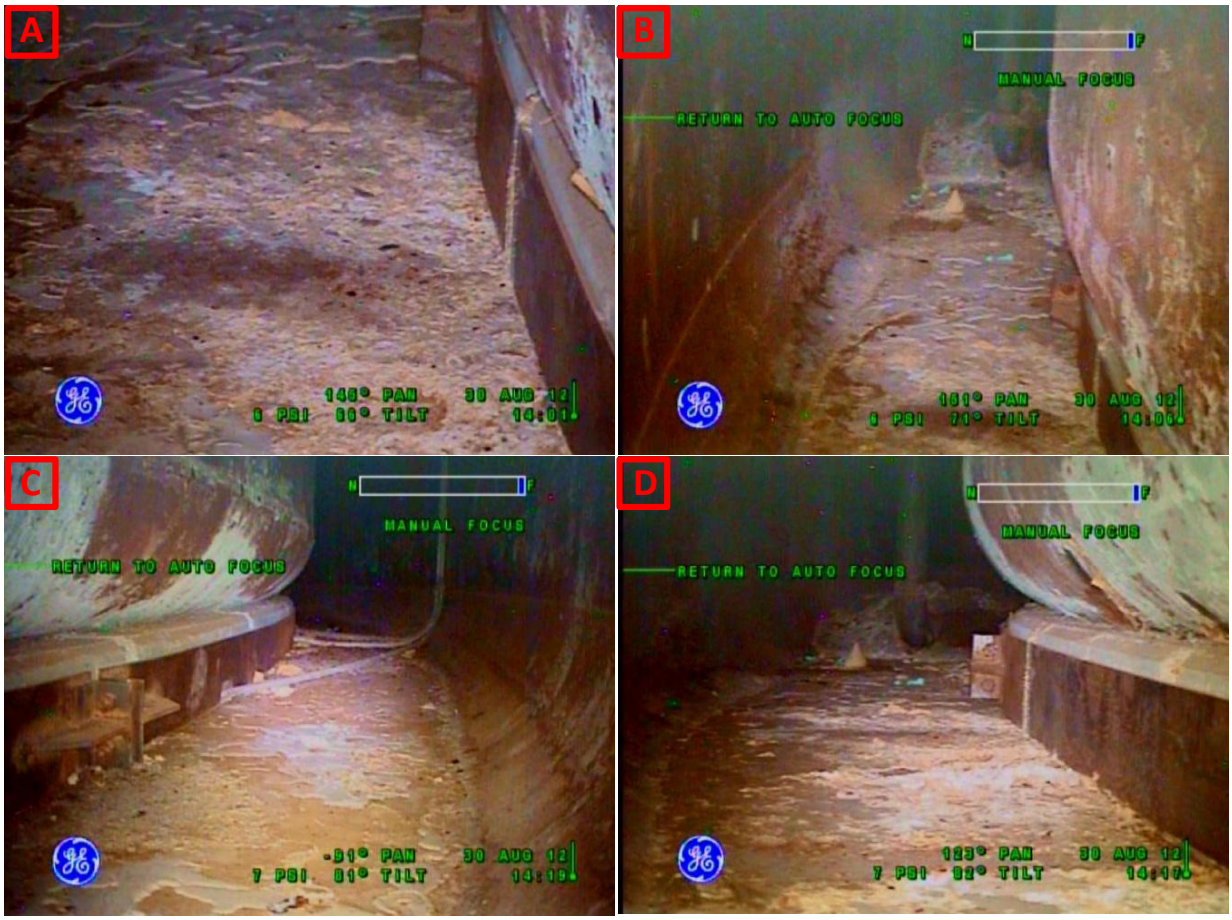


Figure 4-43. Highlighted Area Viewed During the Riser 87 Inspection on August 30, 2012

4.2.6.3 2012 Riser 89 Inspection

The inspection of Riser 89 occurred on August 1, 2012. During the inspection an accumulation of material on the primary top knuckle wall was discovered. The location is well above the maximum allowable liquid level in the tank. The material was not present in the 2006 inspection. Figure 4-44 provides views showing the change that occurred between 2006 and 2012. The new accumulation has crystal-like characteristics with a significant amount of corrosion product build-up located underneath.

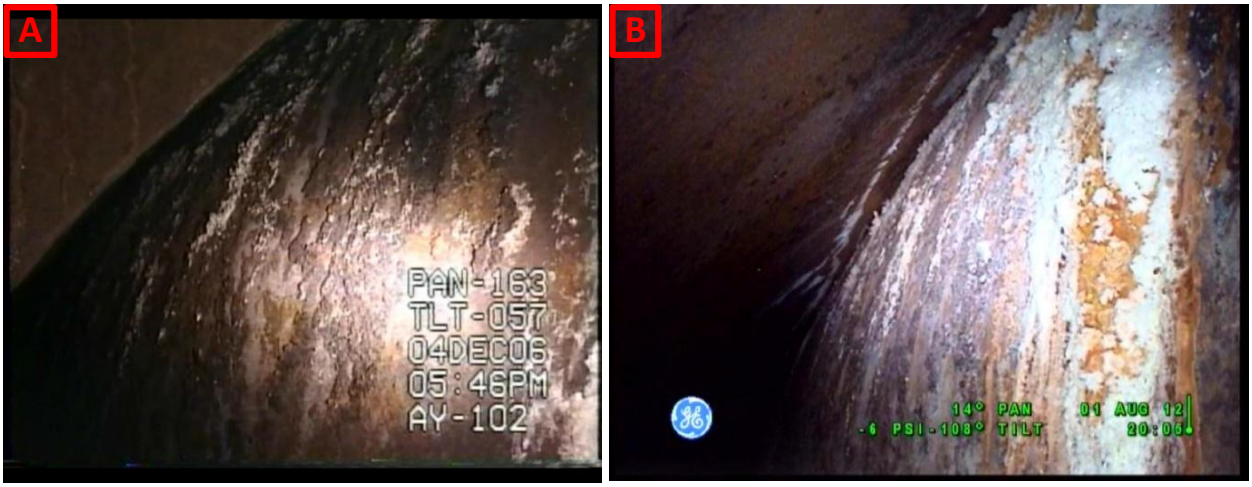


Figure 4-44. Riser 89 Primary Top Knuckle Comparison on December 4, 2006 (A) and August 1, 2012 (B)

Figure 4-45 provides a close-up view of the crystal-like material. The Tank AY-102 annulus was not inspected in 2009 after completion of the actions identified in the Tanks AY-101 and AY-102 Annulus Corrosion Recovery Plan (Ferrera 2007) intended to stop ingress into the annulus. It is, therefore, not possible to know when this accumulation occurred. There were no anomalies observed from Riser 89 along the annulus floor.

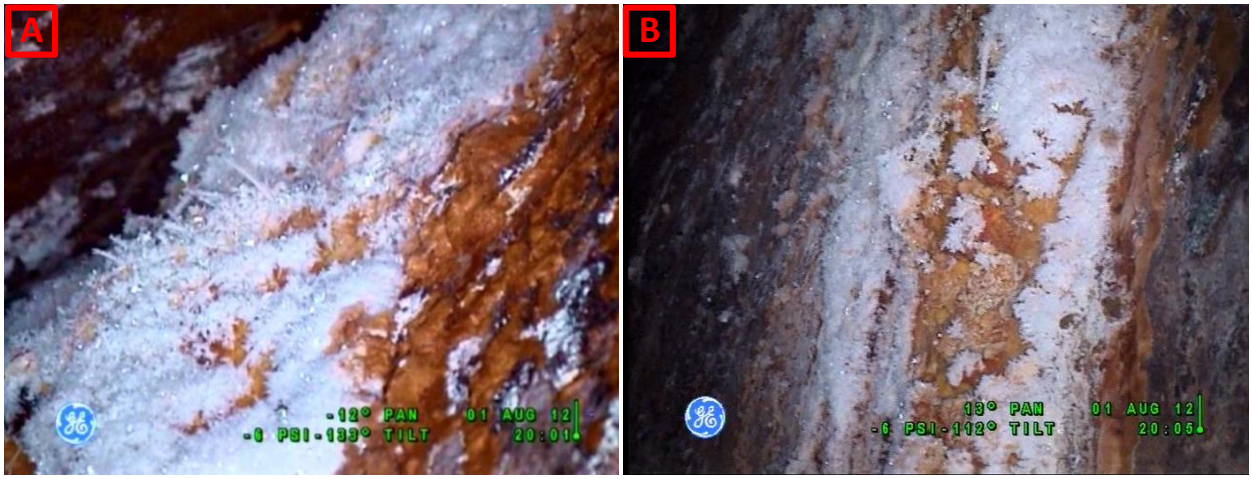


Figure 4-45. Riser 89 Close Up of Crystal-Like Material on August 1, 2012

The second Riser 89 inspection occurred on September 5, 2012. Part of the crystalline material had dislodged from the tank wall, leaving behind the underlying brown corrosion product. Figure 4-46 illustrates the change that occurred during the month between the two Riser 89 inspections.

Figure 4-46. Riser 89 Crystal-Like Material Comparison on August 1, 2012 (A) and September 5, 2012 (B)

The appearance of this area has significantly changed since the 2006 inspection. In 2006, the appearance of the white material was consistent with calcium carbonate buildup caused by water leaching through the concrete dome and infiltrating the annulus. Some of this material is still present in the 2012 inspections. There has been no detectable change in the amount or visual characteristics of this material. Figure 4-47 provides a comparison photo of the white material build-up seen in 2006 and 2012.

Figure 4-47. Riser 89 White Material Comparisons on December 4, 2006 (A) and September 5, 2012 (B)

While the camera was near the bottom of the annulus during the Riser 89 September 5, 2012 inspection, a refractory slot was inspected to the extent possible. There appeared to be some broken pieces of either concrete or refractory material lying in the slot. Figure 4-48 provides a view of the Riser 89 refractory slot.

Figure 4-48. Riser 89 Refractory Slot Debris on September 5, 2012

4.2.6.4 2012 Riser 80 Inspection

The inspections of Riser 80 occurred on August 5, 2012 and September 7, 2012. No anomalies were identified during either inspection. Figure 4-49 shows the condition of the annulus floor as seen from Riser 80.

Figure 4-49. Riser 80 Annulus Floor on September 7, 2012 Looking Towards Riser 91 (A) and on August 5, 2012 Looking Towards Riser 88 (B)

4.2.6.5 2012 Riser 90 Inspection

The first inspection in Riser 90 occurred on August 10, 2012. To access the annulus from Riser 90, the ENRAF annulus leak detector was removed. During the inspection, no anomalies were noted along the primary tank wall.

Once the camera was lowered toward the bottom of the tank, the mound first identified via Riser 77 was inspected. The mound covers the top of the existing 4-in. diameter ventilation piping and most of the ventilation piping on the annulus floor (approximately 3 ft), spans the width of the annulus (approximately 2.5 ft), and is near the same height as the refractory concrete (approximately 8 in). Figure 4-50 shows images of the mound.

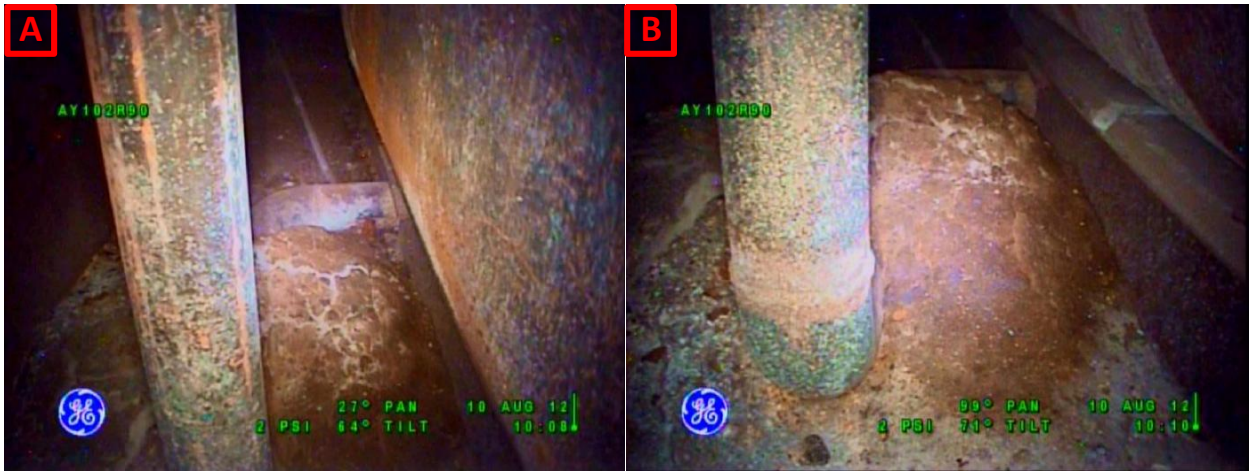


Figure 4-50. Riser 90 Annulus Floor Mound on August 10, 2012

The white material discovered near the centerline of Riser 90 during the August 5, 2012 Riser 77 inspection appears to have originated from the refractory slot. It has cascaded from the refractory slot onto the annulus floor and appears to have flowed towards Riser 87. Figure 4-51 shows the cascade material as viewed from Riser 90. Approximately 5 ft along the refractory towards Riser 87, an additional refractory slot shows signs of cascaded material; however, it is not involved to the same degree as the earlier slot.

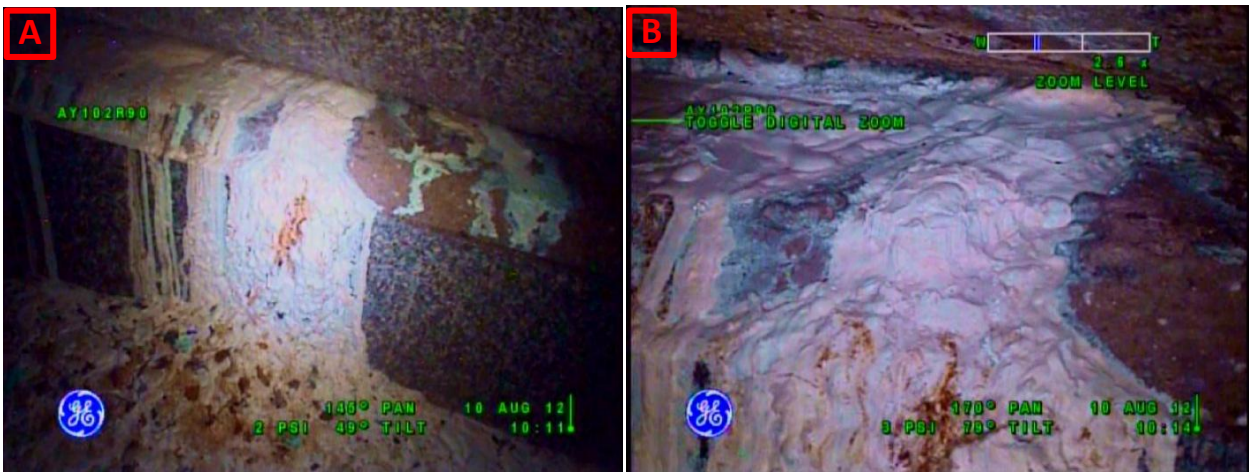


Figure 4-51. Riser 90 Cascade of White Material from Refractory Slot on August 10, 2012

Biweekly Riser 90 inspections occurred for several weeks after the initial August 10, 2012 inspection. Figure 4-52 shows an August 16, 2012 inspection image of previous flow onto the annulus floor. No active movement/flow of material was identified during any of the Riser 90 inspections.

Figure 4-52. Riser 90 Cascade of White Material From Refractory Slot on August 16, 2012

Figure 4-53 provides a composite/panoramic view of the anomalies noted during the inspections through Riser 90.

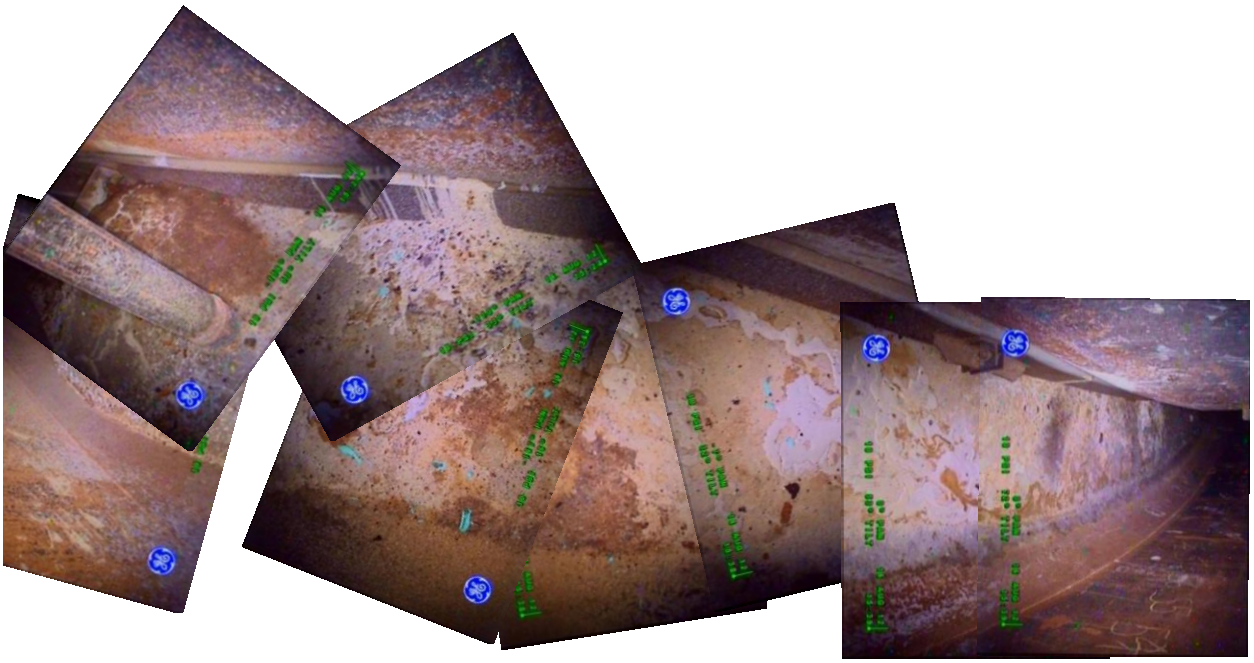


Figure 4-53. Riser 90 Composite/Panoramic View of Anomalies on August 16, 2012 (Camera Accounts for Distortion)

4.2.6.6 2012 Riser 86 Inspection

The Riser 86 inspection occurred on September 7, 2012, and identified no additional anomalies on the annulus floor or exiting the refractory slots. Figure 4-54 shows the views from each side of Riser 86. Discoloration on the annulus floor was noted when inspecting the annulus looking towards Riser 89. The color of the staining is uniform along the floor and is consistent with the characteristics seen in other DSTs after UT testing is completed and the couplant used during UT inspections has dried.

Figure 4-54. Riser 86 Annulus Floor on September 7, 2012 Looking Towards Riser 87 (A) and Looking Towards Riser 89 (B)

Figure 4-55 provides a composite view of the white material originating at the refractory slot near Riser 90 and ending near Riser 86. Estimated flow distance is approximately 25 ft based on the distance between Riser 90 and Riser 86.

Figure 4-55. Riser 86 Composite of White Material on Annulus Floor on September 7, 2012

4.2.6.7 2012 Riser 83 Inspection

The inspection of Riser 83 occurred on August 29, 2012. There were no anomalies noted on the primary tank wall. An anomalous area of material was identified on the annulus floor midway between Riser 83 and Riser 82. The appearance and color of the material was different than the material seen near Riser 90 and Riser 87, and showed evidence of evaporating liquid based on the presence of crystal nodules farthest away from the origin. The source of the material appeared to be from a refractory slot. Figure 4-56 provides comparison views of the annulus floor area from two inspections. The material was not present during the last inspection of this area using Riser 82 on December 28, 2006.

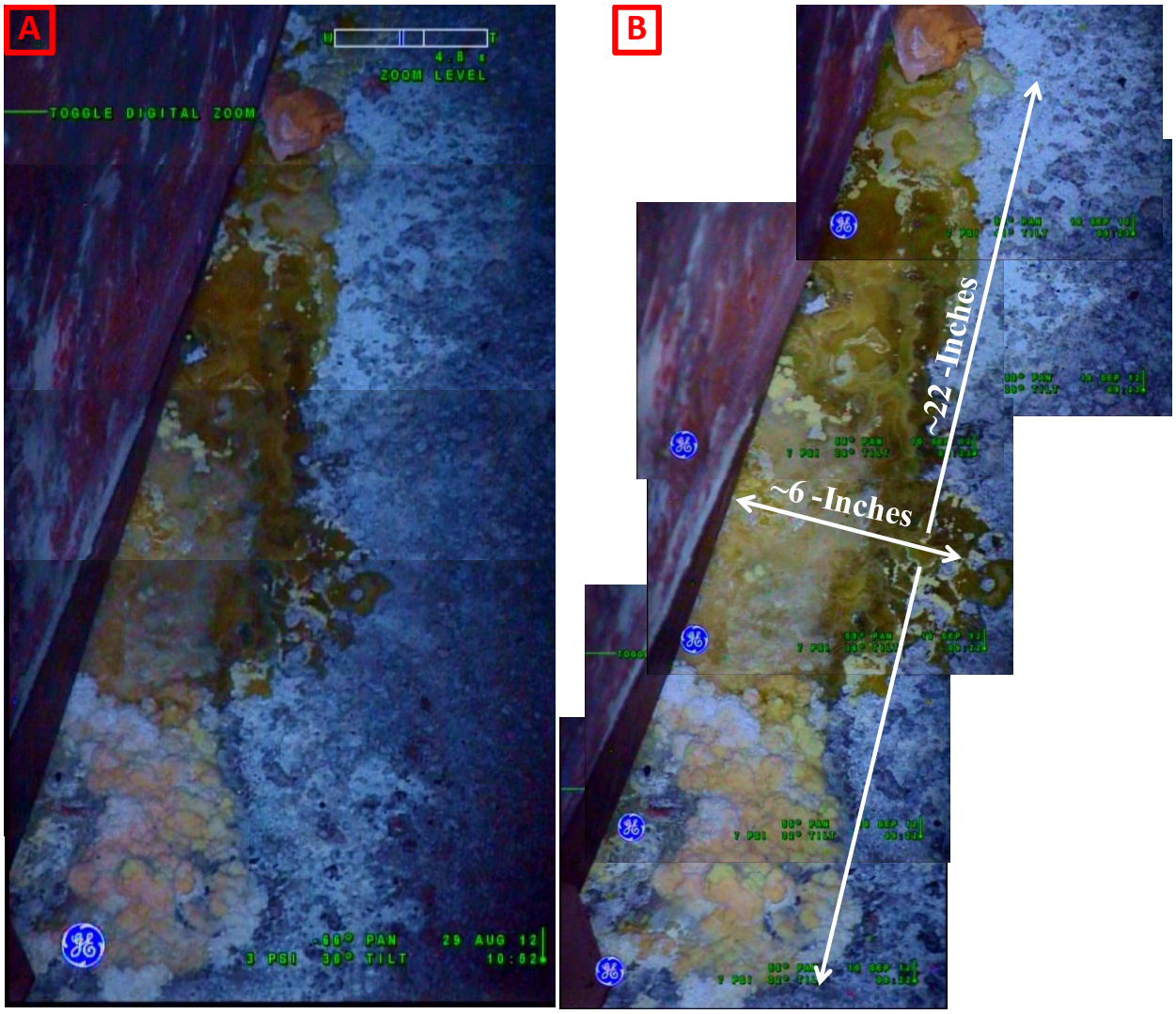


Figure 4-56. Riser 83 Material On Annulus Floor on August 29, 2012 (A) and September 10, 2012 (B)

Figure 4-57 provides another comparison of the region near Riser 83 between 2006 and 2012.

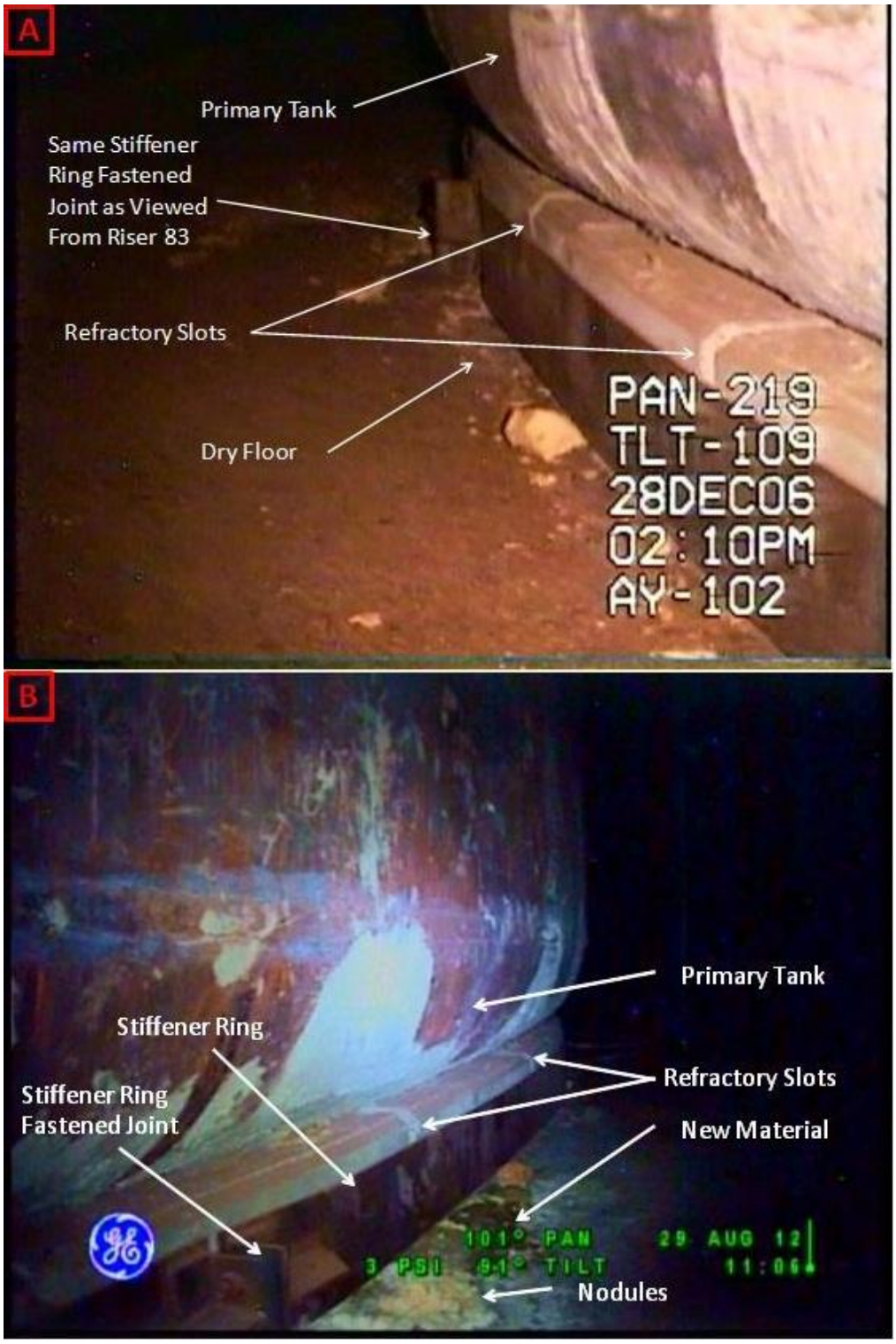


Figure 4-57. Annulus Condition Comparison From Riser 82 on December 28, 2006 (A) and From Riser 83 on August 29, 2012 (B)

Figure 4-58 shows the condition of the refractory slot where the cascade of material exited from beneath the primary tank bottom and flowed behind the stiffener ring prior to reaching the annulus floor. Inspections subsequent to the initial August 29, 2012 inspection identified no changes in the appearance through October 8, 2012 except for changes resulting from sampling activities.

Figure 4-58. Riser 83 Refractory Slot on September 10, 2012 (A) and September 17, 2012 (B)

A wheeled off-riser sampler (ORS) was deployed to obtain a sample of the material on September 26, 2012. Observations during the sampling effort confirmed the presence of liquid on the annulus floor. The sampler broke through the thin surface crust, wetting its wheels and leaving damp tracks on the annulus floor. Section 4.2.7 provides more details of sampling activities in the annulus.

On October 1, 2012, a follow-up inspection noted that a thin, cloudy crust was beginning to re-form on the liquid exposed during the sampling event five days earlier. Figure 4-59 provides a view of the region after the samples were taken on September 26, 2012. Figure 4-60 provides a view of the region on October 1, 2012.

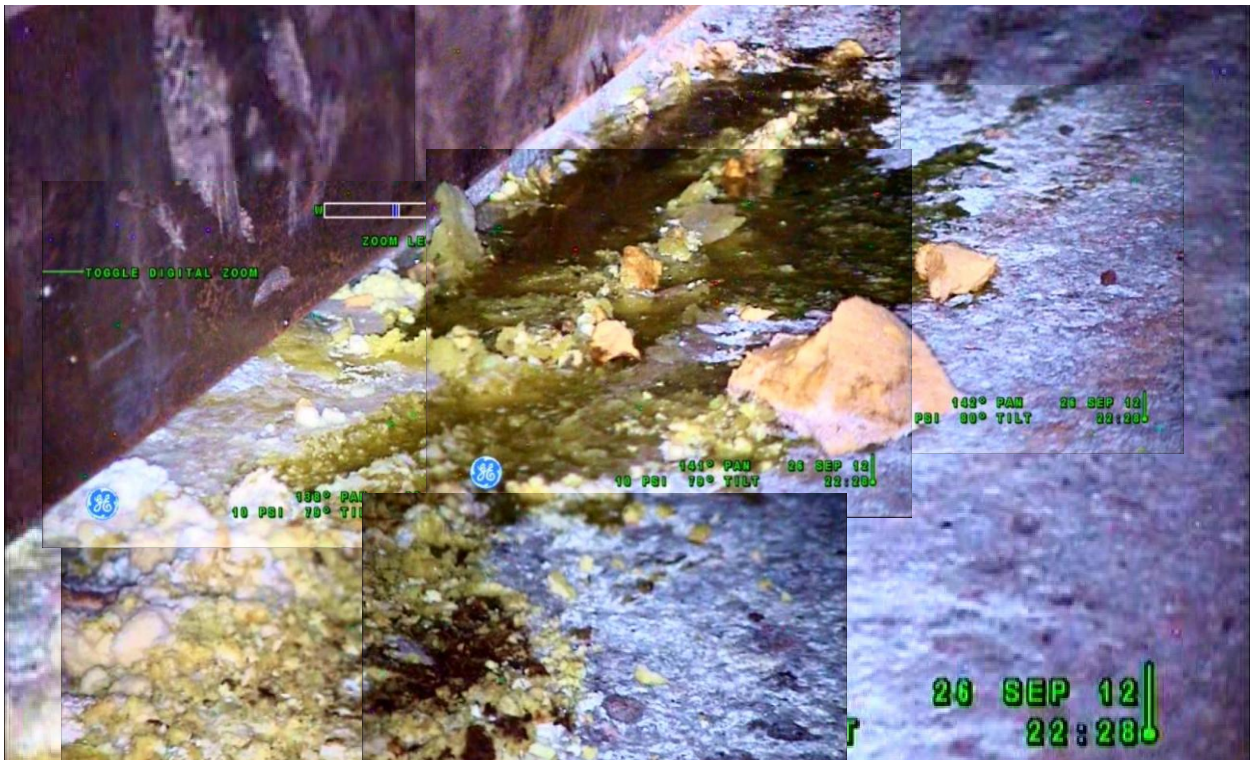


Figure 4-59. Riser 83 View of Material on Annulus Floor After Sampling Activities on September 26, 2012

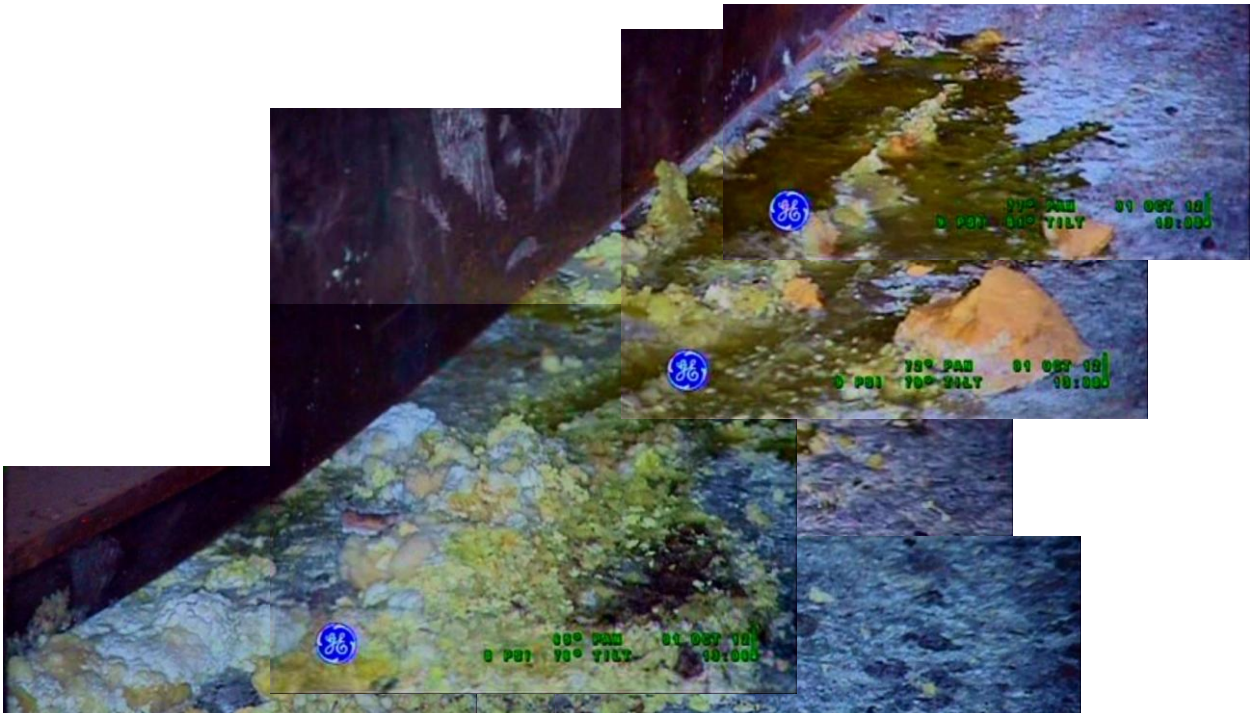


Figure 4-60. Riser 83 View of Material on Annulus Floor on October 1, 2012

The next inspection after October 8, 2012 occurred on October 18, 2012. A color change from white to green had occurred in the refractory slot material. A small expansion in the floor area covered by the green fluid had also occurred.

An inspection on October 21, 2012 identified further change in the refractory slot and on the annulus floor. Figure 4-61 provides a composite view of the region on October 1, 2012. Figure 4-62 provides a composite view of the region on October 21, 2012.

Figure 4-61. Riser 83 View of Material on Annulus Floor on October 1, 2012

Figure 4-62. Riser 83 View of Material on Annulus Floor on October 21, 2012

Figure 4-63 illustrates the progressive change in the refractory slot material observed on October 8, October 18, and October 21, 2012. The difference between the material on October 18 and October 21 is subtle; close inspection showed what appeared to be a small increase in volume.

Figure 4-64 illustrates the change in the annulus floor material appearance between the October 1, October 18, and October 21, 2012 inspections. Regions of interest and visual reference landmarks are highlighted in the figure.

Figure 4-65 highlights the change in appearance on the annulus floor. There is evidence that the additional material has flowed into the depressions created by the off-riser sampler (ORS) during the September 26, 2012 sampling activities.

Figure 4-63. Riser 83 View of Changes in Condition of Refractory Slot Material

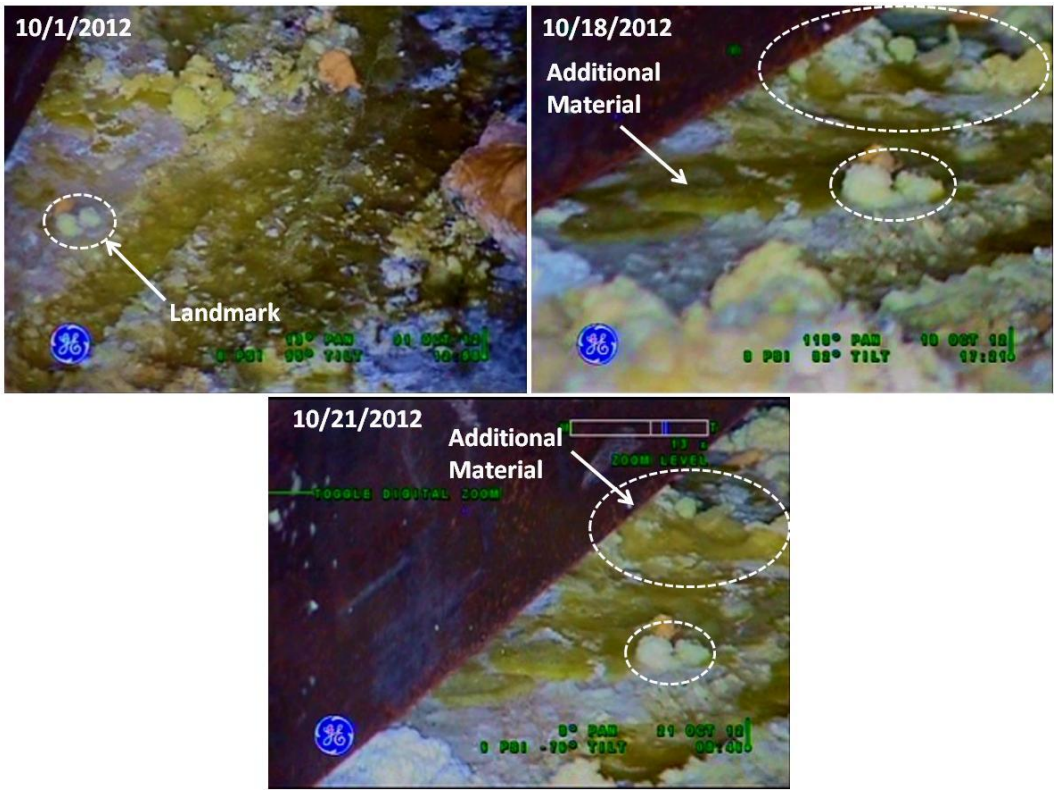


Figure 4-64. Riser 83 View of Changes in Condition of Annulus Floor Material Directly Below Refractory Slot

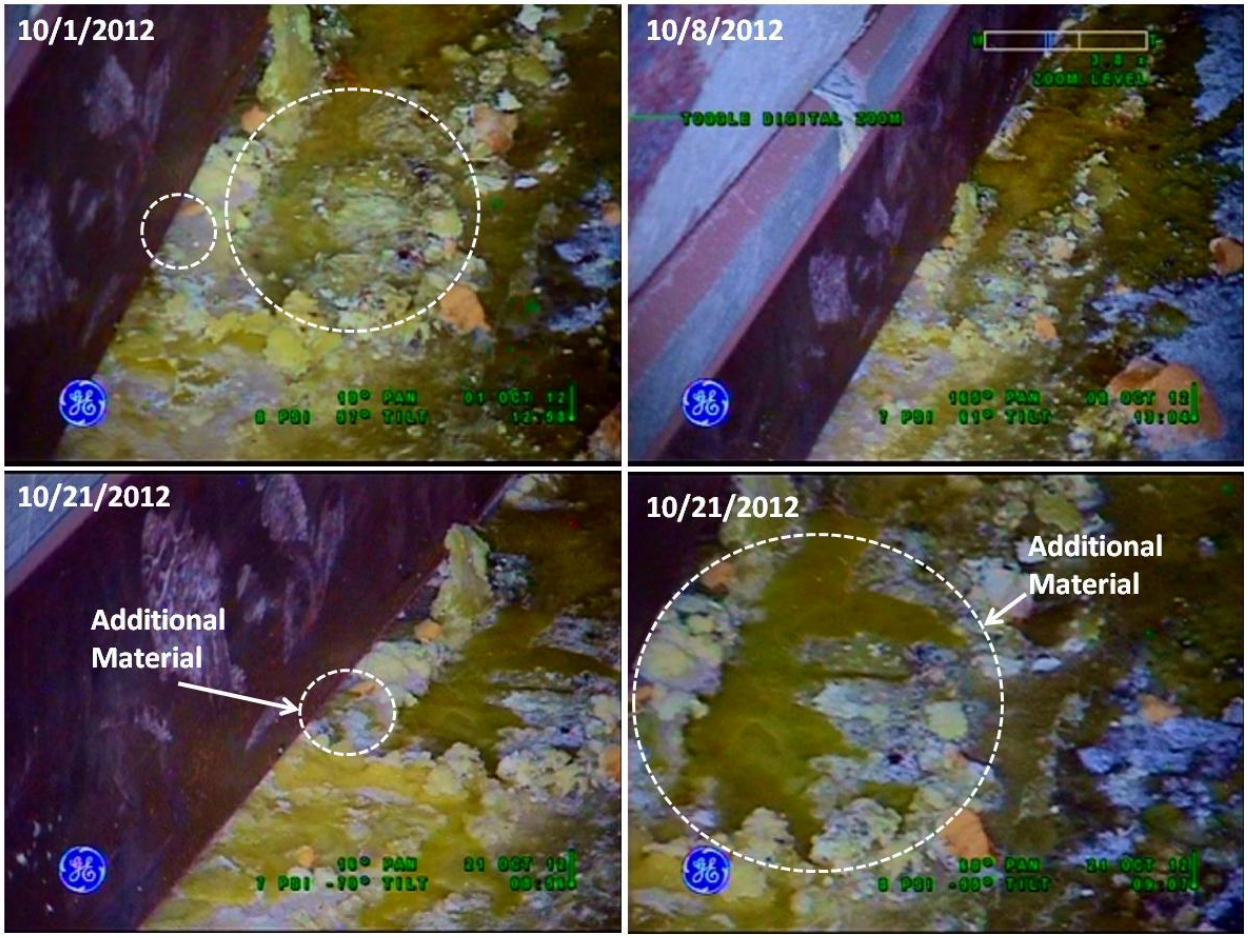


Figure 4-65. Riser 83 View of Changes in Condition of Annulus Floor Material near Off-Riser Sampler Tire Depressions

4.2.6.8 2012 Riser 91 Inspection

The Riser 91 inspection occurred on September 6, 2012. No anomalies were identified along the primary tank wall or the annulus floor. Figure 4-66 shows the condition of the annulus as viewed from Riser 91. Looking towards Riser 83, there are signs of previous water intrusion originating from annulus Riser 82. This ingress has been noted in historical inspections and is attributed to the fact that the top of Riser 82 terminates below grade. Looking towards Riser 80, there is some discoloration on the annulus floor consistent with other DST annuluses and not considered unusual.

Figure 4-66 provides the condition of the annulus floor as seen from Riser 91. Figure 4-67 provides a view of the refractory slot located near the centerline of Riser 91. There is some debris inside in the refractory slot, but the overall condition is better than the refractory slot inspected below Riser 89 (see Figure 4-48).

Figure 4-66. Riser 91 Annulus Floor on September 6, 2012 Looking Towards Riser 83 (A) and Looking Towards Riser 80 (B)

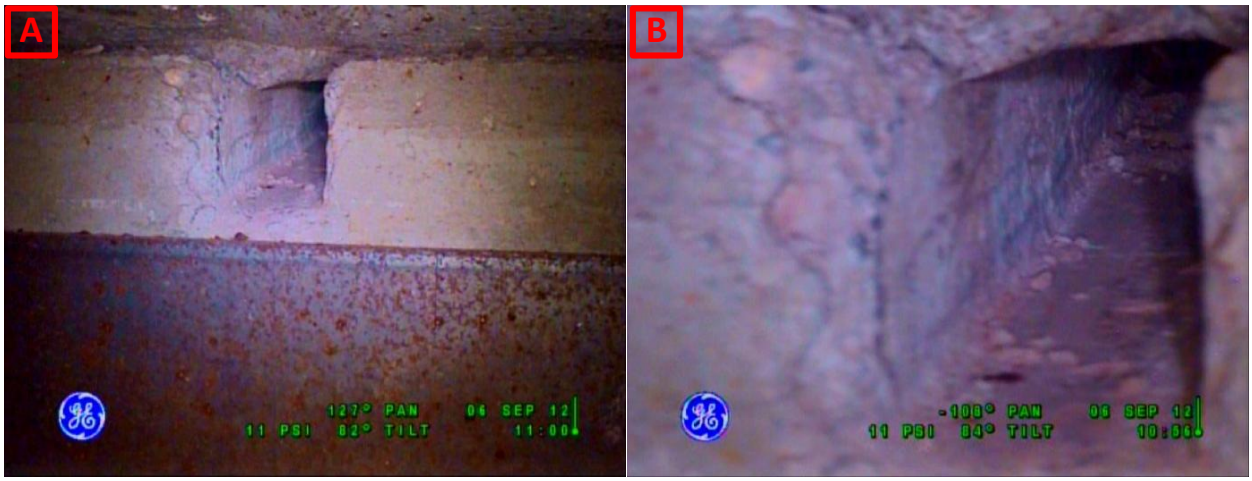


Figure 4-67. Riser 91 Refractory Slot Debris on September 6, 2012

4.2.6.9 2012 Riser 88 Inspection

The Riser 88 inspection occurred on September 5, 2012 and identified no anomalies on either the primary tank wall or the annulus floor. Figure 4-68A shows the condition of the annulus floor looking toward Riser 80. Figure 4-68B shows the one side of a metal grating looking toward Riser 79 (see Figure 4-70 for opposite view). Figure 4-69 provides a view of the refractory slot located near the centerline of Riser 88 with debris back inside the refractory slot.

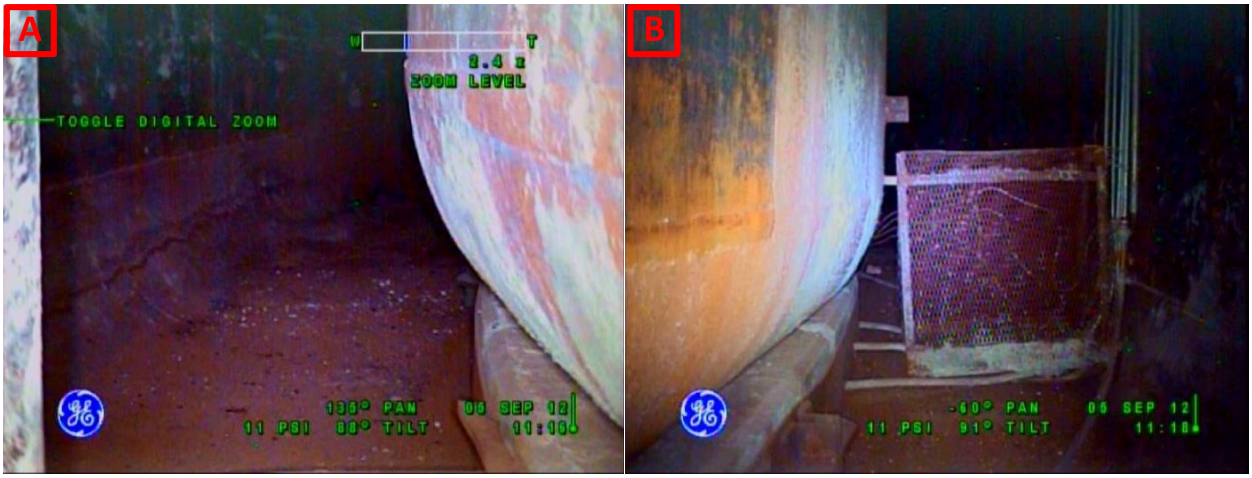


Figure 4-68. Riser 88 Annulus Floor on September 5, 2012 Looking Towards Riser 80 (A) and Looking Towards Riser 79 (B)

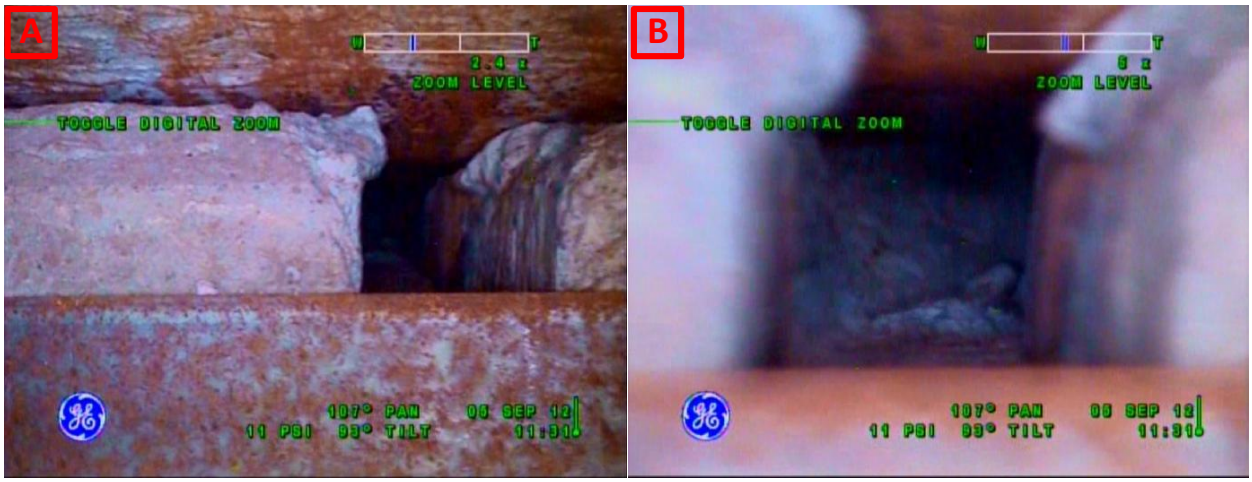


Figure 4-69. Riser 88 Refractory Slot Debris on September 5, 2012

4.2.6.10 2012 Riser 79 Inspection

The Riser 79 inspection occurred on September 7, 2012 and identified no anomalies on the primary tank wall or the annulus floor other than typical debris seen elsewhere. Figure 4-70A shows the condition of the annulus floor as seen from Riser 79. This photograph shows the opposite side of the grating from that pictured in Figure 4-68. Figure 4-70B shows the condition of the annulus floor looking toward Riser 77.

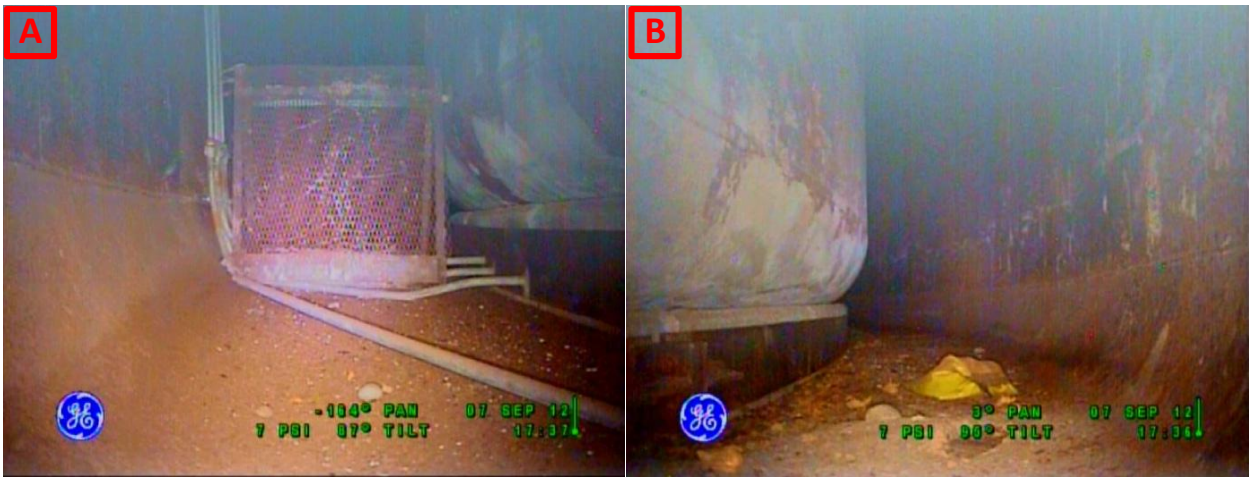


Figure 4-70. Riser 79 Annulus Floor on September 7, 2012 Looking Towards Riser 88 (A) and Looking Towards Riser 77 (B)

4.2.6.11 2012 Annulus Visual Inspection Results Summary

The results of the comprehensive annulus inspections identified unexpected changes near in Risers 77, 83, 87, 89, and 90. All of the areas are located on the annulus floor or on the refractory except for Riser 89 where crystal-like growth was found on the primary top knuckle where the primary tank and the secondary liner converge. Figure 4-71 provides a visual summary of the inspections.

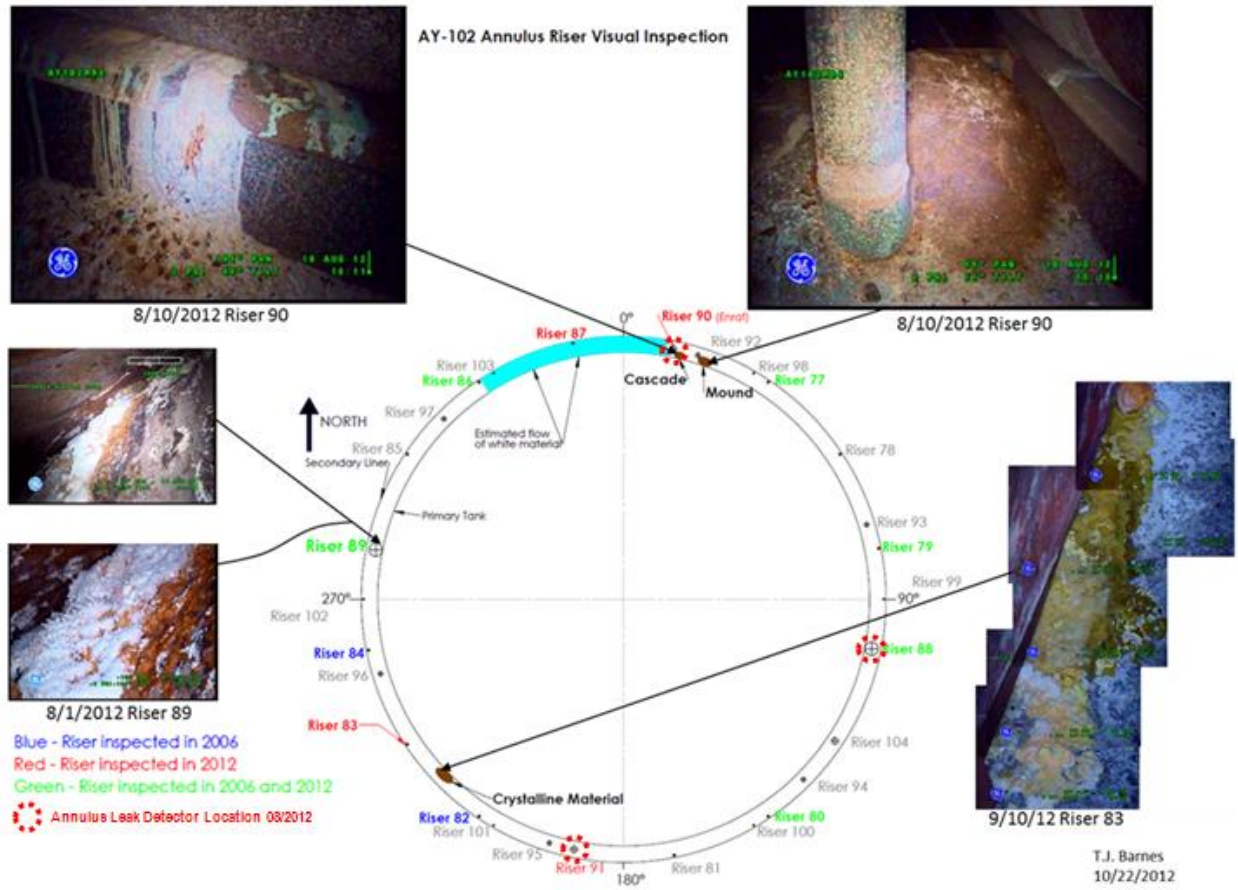


Figure 4-71. Tank AY-102 Visual Inspection Results

4.2.7 Samples 2012

An initial survey swab of the material in the Tank AY-102 annulus underneath Riser 90 occurred on August 10, 2012. Sample collection of material on the annulus floor near Riser 83 occurred on September 26, 2012. Further samples to characterize the material underneath Riser 90 were retrieved on October 15 and 17, 2012. The field sample collection and analytical results are described in this section as well as effects on the secondary liner should the primary tank waste leak to the annulus.

4.2.7.1 Riser 90 – August 2012

On August 10, 2012, survey swabs of the material on the annulus floor underneath Riser 90 were retrieved. Three surveys were collected using double-sided duct tape placed on a metal weight

and lowered into the annulus on a cable. The samples were placed into yellow plastic bags for transmittal to the 222-S Laboratory. The particles adhered to the duct tape had a measurable dose rate when retrieved from the annulus space, and a surface contamination reading of 800,000 dpm was reported with a detector near the sample material. The sample description and analysis are documented in RPP-RPT-53511, *Final Report for Tank 241-AY-102 Annulus Solids Sample Taken in August, 2012*.

Based on the appearance of the duct tape when received at the laboratory, it was decided to remove the double-sided tape, along with the sample, instead of attempting to scrape the sample off of the tape. The tape and sample were removed from the weight and then divided into four sections (see Figure 4-72). Each of the four sections appeared fairly homogenous due to appearance and dose rate. Most of the particulates observed on the tape appeared to be rust, with a few blue-colored flecks.

Figure 4-72. Tank AY-102 Riser 90 Duct Tape Survey of Residual Sample Material

Qualitative analysis of the particulates was completed using scanning electron microscopy (SEM) by removing individual particles from the duct tape and placing them on an adhesive tab on an SEM mount.

Results of the SEM analysis concluded that the particulate appeared to be dominated by rust, composed primarily of iron and oxygen, as expected.

The scattered blue particulate appeared to be a type of paint. Analysis by energy-dispersive X-ray spectroscopy (EDS) indicated a kaolinite mineral is the filler in the paint. Cellulose fibers were also present.

The remainder of the particulate was mostly light gray to amber-colored aggregates of fine-grained crystalline material. Several of these particles were examined. The chemistry was fairly uniform, with sodium, potassium, carbon, oxygen, nitrogen, phosphorous, and chlorine identified in the EDS spectra (see Figure 4-73). These sodium salt crystals are all water soluble phases that have been previously identified in Hanford tank waste. Tank AY-102 is known to also have high levels of potassium, which is less common in most tank waste.

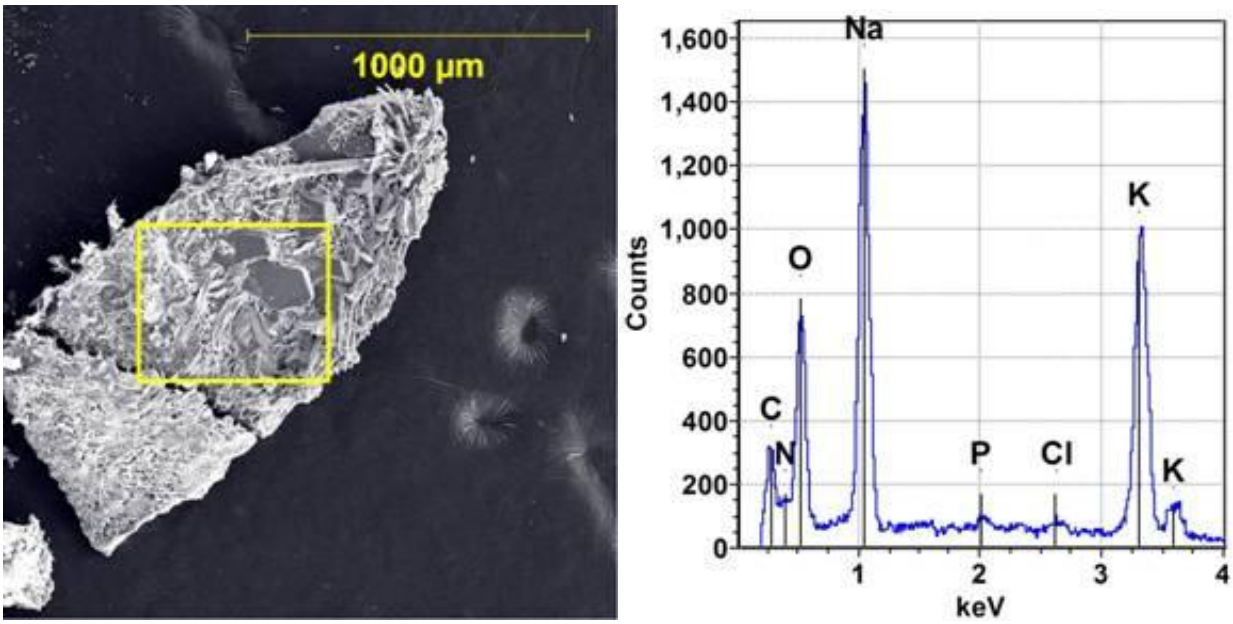


Figure 4-73. Tank AY-102 Annulus Duct Tape Survey Particulates of Light Gray and Amber-Colored Aggregates of Fine Grained Crystalline Material

Quantitative analysis included gamma energy analysis (GEA), alpha energy analysis for isotopic plutonium, isotopic curium and ^{241}Am analysis, and gas proportional counting for $^{89/90}$Sr. The section with the least amount of plastic adhering to the tape was chosen for digest in concentrated nitric acid. The digest with the duct tape is not ideal, but was performed successfully, while attempting to minimize possible matrix effects and removing as much contamination as possible. The results are reported on a per sample basis as the mass of dissolved sample could not be determined. The analytes that were above the detection limit are presented in Table 4-22.

Table 4-22. Detectable Radionuclide Results in Swab from Riser 90

Analyte	Result (µCi/sample)	Duplicate (µCi/sample)	Average (µCi/sample)
$^{243/244}$Cm	<2.01E-06	<2.06E-06	n/a
^{241}Am	1.57E-04	1.48E-04	1.52E-04
^{137}Cs	3.91	n/a	n/a
^{208}Tl	3.88E-03	n/a	n/a
^{214}Pb	7.71E-03	n/a	n/a
^{226}Ra	0.0664	n/a	n/a
$^{239/240}$Pu	2.71E-05	2.78E-05	2.74E-05
^{238}Pu	8.79E-06	1.05E-05	9.64E-06
^{242}Pu	3.26E-06	2.20E-06	2.73E-06
$^{89/90}$Sr	0.0965	n/a	n/a

The analysis of the Riser 90 survey indicated contaminated material; however, the radionuclide content was judged to be lower than what would be expected of Hanford tank waste. Some of the chemicals identified were also consistent with tank waste. However, the sample was very small and the floor under Riser 90 had been flushed with water during troubleshooting of the ENRAF (see Section 4.2.4), so the swab results are at best indeterminate.

4.2.7.2 Riser 83 – September 2012

4.2.7.2.1 Sample Collection

An ORS was lowered into the Tank AY-102 annulus on September 26, 2012 via Riser 91 to sample the annulus floor material located midway between Riser 82 and Riser 83. Remote cameras were installed in Riser 91 and Riser 83 to support the sampling effort. The ORS had to travel approximately 25 ft to reach the intended sampling location, past an annulus 4-in. ventilation piping located along the annulus floor, and over three thermocouple conduits. Section 4.2.6 provides a description of annulus ventilation piping and configuration along the annulus floor. Figure 4-74 shows the location of the sampling region with respect to these features. Figure 4-75 is shows the ORS traversing over the thermocouple conduit in route to the sampling area.

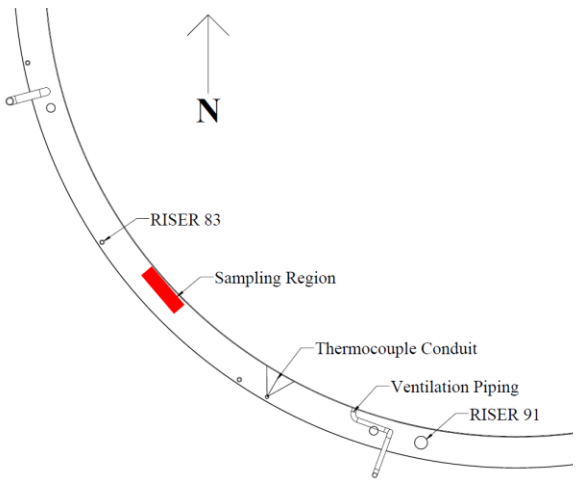


Figure 4-74. Tank AY-102 Sampling Region and Riser Location Diagram

Figure 4-75. Off-Riser Sampler Traversing Over Thermocouple Conduit

Once the ORS reached the sampling location it was positioned to collect a sample of the nodules located closest to Riser 83. Figure 4-76 is a composite image showing the sampling location and position of the OSR prior to the attempts to obtain the sample. Once in contact with the nodules, the resistance of the nodules caused the ORS scoop to bend slightly. The strength of the ORS scoop would continue to be an issue in the sample collection process.

After the nodules broke free, it could be seen that the base of the broken nodules was a bright yellow color. Figure 4-77 provides a view of broken nodules. The ORS retrieved a sample of the nodules and placed the material in the sampling jar.

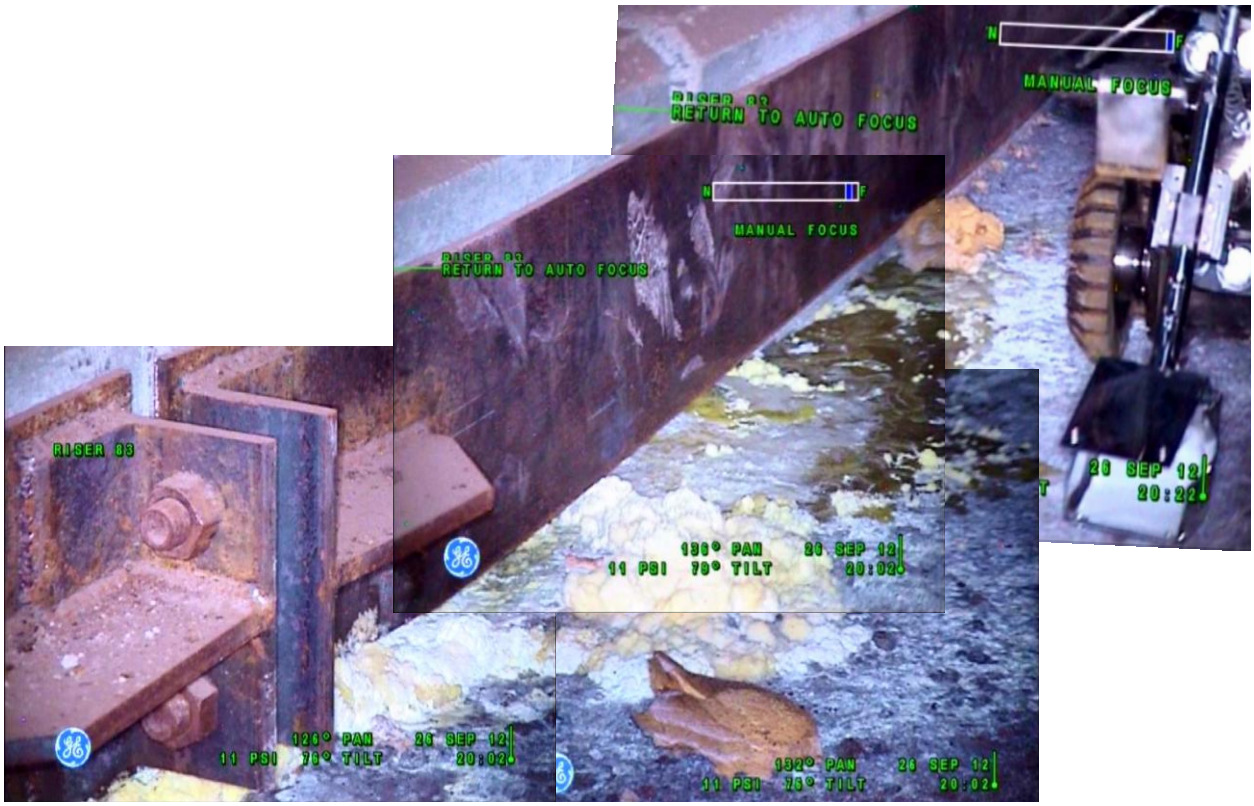


Figure 4-76. Composite Image of Material on Annulus Floor Prior to Sampling Attempts

Figure 4-77. Crystal Nodules During Sampling Effort

The ORS was then returned to the material near Riser 83 to retrieve samples for analysis. During the attempts to retrieve additional material it was noted that the previous green material was beginning to break up due to the weight of the ORS and the rotation of the wheels. Continuing attempts to obtain samples provided indications of liquid along the areas where the wheels of the ORS had traversed. These indications included reflections seen on the surface of the green material, drips seen coming off the ORS scoop, and ripples along the green material when the scoop traversed through it in the attempts to obtain a sample. Figure 4-78 provides a view of the material and liquid indications along the annulus floor during the sampling activities.

Figure 4-78. View of Material and Liquid Indications During Sampling Activities

No additional samples could be collected on September 26, 2012 due to deformation of the scoop. It was determined that the ORS scoop and attaching arm would require repair prior to executing further sample attempts. Figure 4-79 provides an "as-left" view of the sampling location at the conclusion of the sampling effort.

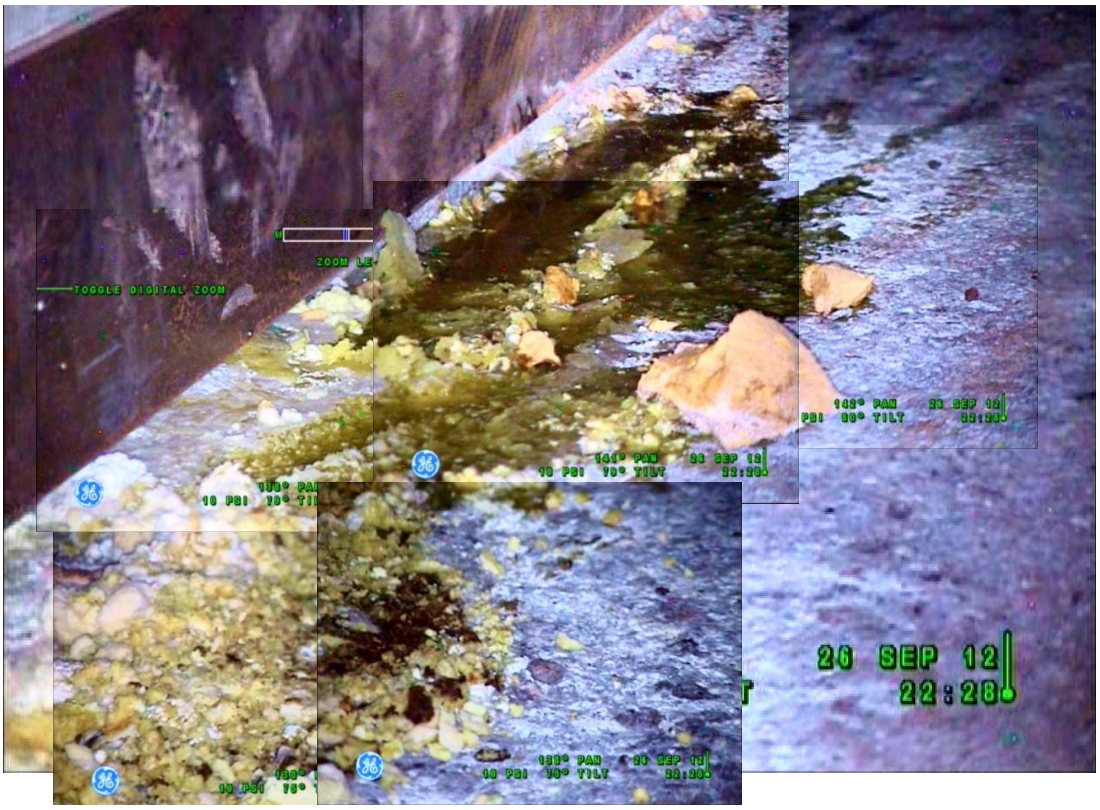


Figure 4-79. Composite Image of Material on Annulus Floor After Sampling Attempts

On September 27, 2012, the day after the sampling activity, the CAM alarmed. It is likely that the disturbance of the material along the annulus floor caused this alarm. Section 4.2.5 provides further details of the CAM alarm.

4.2.7.2.2 Sample Analytical Results

Upon retrieval of the sample material from the annulus, a 45 mR/hr 'window open' reading was reported. The 'window open' reading is believed to have been taken directly above the open sample pig. The sample was transported to the 222-S Laboratory for analysis in accordance with RPP-PLAN-53352, *Tank AY-102 Annulus Sampling and Analysis Plan*. The material was received at the laboratory on September 27, 2012, and introduced into the hot cell. The net weight of the sample was 12.8 g. The sample contained a few chunks of white crystalline material and large black flakes of what appear to be mill scale, as shown in Figure 4-80.

Figure 4-80. Tank AY-102 Annulus Sample (12.8 g) Taken Underneath Riser 83 Deposit on September 26, 2012

The presence of mill scale was confirmed using a magnet. The mill scale was separated from the white material and was weighed out as 7.6 g, or more than half the sample, as shown in Figure 4-81.

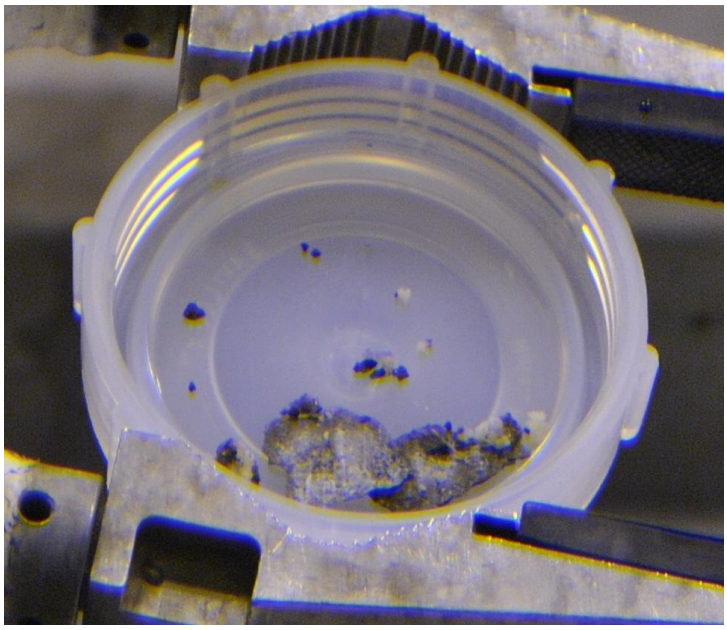


Figure 4-81. Mill Scale Removed from Tank AY-102 Annulus Sample (7.6 g)

Since only 5.2 g of actual chemical deposit material remained, there was insufficient material to complete all of the planned analyses. To conserve sample and maximize the analyses judged most beneficial, it was determined that the solid pH, thermogravimetric analysis (TGA), TIC/TOC (total inorganic carbon/total organic carbon), and ammonia analysis would not be performed.

It was decided to use 3 g of sample for analysis and archive the remaining portion of the sample for later analyses. Inductively coupled plasma (ICP) analysis for metals/cations, GEA for radionuclides, ion chromatography for anions, and the surface chemistry suite of analysis (polarized light microscopy [PLM], XRD, SEM/EDS) were completed on the sample. The surface chemistry suite of analyses was also performed on a portion of the black mill scale flake.

The white crystalline was crushed using a mortar and pestle to prepare it for splitting into the two parts. As the sample was crushed, it became noticeably moister, whether through release of pore water or bound water, or through deliquescence during crushing. It was decided to not use water in subsequent sample preparation steps to avoid altering any water soluble compounds present. After homogenation, only 3.2 g of sample were collected in the sample vial. The remainder was stuck to mortar and pestle and sample spatula. It was allowed to dry to collect as much archive as possible. The final amount of archive material that could be set aside for future analyses was 0.9 g.

Quantitative Analysis Results

The solid mineral phases were analyzed using PLM, SEM-EDS, and XRD. The major phases of the white crystalline sample were identified by XRD analysis as sodium carbonate ($Na_2CO_3 \cdot [H_2O]$) and sodium nitrate ($NaNO_3$). Sodium nitrite ($NaNO_2$) and potassium nitrate (KNO_3) were identified as minor phases.

The phases identified by XRD analysis were further confirmed by SEM analysis. Sodium carbonate was the dominant phase along with nitrate and nitrite phases. One minor phase identified by the SEM included sodium fluoride sulfate. The SEM analysis indicated that the remaining material in the white particulate was one or more potassium salts (Figure 4-82). Potassium salts are uncommon in most Hanford waste types, and thus is a unique finding.

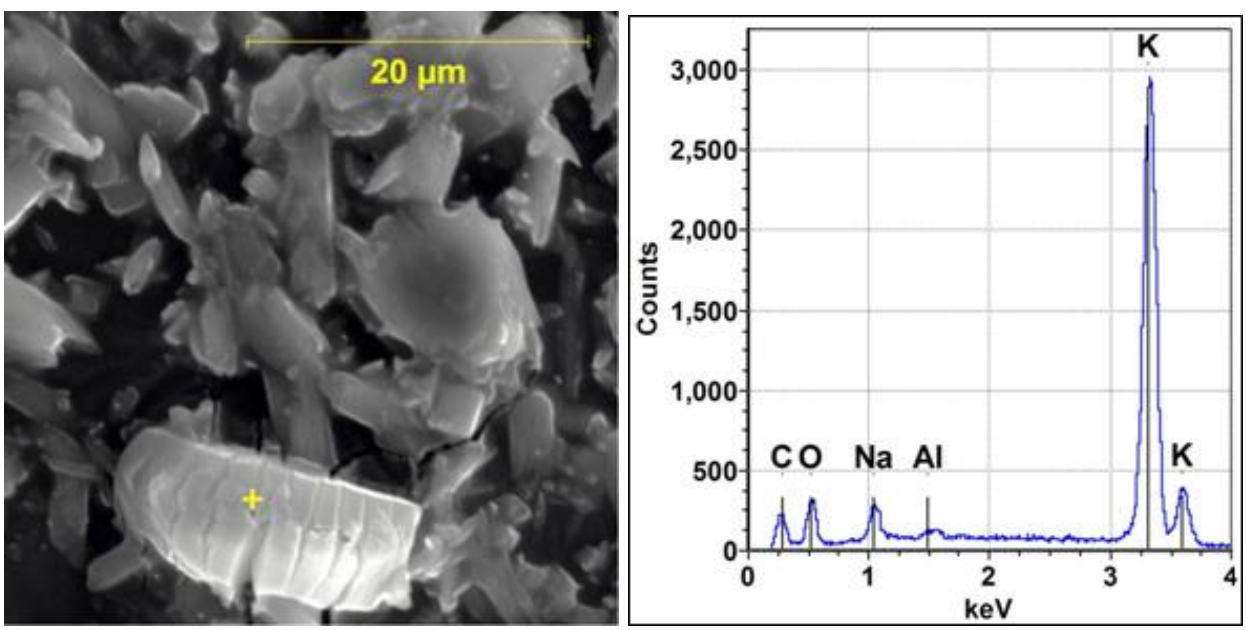


Figure 4-82. Scanning Electron Microscope Photo (left) from Sample and Energy-Dispersive X-ray Spectroscope Spectrum (right) from Spot Marked with a Cross Indicating a Potassium-Rich Phase

The primary potassium-bearing phase was identified as potassium nitrate using XRD analysis. The potassium-bearing phase comprised about 5-10 percent of the sample by volume.

The Best-Basis Inventory (BBI) for the current supernatant liquid in Tank AY-102 (RPP-RPT-44630, *Derivation of Best-Basis Inventory for Tank 241-AY-102 as of July 1, 2012*) shows a high potassium concentration of (24,281 µg/g in the current supernatant.).

The current supernatant was transferred into the tank from Tank AP-101in 2007. The Tank AP-101 supernatant was high in potassium. Another source of potassium in Tank AY-102 is the 4,000 gal of KOH addition in 1994 for chemistry mitigation (Memo 7CF10-023-094, "Action Plan for Caustic Addition to Tank 241-AY-102" [Dodd 1994]).

The only other DST known to have considerable amounts of potassium is Tank AW-101. Tank AW-101 has an estimated 9.45E+05 kg of potassium, where Tank AY-102 has an estimated total amount of 1.01E+05 kg. The amount of potassium in these two tanks is greater than two times the amount in any other SST or DST (TWINS, Best Basis Summary). The presence of potassium in the Riser 83 sample suggests the origin is tank waste.

The PLM generally confirmed the SEM and XRD observations. Sodium carbonate and sodium nitrate dominate the PLM specimen; trace amounts of sodium oxalate were also observed.

The XRD analysis of the dark metallic material revealed that the presumed iron-bearing, partially magnetic phase is not crystalline. The only crystalline peaks observed were of the same sodium-bearing phases. However, the intensity (and therefore concentration) of these sodium phases is about a tenth as large as the concentrations found in the white crystalline material. The SEM analysis confirmed that the sodium and potassium salts were also present in this sample. However, the bulk of the sample is an iron oxide. PLM analysis revealed a mixture of the sodium salts and a fine-grained opaque material. The chemistry, magnetic attraction, and morphology of the dark material are consistent with mill scale, or a mixture of mill scale and corrosion.

Quantitative Analysis of White Crystalline Material

Quantitative analysis of the sample included ICP analysis for metals/cations, GEA for radionuclides, and IC (ion chromatography) for anions. For the anion analysis, both fusion and acid digest were used for analysis. The fusion digest concentration results were generally higher and were reported, consistent with BBI protocol (RPP-7625, *Guidelines for Best-Basis Inventory*).

To determine the likelihood that the annulus sample results were similar to the tank waste in Tank AY-102, the sample constituents were compared with the BBI compositions. The BBI estimates for both the supernatant and interstitial liquids of Tank AY-102 were converted to a dry weight basis for direct comparison to the solid material. The estimated densities for the supernatant and interstitial liquids are 1.35 g/mL and 1.15 g/mL, respectively.

The current tank waste characterization report identifies the sludge interstitial liquids are 82 wt% water and the supernatant is 59.3 wt% water (RPP-44630). The estimated dry weight basis constituents in the supernatant and interstitial liquid are compared to the sample results presented in Table 4-23 and Table 4-24.

Table 4-23. Riser 83 Material Ion Chromatography Results

Analyte	Riser 83 Sample Average Result (µg/g)	AY-102 BBI Supernatant (µg/g)	AY-102 BBI Interstitial Liquid (µg/g)
Aluminum	9.56E+03	1.51E+04	1.65E+03
Calcium	5.80E+03	1.62E+01	1.66E+01
Fluoride	8.60E+02	3.84E+03	3.17E+02
Iron	5.65E+03	7.81E+00	4.83E+00
Potassium	3.90E+04	6.90E+04	2.43E+03
Sodium	2.91E+05	2.73E+05	3.40E+05
Nitrite	5.87E+04	8.85E+04	3.50E+04
Nitrate	1.81E+05	2.40E+05	1.87E+03
Phosphate	2.15E+03	2.98E+03	1.90E+04
Silicon	8.44E+02	2.15E+02	1.14E+02
Magnesium	1.45E+02	5.77E+00	4.83E+00
TIC as CO_3	4.31E+04	7.50E+04	3.99E+05
TOC	1.05E+03	4.02E+03	7.34E+03

BBI = best-basis inventory.
CO_3 = carbonate ion.
TIC = total inorganic carbon.
TOC = total organic carbon.

Table 4-24. Riser 83 Material Radionuclide Results

Analyte	Riser 83 Sample Average Result (µCi/g)	AY-102 BBI Supernatant (µCi/g)	AY-102 BBI Interstitial Liquid (µCi/g)
^{60}Co	1.51E-02	2.71E-03	1.19E-02
$^{89/90}Sr$	1.20E-01	3.57E-01	7.49E+00
^{137}Cs	9.10E+01	2.62E+02	1.36E+02
^{228}Ac	5.0E-02	N/A	N/A

BBI = best-basis inventory.
N/A = not applicable.

The major constituents identified in the Riser 83 sample material were (in order) sodium, nitrate, nitrite, TIC, and potassium. The supernatant composition showed the same major constituents in relative magnitudes. In contrast, the interstitial liquid (IL) included TIC, sodium, nitrite, phosphate, and aluminum as the five major constituents. Nitrate and potassium were still present in the IL at notable quantities, but not at the order of magnitude as shown in both the annulus sample results and estimated supernatant concentrations.

The pH of the sample was estimated by adding a couple drops of water to less than 1 mg of sample and testing with pH paper. Although this method only provided a rough estimate, the pH test paper indicated a pH of 11 which is consistent with the alkaline tank waste.

The ^{137}Cs and $^{89/90}Sr$ were also identified as major constituents expected to be present in Tank AY-102 waste. The strontium content in the annulus sample was approximately 33 percent of the supernatant content, and only 0.02 percent of the estimated content in the IL. The ^{137}Cs content in the sample was approximately 35 percent of the supernatant content, but 67 percent of the IL content, which are both fairly comparable.

The most recent tank characterization report (RPP-RPT-42920) discusses the unique characteristic of the cesium content in Tank AY-102 waste. Studies have shown that most of the ^{137}Cs is associated with the sludge solids, in contrast to other DSTs where most of the ^{137}Cs is held in the supernatant. The lack of ^{137}Cs in the liquid implies the presence of other species such as aluminosilicates that hold the ^{137}Cs in the solids. A solubility study conducted in 2002 on the core 270 and 273 centrifuged solids found that 81 percent of the ^{137}Cs in the tank was associated with the solids (HNF-6047, *Tank 241-AY-102 Cores 270, 271, 272, and 273 Analytical Results for the Final Report*).

The lower ^{137}Cs content in the sample material is probably attributed to the ^{137}Cs being retained in the solids in Tank AY-102. Additionally, some could have been retained in the refractory. As discussed in Section 3.3.1, the refractory is mainly composed of calcium aluminosilicate. Degraded refractory consisting of aluminum, iron, and silicon oxides have the ability to retain ^{137}Cs. Thus, it is possible that the ^{137}Cs passed through the equivalent of two stages of ion exchange before reaching the annulus floor—first in the sludge, and then in the refractory. With that consideration, the amount of ^{137}Cs found in the sample material is very comparable to the Tank AY-102 supernatant.

Two possible sources of material in the annulus identified in RPP-53434, *241-AY-102 Annulus Sampling Data Quality Objectives*, were the refractory and tank waste. As previously stated, the major constituents found in the refractory are silicon, aluminum, and calcium. Aluminum is prevalent in the Tank AY-102 supernatant and IL; the sample results identified higher concentrations of both calcium and silicon than were expected in either the supernatant or IL of Tank AY-102.

The sample has constituents that are common to both the tank liquids and the refractory. It is possible that the material on the annulus floor has a shared origin of tank liquids and partially dissolved refractory.

4.2.7.3 Riser 90- October 2012

4.2.7.3.1 Sample Collection

The remote underground sampler (RUS) was installed through Riser 90 on October 10, 2012 to sample the mound and cascade crystalline material. The RUS, shown in Figure 4-83, was designed to obtain an auger sample using a drill bit and spring-loaded scoop.

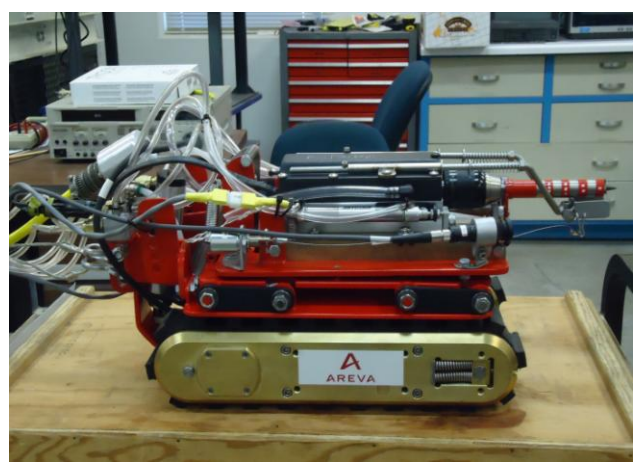


Figure 4-83. Remote Underground Sampler (RUS) for Riser 90

Sampling of the mound and the refractory slot crystalline material near Riser 90 occurred on October 15, and October 17, 2012. On October 15, 2012, the crystalline material was sampled prior to the mound. On October 17, 2012 the mound was sampled, then the crystalline material. Difficulties retrieving the samples and then keeping the samples intact

until deposited in the sample bottle were experienced during both sampling events. Minimal sample material was obtained during both events.

Mound

During the first sample attempt on October 15, 2012, it was observed that any quick jerking movements of the RUS resulted in loss of sample held in the auger. Only a small sample was obtained. The second sampling event occurred on October 17, 2012. During drilling, underneath the rust covered crust the underlying material was a grey, granular solid which was easily broken up (see Figure 4-84). The mound material was easily broken up by driving over portions of the mound or using the RUS auger. By the end of the second sampling event, many chunks had broken off of the mound due to the sampling activity. Figure 4-85 shows the condition of the mound after the sampling events.

Figure 4-84. Auger Sampling Mound on October 15, 2012, Showing the Break-up of the Crust and Underlying Material

Figure 4-85. Condition of the Mound after the Sampling Events

Refractory Slot Crystalline Cascade Material

The crystalline cascade material located near the refractory slot did not exhibit the same physical characteristics as the mound (see Figure 4-86). It stayed relatively intact throughout both sampling events. Some of the material on the refractory stiffener ring was dislodged from contact by the RUS. The auger was able to break apart and drill into some of the material, but the crystalline material was not broken up from driving the sampler over the material. A few discrete pieces of the white crystalline material were recovered. Figure 4-87 shows the condition of the crystalline material after the sampling events.

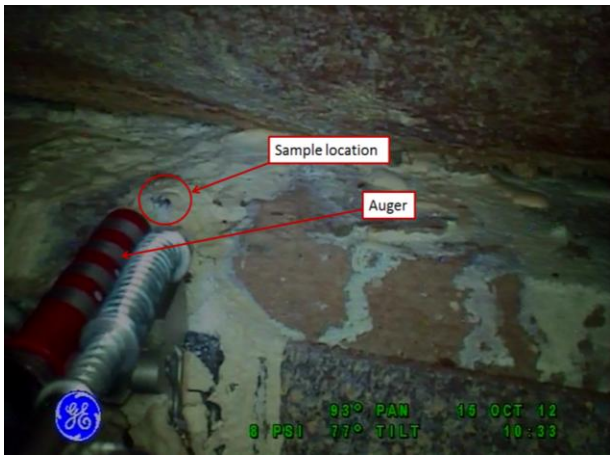


Figure 4-86. Auger Collecting Sample of the Refractory Slot Crystalline Material near Riser 90 October 15, 2012

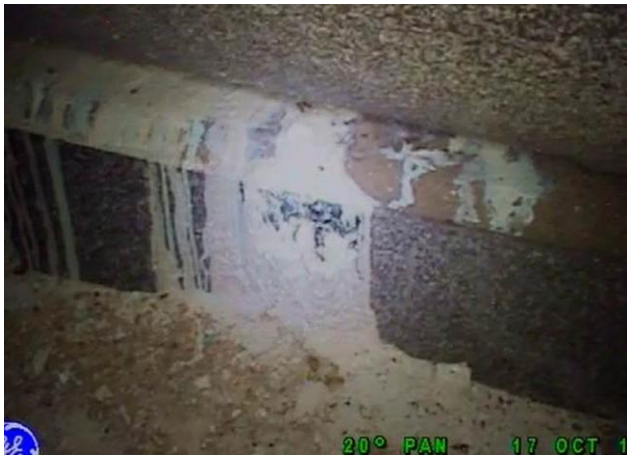


Figure 4-87. Condition of the Crystalline Material after the Sampling Event

4.2.7.3.2 Sample Analysis

The samples taken on October 15, 2012 mostly consisted of rust identified by magnetic response. Much of the rust could have fallen into the sample jar during the sampling event, as rust particulates were observed falling down the riser as the sample jar and camera were lowered into the annulus. The samples taken October 15, 2012 are shown in Figure 4-88 and Figure 4-89. The samples of both the mound and the refractory slot crystalline material were judged to be too small to be useful for even qualitative results after inspection at the 222-S Laboratory. The sampling effort was repeated on October 17, 2012.

Figure 4-88. Riser 90 Mound Material Sample October 15, 2012

Figure 4-89. Riser 90 Refractory Slot Crystalline Material Sample October 15, 2012

Mound

The October 17, 2012 sample sent to the 222-S Laboratory contained 0.12 g of material (Figure 4-90). The sample was crushed in its entirety. No attempt was made to separate the rust from the few light colored fragments that were present.

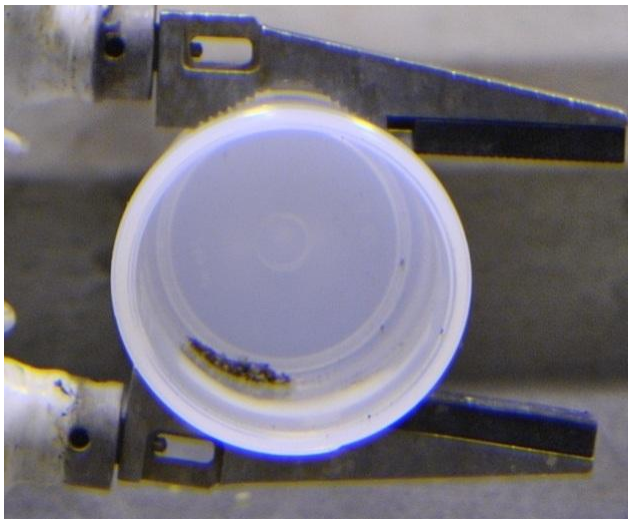


Figure 4-90. Riser 90 Mound Material Sample October 17, 2012 (0.12 grams)

The particulate was identified by SEM as a mixture of rust and soil with a small amount of a sodium rich phase. The soil constituents were quartz and feldspar, consistent with Hanford soils (see Figure 4-91). The XRD pattern for this sample showed no significant peaks for any crystalline phase.

The SEM sample specimen contained no detectible beta/gamma radiation using the room monitors. The sample size was too small to conduct a GEA analysis. The only evidence linking the material to tank waste was the sodium-rich particulate. Whether this sample can be considered representative of the mound material is questionable due to the small sample size, and the material cross-contamination that may have occurred during the sampling activities and RUS travel in the annulus. No quantitative analysis was performed on the mound sample.

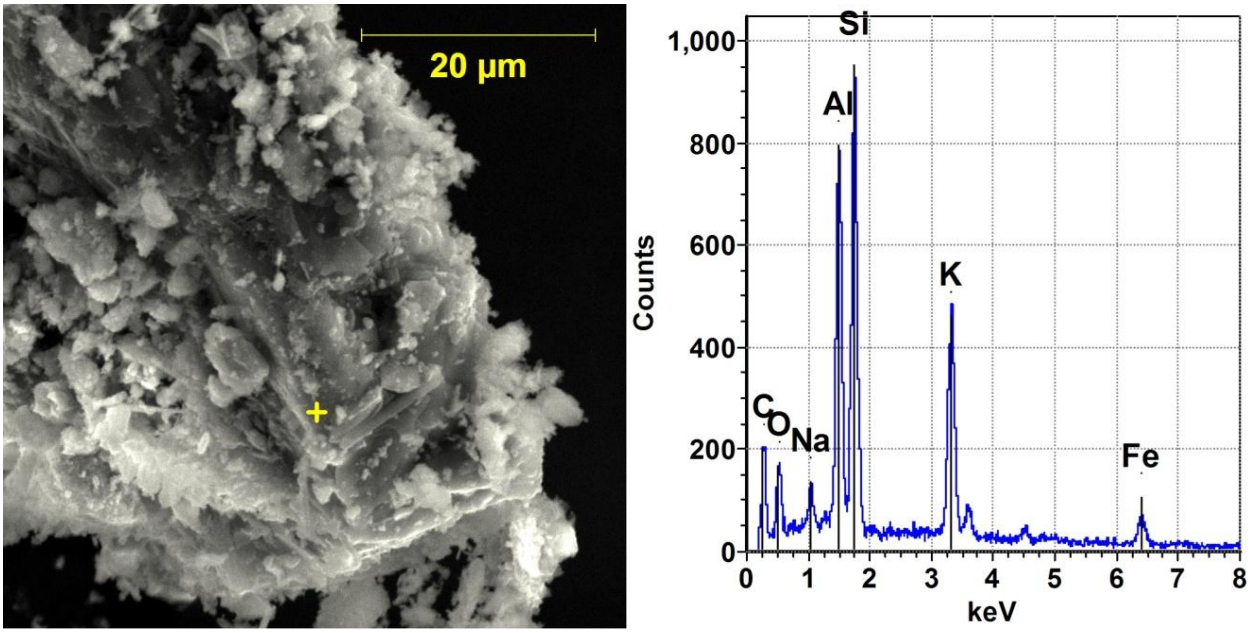


Figure 4-91. Scanning Electron Microscope Photo (left) from Sample and Energy-Dispersive X-ray Spectroscope Spectrum (right) from Spot Marked with a Cross Indicating Potassium Feldspar

The lack of conclusive laboratory data for the mound material leaves its origin open to speculation. However, visual observation of the sampling operations on October 15 and October 17, 2012, and the limited qualitative information provided by the laboratory analysis, indicates that the mound is probably not tank waste. The information supporting this conclusion includes:

- The physical nature and apparent chemical composition of the material are clearly different from the Riser 83 material or the Riser 90 white crystalline cascade material.
- The outer crust is easily broken. The material beneath the crust is granular and easily broken up.
- The location of the mound somewhat away from the refractory, suggests it was not formed by a flow of material from beneath the primary tank.
- The SEM results indicate a mixture of rust and soil with a small amount of a sodium-rich phase. Sampling activity more than likely resulted in cross-contamination that accounts for the tramp sodium.
- The XRD pattern showed no significant peaks for any crystalline phase. Sample material from Riser 83 and the white crystalline cascade from Riser 90 have crystalline phases.
- The sample specimen contained no detectible beta/gamma radiation using the 222-S Laboratory room monitors.
- The material is directly under an active annulus ventilation exhaust outlet. In 1989, when the annulus ventilation system underground ductwork was replaced, both the annulus supply and exhaust duct penetrations were open to the annulus near Riser 90 for the ductwork tie-ins. Soil could have inadvertently entered the penetrations and fallen directly into the annulus (see Figure 3-67 and Table 3-10).

These observations support the conclusion that the mound material near Riser 90 is soil rather than tank waste.

Refractory Slot Crystalline Material

A total of 0.20 g of the refractory slot crystalline material was retrieved during the October 17, 2012 sampling event and sent to the 222-S Laboratory (Figure 4-92). Solid phase characterization (SEM and XRD) was performed and the remaining material was used to perform GEA and ICP analysis.

The solids phase characterization indicated that the sample consisted of pieces of rust and large (up to ½ in.) white particulate that appeared to be aggregates of finer material.

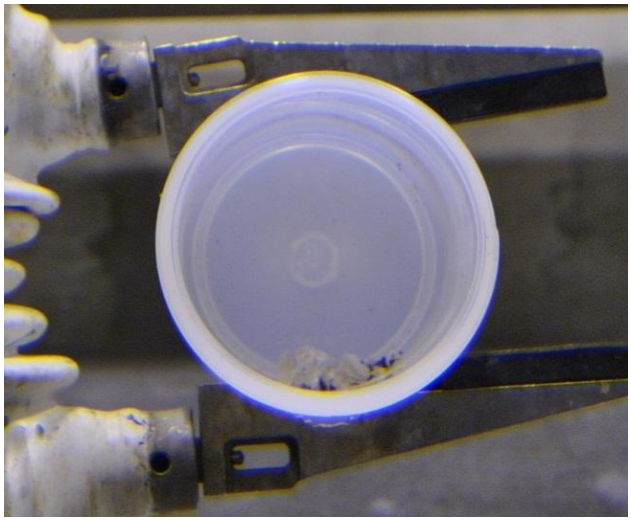


Figure 4-92. Riser 90 Refractory Slot Crystalline Material Sample October 17, 2012 (0.20 g)

The white particulate from the sample consisted entirely of water soluble salts that were consistent with tank waste saltcake or supernatant dissolved solids. However, there are some notable differences between this material and the Riser 83 annulus material. The primary phase was sodium carbonate without waters of hydration. The dehydrated sodium carbonate suggests the material was exposed to elevated temperatures.

After the solids phase characterization analyses were complete, the remaining 0.1 g of ground white material was used for GEA and ICP analyses. During sample preparation for the GEA analysis, it was noted that the sample effervesced very strongly, indicating carbonate content.

The sample chemical and radionuclide results are compared to the BBI Tank AY-102 supernatant and interstitial liquid concentrations in Table 4-25 and Table 4-26.

Table 4-25. Riser 90 Refractory Slot Crystalline Material Sample Chemical Results Compared to Best Basis Inventory

Analyte	Riser 90 Crystalline Sample Average Result (µg/g)	AY-102 BBI Supernatant (µg/g)	AY-102 BBI Interstitial Liquid (µg/g)
Aluminum	9.82E+02	1.51E+04	1.65E+03
Calcium	< 3.70E+02	1.62E+01	1.66E+01
Fluoride	n/a	3.84E+03	3.17E+02
Iron	5.47E+01	7.81E+00	4.83E+00
Potassium	7.15E+03	6.90E+04	2.43E+03
Sodium	3.75E+05	2.73E+05	3.40E+05
Nitrite	n/a	8.85E+04	3.50E+04
Nitrate	n/a	2.40E+05	1.87E+03
Phosphate	3.34E+04	2.98E+03	1.90E+04
Silicon	5.09E+02	2.15E+02	1.14E+02
Magnesium	< 9.26E+00	5.77E+00	4.83E+00

Table 4-26. Riser 90 Refractory Slot Crystalline Material Sample Radionuclide Results Compared to Best Basis Inventory

Analyte	Riser 90 Crystalline Sample Average Result (µCi/g)	AY-102 BBI Supernatant (µCi/g)	AY-102 BBI Interstitial Liquid (µCi/g)
$^{89/90}Sr$	6.88E+00	3.57E-01	7.49E+00
^{137}Cs	4.21E+01	2.62E+02	1.36E+02

The crystalline material chemical results are consistent with both the BBI IL (interstitial liquid) and supernatant estimates for the tank. However, the small sample size creates a large measurement uncertainty, high minimum detection thresholds, and also questions about material representativeness, making side-by-side comparisons problematic at best. An example of this is the nondetectable measurement of calcium.

The higher concentration of sodium and the lower concentration of aluminum in the sample compared to the tank waste have no obvious explanation and could also result from sample representativeness or measurement uncertainty. The higher concentration of phosphate in the sample is unusual, as it is not expected to be present in the refractory and is expected to be at lower concentrations in the Tank AY-102 waste. The elevated silicon seen in the sample material could be due to presence of silicon in the refractory material.

The GEA analysis of the crystalline material is indicative of Tank AY-102 waste. The ^{137}Cs measured in the sample is reasonable due to the retention of ^{137}Cs in the solids and a possible exchange in the refractory, as discussed previously. The ^{90}Sr is more indicative of the interstitial liquid, as it was measured to be higher than what is expected to be present in the supernatant. Small amounts of sludge particulate being transported from the tank with the interstitial liquid could explain the higher levels of ^{90}Sr observed in the crystalline sample.

The sample chemical and radionuclide analyses support the conclusion that origin of the white crystalline material near Riser 90 is tank waste.

4.2.7.4 Secondary Liner Waste Containment Duration Limit

The secondary liner containment evaluation (RPP-ASMT-27062, *Stress Corrosion Cracking Evaluation for the Secondary Liner Exposed to In-Specification Waste in a Double-Shell Tank Annulus)* concluded that, based on Savannah River Site (SRS) testing, a leak of a relatively large volume waste into a DST annulus would not lead to a breach of the secondary liner in the foreseeable future. The SRS experiments were conducted with steels similar in composition to Hanford Site DSTs at 95°C to 105°C in solutions containing adequate amounts of corrosion inhibitors. This testing showed a lack of crack initiation and crack growth, even if it is assumed that cracks are already present in the secondary liner. It should be noted that it was not likely that cracks are present given that the secondary liner had never been exposed to any non-compliant waste or aggressive environment. Anticipated secondary liner temperatures in the event of large leak would much less than the SRS tests, current tank AY-102 maximum waste temperature is about 150°F (65°C).

If the waste remained as a solution and was left in the annulus for an extended period of time, the evaluation noted that the liquid-air interface would become caustic deficient because of reaction with carbon dioxide in the annulus air. The evaluation estimated that eight to 44 weeks would be required for the waste surface to become caustic deficient and support crack initiation, and then three to five weeks for crack growth to penetrate the secondary liner. The time to depletion varied inversely with the leak volume residing in the annulus, and could be extended by shutting down the annulus ventilation system. The evaluation concluded that it would be prudent to pump the waste from the annulus of the leaking DST into a sound DST at the earliest possible opportunity.

Leakage from Tank AY-102 primary tank, as of October, 2012, is estimated to be less than 520 gallons. The liquid on the annulus floor shows evidence of drying or has already dried. The situation does not match the severe leak model used in the evaluation.

4.2.8 Occurrence Reports

Eleven ORs and PERs were found that relate to the Tank AY-102 annulus (summarized in Table 4-27). The most important PERs associated with the annulus are those associated with corrosion and the visual inspections.

Table 4-27. Tank AY-102 Tank Annulus Occurrence Reports (2 pages)

Tank	OR/PER	Origin	Initial	Description	Final
241-AY-102	Occurrence Report 80-37	V	4/3/1980	High vacuum - Tank AY-102 annulus	6/27/1980
241-AY-102	RL-PHMC-TANKFARM-1999-0024		4/12/1999	DST AY-102 CAM anomalous [sic] readings	5/5/1999
241-AY-102	RP-CHG-TANKFARM-2001-0004		1/31/2001	Corrosion observed in DST AY-102 during video inspection and ultrasonic testing	10/4/2001
241-AY-102	RP-CHG-TANKFARM-2001-0065		8/1/2001	Potential unreviewed safety question with respect to power loss to the 241-AY and AZ annulus tank leak detection systems	9/30/2001
241-AY-102	RP-CHG-TANK FARM-2001-0068		8/10/2001	Failure to formally enter LCO 3.2.6 (USQ)	11/18/2002
241-AY-102	RP-CHG-TANKFARM-2001-0106	LL	12/6/2001	Corrosion observed in DST AY-102 during video inspection of the annulus section	5/8/2003
241-AY-102	RP-CHG-TANK FARM-2001-0050	LL	6/21/2001	Tank AY-101, AY-102 annulus CAM discharge air flow into CAM cabinet instead of returning flow to ventilation duct	9/26/2002
241-AY-102	RP-CHG-TANKFARM-2002-0023	LL	2/19/2002	Power pole fire causes loss of electrical utilities to Tank AY-101 and AY-102 annulus ventilation and leak detection systems (USQ)	11/18/2002
241-AY-102	RP-WRPS-TANK FARM-2012-0013	LL	8/20/2012	Video inspection of Tank AY-102 identifies dry material on annulus floor	Update 8/24/2012
241-AY-102	WRPS-PER-2012-1363	LL	8/1/2012	On August 1, and August 5, 2012, a video inspection of the DST AY-102 annulus identified areas containing unidentified material that require additional evaluation. Same issue described in PER-2012-1438	9/17/2012

Table 4-27. Tank AY-102 Tank Annulus Occurrence Reports (2 pages)

Tank	OR/PER	Origin	Initial	Description	Final
241-AY-102	WRPS-PER-2012-1438	LL	8/20/2012	Periodic visual monitoring (via camera) of the DST AY-102 annulus, part of the tank integrity program, identified dry material on the annulus floor. Survey results near the material identified contamination levels higher than expected. From the inspections the condition is stable and the identified material is contained in the secondary tank structure	In process

I	=	visual inspection.	LL	=	liquid level.
CAM	=	continuous air monitor readings.	M	=	miscellaneous.
DST	=	double-shell tank.	USQ	=	unreviewed safety question.
LCO	=	limiting condition for operation.	V	=	vent system.

4.2.9 Leak Volume Estimate

The volume of material discovered on the annulus floor near Riser 83, and the dried material that flowed from the refractory slot near Riser 90 and spread onto the annulus floor between Risers 90 and 86, is estimated in this section. The floor volume is converted to an equivalent liquid volume to determine the size of the tank leak that would be required to present the floor material volumes.

Estimate of Material Volume in the Annulus

The material volume estimate includes material on the annulus floor between Riser 90 and Riser 86, and on the floor near Riser 83. The estimate includes an allowance for material retained in the refractory.

Each volume element has been estimated separately. Both low and high range estimates are provided. The basis of each estimate is as follows:

Low volume range:

1. Dried material filling a ventilation slot at Risers 83 and 90
2. Floor deposit between Risers 90 and 86
3. Floor deposit near Riser 83
4. No waste retention in the refractory

High range:

1. Dried material based on saturation of the refractory concrete, excluding the center air chamber and the 21 in. of the perimeter repair. The saturation zone is a 10-degree “pie” slice at Riser 90 and a 5-degree “pie” slice at Riser 83 based on the observed ventilation slot involvement
2. Floor deposit between Risers 90 and 86
3. Floor deposit near Riser 83

For dried deposits, it is assumed that 10 L of liquid results in 1 L of evaporated, dry residue. The specific gravity of the Tank AY-102 sludge interstitial liquid is 1.15, or equal to about a 15 wt% solution of sodium carbonate. Evaporation of 10 L would leave about 1.5 kg of solid material, with an assumed density of 1.5 g/cc, and a volume of 1 L.

Estimate of Volume Retained in the Refractory (W1) High

Retention of a synthetic supernatant in Tank AY-102 refractory was determined to be:

80 wt% or 39.2 lb/ft^3 (ARH-1833, page 6).

The volume of the refractory "pie" slice is determined by the following:

$$Volume\ of\ "Pie"\ Slice = \left(\frac{Angle\ (degrees)}{360}\right)(\pi)(r^2)(thickness)$$

The refractory radius is 37 ft-3 in. minus the outer 21 in., which was damaged and replaced with reinforced concrete. Therefore:

R (refractory) = 35.5 ft (H-2-64307, H-2-35299).

Less the volume of the center air chamber where R =1.5 ft is the following:

$$Volume\ of\ Center\ Air\ Chamber = \left(\frac{Angle\ (degrees)}{360}\right)(\pi)(1.5\ ft)^2(thickness)$$

Nominal Refractory Thickness = 8 in. = 0.67 ft

Assume 2 pie slices, one at 10 degrees by Riser 90, one 5 degrees by Riser 83, each totally saturated.

Example for 10 degree case:

$$\left[\left(\frac{10\ degrees}{360\ degrees}\right)(\pi)(0.67\ ft)(35.5\ ft)^2\right] - \left[\left(\frac{10\ degrees}{360\ degrees}\right)(\pi)(0.67\ ft)(1.5\ ft)^2\right] = 73.55\ ft\text{^}3$$

The liquid loading is the following:

$$(73.55\ ft^3)\left(\frac{39.2\ lbs}{ft^3}\right) = 2{,}883\ lbs = 1{,}310\ kg$$

Converted to volume using sludge interstitial liquid specific gravity of 1.15 (BBI / core 319/312 sample results from RPP-RPT-44630) is the following:

$$\left(\frac{1310\ kg}{1.15\frac{kg}{L}}\right) = 1{,}139\ L = 301\ gal$$

Thus, the volume of liquid for the 10 degree pie case is 301 gal or ~300 gal (Table 4-28). The total volume would equate to 450 gal of waste retained in the refractory on a wet basis and 45 gal on a dry basis using the 10:1 liquid-to-solid evaporation factor.

Table 4-28. Volume of Liquid

Angle of "Pie" Slice	Volume of Liquid (gal)
5 degrees	150
10 degrees	300
Total	450

Estimate of Volume Retained in the Refractory (W1) Low

In the low estimate, only the ventilation slots are assumed to be filled with waste. The volume in each ventilation slot was estimated to be ~6 gal. This volume would equate to 60 gal of waste using the 10:1 liquid-to-solids evaporation factor. The total in the low estimate for two ventilation slots is therefore 120 gal on a wet basis and 12 gal on a dry basis.

Estimate of Volume in Floor Deposit between Riser 90 and 86 (W2)

Material flowed about 25 ft along the annulus floor from Riser 90 towards Riser 86.

Based on visual observation, the material spread about 21 in. across the annulus, and is estimated to be about ¼-in. deep. The volume is:

$$(25\ ft)\left(\frac{21\ in.}{12\frac{in.}{ft}}\right)\left(\frac{0.25\ in.}{12\frac{in.}{ft}}\right) = 0.91\ ft^3 = 6.8\ gal$$

The volume rounds to 7 gal of dried material. This would equate to 70 gal of liquid.

Estimate of Volume in Floor Deposit near Riser 83 (W3)

The flow of material originates next to the refractory retaining band and extends irregularly for about 2 ft on the floor near Riser 83. Visual observation using the retaining band for reference indicates the material covers an approximate 22-in. long, 6-in. wide area and is about ½-in. thick, the volume is:

$$\left(\frac{22\ in.}{12\ \frac{in.}{ft}}\right)\left(\frac{6\ in.}{12\frac{in.}{ft}}\right)\left(\frac{0.5\ in.}{12\frac{in.}{ft}}\right) = 0.04\ ft^3 = 0.3\ gal$$

The estimated volume near Riser 83 is 0.3 gal of dried material. This volume would equate to 3 gal of liquid.

Estimate of Total Volume

The high and low volume estimates are presented in Table 4-29. The high estimate is dominated by the assumed complete involvement and saturation of the 5 degree and 10 degree pie-shaped sections of refractory. The assumptions are likely to be very conservative, making the high estimate an upper bound estimate.

Table 4-29. Total Estimates of Waste Leaked, High and Low Range, Wet and Dry Basis

Option	Retained in the Refractory (W1)	Floor Deposit Between Risers 90 and 86 (W2)	Floor Deposit Near Riser 83 (W3)	Total Estimated
High estimate (wet basis)	450	70	3	~ 520 gal
High estimate (dry basis)	45	7	0.3	~50 gal
Low estimate (wet basis)	120	70	3	~190 gal
Low estimate (dry basis)	12	7	0.3	~20 gal

The total volume of material on a liquid basis ranges from about 190 gal to 520 gal. The high estimate assumes saturation of two sections of the refractory slab and is conservative.

The total volume of material on a dry basis ranges from about 20 gal to 50 gal based on the 10:1 waste to solids evaporation factor.

4.3 LEAK DETECTION PIT HISTORY AND EVALUATION

4.3.1 Leak Detection Pit Description

The DST leak detection pits (LDPs) are tertiary containment systems designed to collect any liquid draining from beneath the secondary liner. The concrete foundation beneath the secondary liner is slotted and fitted with drain connections at the center, mid-point, and edge of the slab. Tank waste that has breached both the primary tank and secondary liner would accumulate in the foundation slots and drain into the LDP. The leak would be indicated by an increase in the LDP liquid level, and, if installed and operable, and increase in radiation reported by the radiation well detector. In order for a breached secondary liner to be detected the LDP and the foundation drain system must be leak-free, and LDP must maintain a stable liquid level during normal tank operation.

For AY Farm, the 6-in. diameter drain line manifold runs to a 4-ft diameter by 1.5-ft high carbon steel sump tank that is located approximately 62 ft below grade, and below the level of the tank foundation (see Figure 4-93). The tank is equipped with a single 24-in. riser extending to a leak detection pump pit that is located flush with the ground surface. The LDP is also equipped with a separate, closed 6-in. diameter radiation detection well that extends from the surface and terminates adjacent to, but outside the 4-ft diameter tank. The radiation detection well is not currently in service.

The LDPs are ventilated via a 2-in. line connected to the DST annulus ventilation exhaust. The leak detection pump pits are equipped with floor drains. In the AY and AZ Farms, these floor drains are connected to a drop leg in the primary tank. In the other DST farms these pump pit drains are routed back to the LDP riser. Figure 4-94 and Figure 4-95 illustrate some of the design features of the AY Farm LDPs.

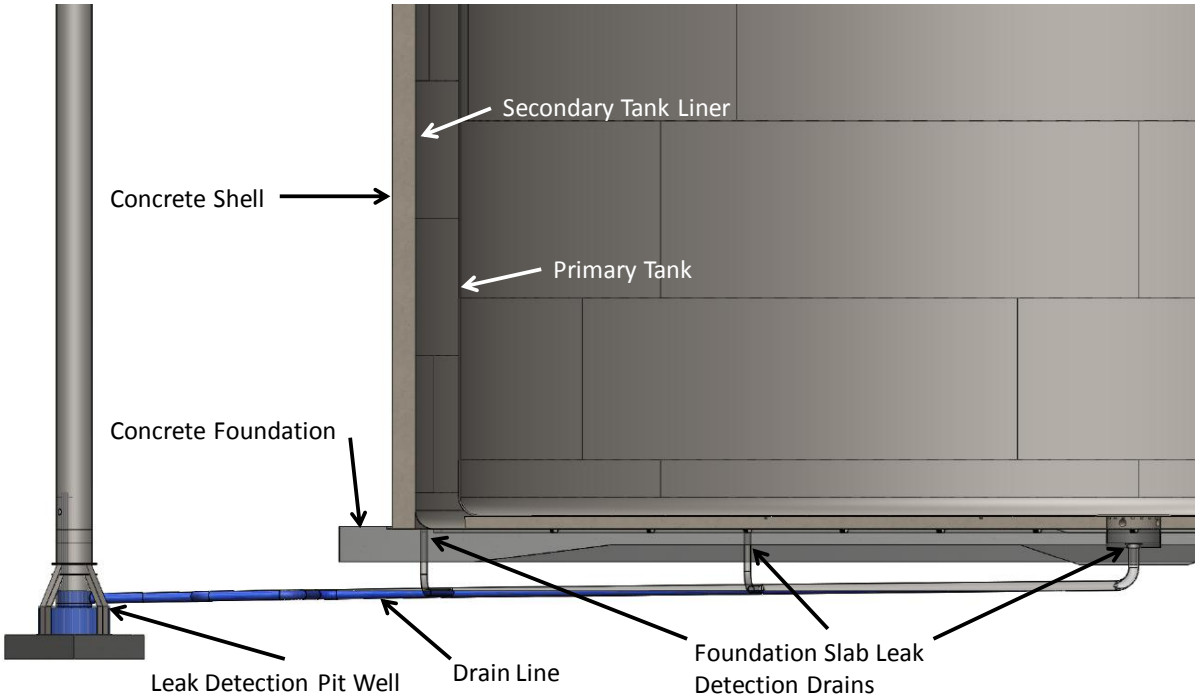


Figure 4-93. General Leak Detection Pit Layout

Figure 4-94. Concrete Base Slabs for AY Farm Showing Drain Slots (8041-1)
(Tank AY-102 in foreground)

Figure 4-95. Leak Detection Pits Riser for the AY Farm Tanks (8160-1)
(Tank AY-102 in background)

The LDP liquid levels in AY Farm were historically monitored using bubbler dip tubes and weight factor instrumentation. Field measurements are currently obtained via a remote level pressure sensor referred to as a "Druck." Levels are read and recorded weekly. It is common practice to add water to LDPs to cover the bottom of the lower, weight factor dip tube (high pressure side) to ensure some backpressure and provide a more accurate level reading.

4.3.2 Leak Detection Pit Operating Specification Limits and Basis

The operating specification (OSD) provides two response levels for the liquid level in the LDPs (see Table 4-30 for AY Farm tanks). The maximum authorized dip tube reading corresponds to the bottom of the inlet drain entering the LDP sump tank from the DST foundation. Exceeding that level will allow water to begin backing up into the drain piping.

Table 4-30. AY Farm Limits for Leak Detection Pit Liquid Level

Leak Detection Pit	Maximum Authorized Limit Dip Tube Level (in.)	Structural Limit Dip Tube Reading (in.)
AY-101A/102A	18	68

Source: OSD-T-151-00007, 2012, *Operating Specifications for the Double-Shell Storage Tanks*, Rev. 10, Washington River Protection Solutions, LLC, Richland, Washington

The structural limit dip tube reading represents the level that corresponds to the bottom of the DST secondary liner, meaning that the drain line is full, the concrete foundation slab is flooded and water is in contact with the bottom of the secondary liner. Complete flooding of the base slab would require large amounts of liquid compared to the volume of the LDP. The foundation drain channels' volume is about 1,100 gal in the LDP, compared to about 140 gal to reach the level of the drain line terminating in the LDP sump tank.

A pit level exceeding the structural limit dip tube reading will hydrostatic uplift pressure on the primary and secondary steel tank bottoms. It will also cause corrosion of the carbon steel secondary liner and the LDP drain piping from contact with the uninhibited water.

It was recognized during project construction that flooding the LDP was a hazardous condition that could damage the tank (ARH-1655, *Hazard Evaluation – PUREX Tank Farm Expansion-Project IAP-614*). At that time, it was recommended that "the water lines to the leak detection pits be blanked when not in use." The piping diagram for Tank AY-102 shows these lines as capped, and similar lines to Tank AY-101 were capped in 1970 (H-2-64406, *Piping Plan TK-102 241-AY Tank Farm*, H-2-64405, *Piping Plan TK-101 241-AY Tank Farm*, Note 8).

Early operating specifications for the AY and AZ Farm tanks did not provide a level limit but stated the level in the LDPs should remain as low as practical and that any increase in liquid level should be reported to the manager of Tank Farms Process Engineering (ARH-1601, *Specifications and Standards for the Operation of Radioactive Waste Tank Farms and Associated Facilities*). Later versions of these specifications provided operational limits for the AY Farm LDP levels of 4-in. minimum and 20-in. maximum with action criteria of an 8-in. change from an established baseline (RHO-CD-213, *Waste Storage Tanks Status and Leak Detection Criteria, 200 East Area, Volume 1*). Later operating specifications specified a maximum level of 79 in. for the AY Farm LDP with the basis given as the level at which the secondary liner is contacted (OSD-T-151-00017, *Operating Specifications for the Aging Waste Operations in Tank Farms 241-AY and 241-AZ*).

4.3.3 Leak Detection Pit Liquid Levels

A few historical records of LDP liquid and radiation levels for Tank AY-102 can be found in RHO-CD-213, *Waste Storage Tank Status and Leak Detection Criteria 200 East Area 1 Volume 1*. Liquid levels ranged from 1.8 in. to high of 15 in. They are typically noted as stable or with a slow increase or decrease. Radiation levels were reported to be in the range of 10 to 20 mR/hr in the 1970s and 0 to 35 cps in the 1980s after new radiation instrumentation was installed in 1981.

Leak Detection Pit liquid level PCSACS data available August 29, 2012 are presented in Figure 4-96 through Figure 4-98. In Figure 4-96, the available liquid level data are plotted versus the primary tank liquid level. Figure 4-97 shows the liquid level data for the period 2006-2009 and Figure 4-98 presents the data for 2010 to present. The data have not been adjusted to the actual liquid level by adding the 2-in. diptube offset.

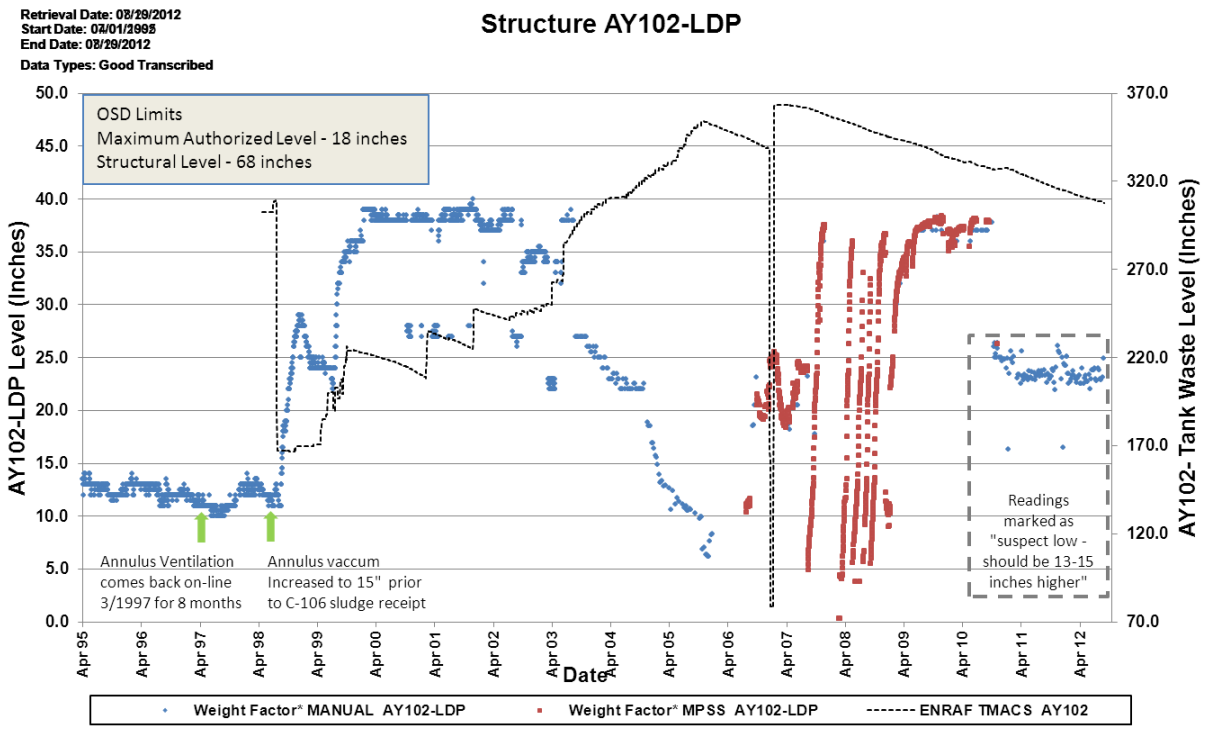


Figure 4-96. Tank AY-102 Leak Detection Pit Level Since 1995 Versus Level in Primary Tank

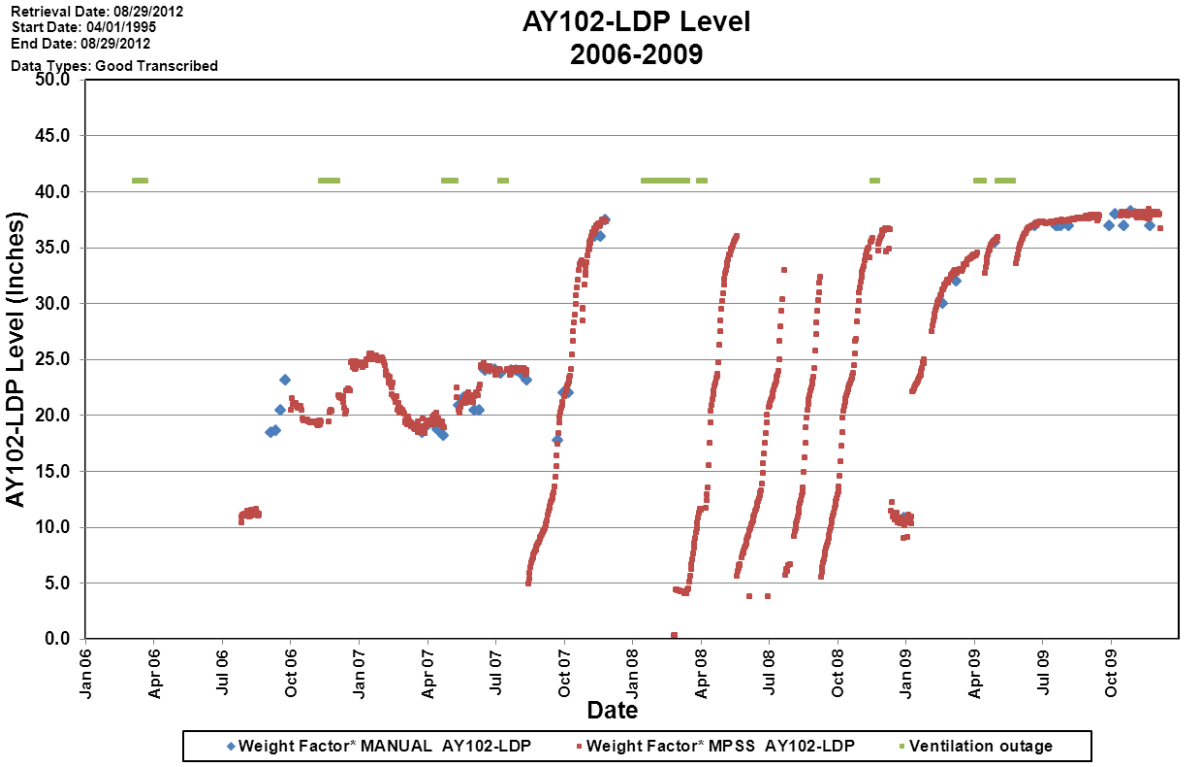


Figure 4-97. Tank AY-102 Leak Detection Pit Level 2006-2009

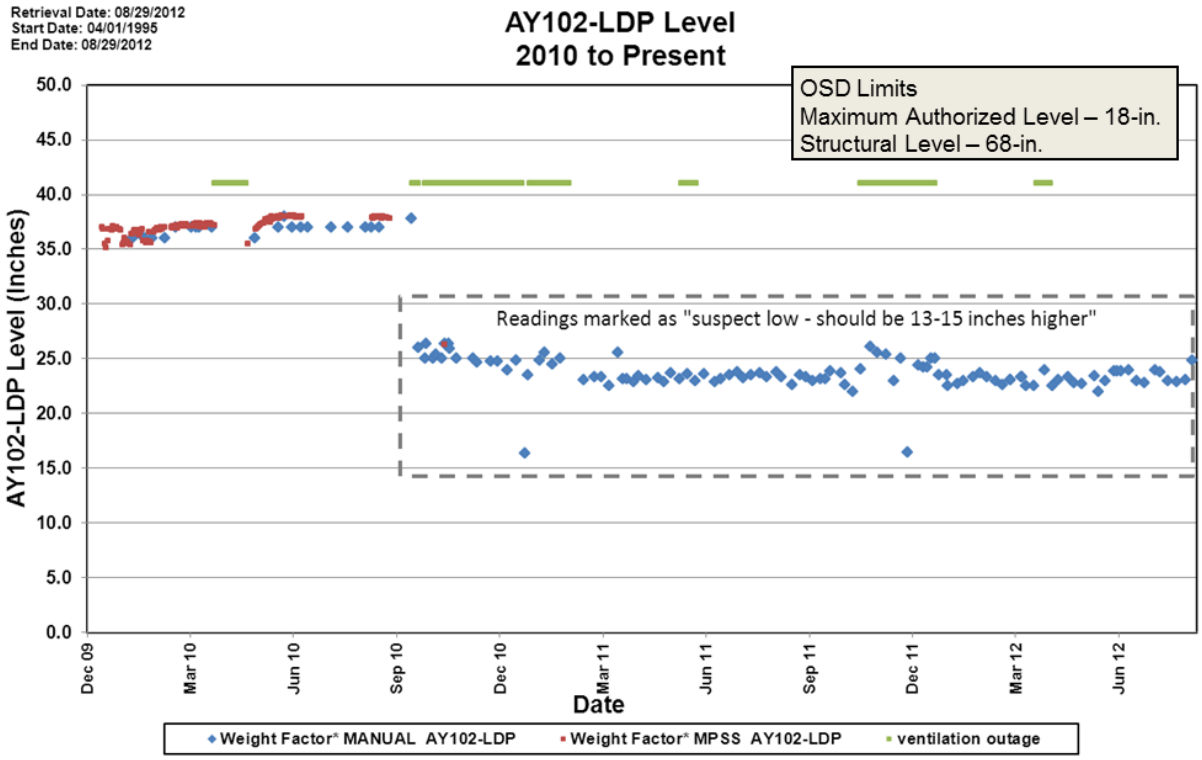


Figure 4-98. Tank AY-102 Leak Detection Pit Level 2010 to Present

For the Tank AY-102 LDP, the following observations are made from the figures:

- The liquid level was low and slowly decreasing from 1995-1998 until the annulus ventilation flow rate was increased for receipt of the Tank C-106 high-heat sludge.
- The liquid level began to increase significantly in 1998 and peaked in 2000 at 39 in. measured (41 in. actual) where it remained for approximately three years.
- The liquid level experienced a slow steady decrease during 2003 - 2006.
- High rates of liquid accumulation occurred during 2007 - 2009. The LDP was pumped several times and immediately re-filled. The accumulation rate ranged between about 1.6 and 3 gal/day.
- The period of 2010 to present is characterized as mostly stable levels. Most data are marked as "suspect low."
- The liquid level has exceeded the OSD maximum authorized level for about two-thirds of the time from 1995 to present.
- Based on the liquid level data, the LDP liquid level has never reached the bottom of the secondary liner.
- Historically, the liquid level increased to about 39 in. (41 in. with the dip tube offset included) and then stabilized. If the liquid level readings are being reported low compared to the actual liquid level, then water could be filling of channels in the base slab.
- The LDP was last pumped in 2009, refilled at the typical rate, and has stabilized at a level of about 23 in. This level is above the OSD maximum authorized limit.
- Between 1998 and 2009 the LDP liquid level increases correlated with annulus ventilation system operation. When the annulus ventilation system was not operating, the level increase stopped. The behavior stopped in 2010.

Prior Investigation of Leak Detection Pit Liquid Level Increases

In 2007-2008, an effort was made to determine the cause of rapid and periodic liquid level increases in the LDPs for Tanks AY-102 and AZ-102. A description is found in Attachment 2 of WRPS-1203624, *Analysis of DST Leak Detection Pit Levels and Determination of Time to Pump Element*. Accumulation rates were reported at an estimated 3 gal/day in Tank AZ-102 LDP and 1.6 gal/day in Tank AY-102 LDP. Later analysis showed the rate in Tank AY-102 as high as 3 gal/day.

Several sources were suspected, including water in the compressed air used to purge the dip tubes, surface water intrusion from snow and rain, leaks from near surface raw water lines, and contributions from the waste tanks. While the instrument air compressors were shut down, level readings were read manually and showed no effect on the accumulation rate.

A correlation was established between annulus ventilation system operation and the liquid level accumulation in the LDP (see Figure 4-99). The LDP liquid level increased when the annulus ventilation was operating and leveled off when the ventilation was shut down. The correlation was shown for both Tanks AY-102 and AZ-102. Leakage from raw water lines was identified as

the possible cause for water intrusion into the annulus of the AY Farm tanks (RPP-RPT-33273, *241-AY-101/ AY-102 Annulus Moisture Intrusion Analysis*).

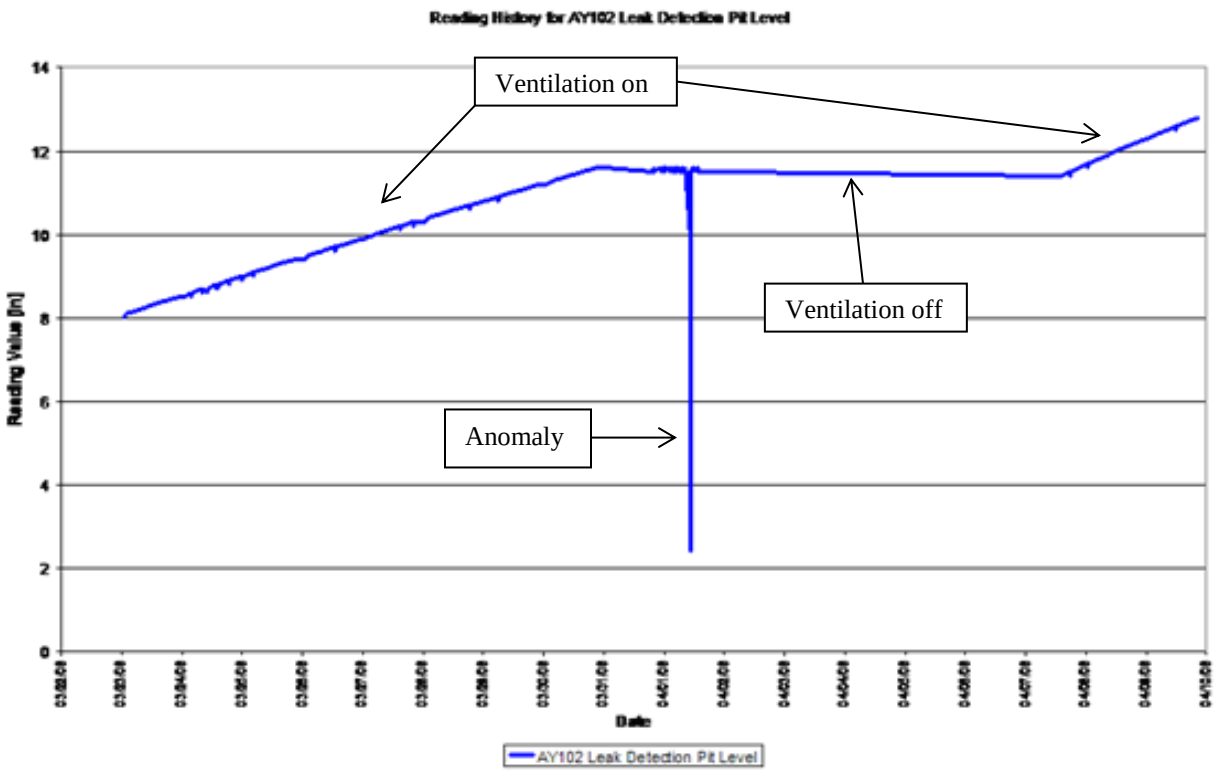


Figure 4-99. Results of Field Test Tank AY-102 Leak Detection Pit in 2008
(Shows LDP level increases correlate to annulus vacuum system operation)

The LDP pump pit drains are a possible source of liquid accumulation. In 2008, the Tank AZ-102 LDP was pumped down and inspected and showed large amounts of water vapor and condensation droplets on cooler pit surfaces. It is postulated that the annulus vacuum which is supplied to the LDP was causing the flow of hot moist air from the primary tank space into the cooler LDP where water vapor condensed to form a standing liquid layer (see Figure 4-100). If the drop leg is intact and submerged, only vapor from the top of the drop leg would be exhausted. If the drop leg has a hole above the liquid level, the vapor flow rate would be greatly increased. This could explain the increases in the LDPs associated with the aging waste tanks but does not explain accumulations in other DST LDPs as they lack this connection to the primary tank space. There are plugs that have been designed to seal these drains; it appears that a drain plug is present in the Tank AZ-102 LDP; however, debris blocks the view of the drain in the Tank AY-102 LDP.

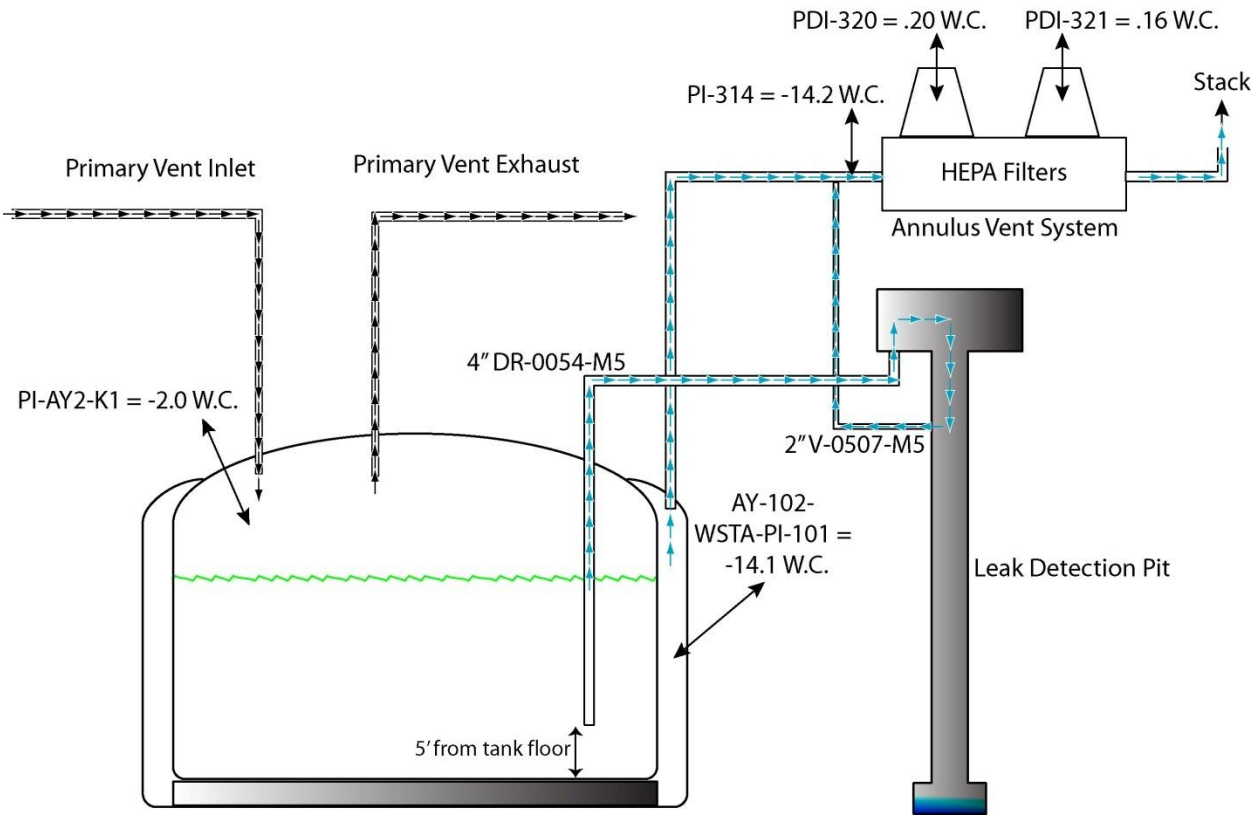


Figure 4-100. Primary-Annulus-Leak Detection Pit Vapor Path Connectivity in Aging Waste Tanks
(Tank AY-102 shown)

It was also suspected that some of the LDPs or the associated drain piping might have leaks because there have been "historic levels" or stagnant equilibrium levels that the liquids rise to and then stabilize for long periods.

Models were developed that showed the height of the reported LDP liquid versus liquid location in the drain system. Figure 4-101 shows the Tank AY-102 model. For liquid levels in LDPs known to have chronic water accumulation, the model can identify the possible leak site.

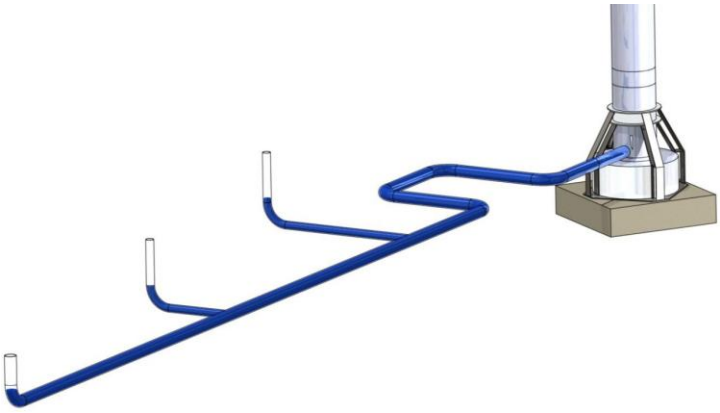


Figure 4-101. Depiction of "Historic Level" for Tank AY-102 Leak Detection Pit at 41 in.

A leak test of the Tank AZ-102 LDP was performed by filling it the historic stable level. The LDP level slowly dropped back to the historic level, suggesting a leak at the historic level for that LDP in either the drain piping or the LDP riser. These activities are described in greater detail in Attachment 2 to WRPS-1203624. A similar leak test was planned for Tank AY-102, but was not performed.

4.3.4 Radiation Detection Well

As discussed in Section 4.3.1, the LDPs have adjacent, but a separate radiation detection well. These wells are no longer used. They were originally equipped with installed radiation detection probes that were monitored in conjunction with the LDP level. In 1997, use of this radiation monitoring equipment was discontinued (USQ-TF-97-0338, *Leak Detection Pit Count Rate Meters*) as greater emphasis and control was placed on primary tank leak detection, such as annulus level alarms, and less on secondary liner leak detection. The LDP liquid level measurement was judged adequate and radiation detection probe use was discontinued.

4.3.5 Leak Detection Pit Sample Results

2007 Leak Detection Pit Sampling

The Tank AY-102 LDP was sampled in 2007 (RPP-RPT-36150, *Final Report for the 241-AY-102A Leak Detection Pit Grab Samples in Support of the Waste Compatibility Program*). Sample results are summarized in Table 4-31. The liquid was determined to be water with radioactive and chemical contamination just above minimum detection levels. These results are similar to other DST LDPs, Tanks SY-103 and AZ-102.

The source of radioactive contamination in Tank AY-102 LDP sample may be cross-contamination from using a contaminated pump, backflow from the leak detection pump pit drain or the vent line inter-tie to the annulus. No source evaluation was found.

Table 4-31. Sample Results from Tank AY-102 Leak Detection Pit Sampling

Date Sampled	12/5/2007
pH	7.92
Appearance	Clear, colorless
Specific Gravity	0.9938
Radioactivity	Uranium, ^{137}Cs and ^{90}Sr above detection levels ^{137}Cs = 6.19 *10^{-4} µCi/ml ^{90}Sr =5.54 *10^{-3} µCi/ml
Other	Very low but detectable sulfate, chloride, and nitrate

Source: RPP-RPT-36150, 2008, *Final Report for the 241-AY-102A Leak Detection Pit Grab Samples in Support of the Waste Compatibility Program*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington

2012 Leak Detection Pit Sampling

The LDP was sampled on September 5, 2012. Two samples were taken at 5 in. below the surface and one sample was taken from the bottom of the sump tank. When the samples were pulled, the liquid was clear and colorless and had a background radiation level. The results and comparison with the 2007 samples are reported in Table 4-32.

Table 4-32. Tank AY-102 Leak Detection Pit Liquid Sample Results- 2007-2012

Analyte	2007 Result	2012 Result
^{137}Cs	Between 3.3 and 6.3 (10^{-4}) µCi/ml	Between 2.2 and 2.4 (10^{-5}) µCi/ml
^{90}Sr	Between 5.5 and 5.6 (10^{-3}) µCi/ml	Between 2.2 and 2.3 (10^{-3}) µCi/ml
pH	Between 7.9 and 8.1	Between 6.6 and 6.9

RPP-RPT-53805, 2012, Fin*al Report for 241-AY-102A Leak Detection Pit Grab Samples in Support of Waste Compatibility*, Washington River Protection Solutions, LLC, Richland, Washington.

The ^{137}Cs is lower by an order of magnitude, the ^{90}Sr lower by about half. The pH of the LDP liquid is reported as just below 7. The pH of the field blank pH was 3.8. The field blank is water prepared by the 222-S Laboratory in sample bottle with the top removed and lowered into the LDP to 2 ft above the liquid surface.

It is suspected that either the sample bottles were contaminated with an acid residual (which could explain the lower pH in all samples) or that the water in the sample blank was already contaminated when they were delivered to the field.

Only trace amounts of ions were detected in the LDP liquid samples. This includes detectable nitrate (about 2 ppm) and detectable sulfate and chloride (both less than 1 ppm).

The low level of radioactive contamination found in the LDP liquid confirms that the liquid source is not tank waste.

During the September 5, 2012 sampling event, the liquid level in the LDP was measured with a zip cord. Based on drawings and calculation, the LDP level would be just under 30 in, which is above the current dip tube level reading and below the "historical level" (see Figure 4-102 for a depiction of the LDP level).

Figure 4-102. Depiction of Tank AY-102 Leak Detection Pit Level Based on Zip Cord Measurement During Sampling
(Calculated as ~30 in. based on zip cord)

A true reading that is above the current dip tube reading could be a hole or leak in the high-pressure leg. A steady level below the historic level could mean a new leak site has developed below the historic level. An inspection performed prior to the pump down indicated that the liquid level was about an inch above the drain line indicating a level of approximately 28 in. At the 28-in. level, the drain line in the LDP riser is submerged by about 1 in. (see Figure 4-103).

Figure 4-103. September 18, 2012 Video of Tank AY-102 Leak Detection Pit After Sampling and Just Prior to Pumpout Showing Drain Line Just Underwater

4.3.6 Leak Detection Pit Water Accumulation at a Constant Fill Rate - Measured and Predicted Liquid Level Increase

During 2008 the LDP experience high rates of water accumulation. The pattern of measured liquid accumulation was compared with the ideal pattern derived from the LDP model described earlier. For the LDP and drain design, and a constant water accumulation rate, the liquid level increase should show a predictable pattern – a steady increase as the LDP sump tank fills, followed by a slower fill increase as water backs up into the nearly horizontal drain pie, and finally nearly unchanged level as the water floods the tank foundation slots. The comparison between the measured increases and the increases predicted by the model for the LDP sump tank are shown in Figure 4-104. Assuming a constant rate of ingress, the ideal fill curve will increase linearly, first until the 47-in. diameter sump is filled and then the rate (fill line slope) will double, but remain linear as the 24-in. diameter riser section is filled.

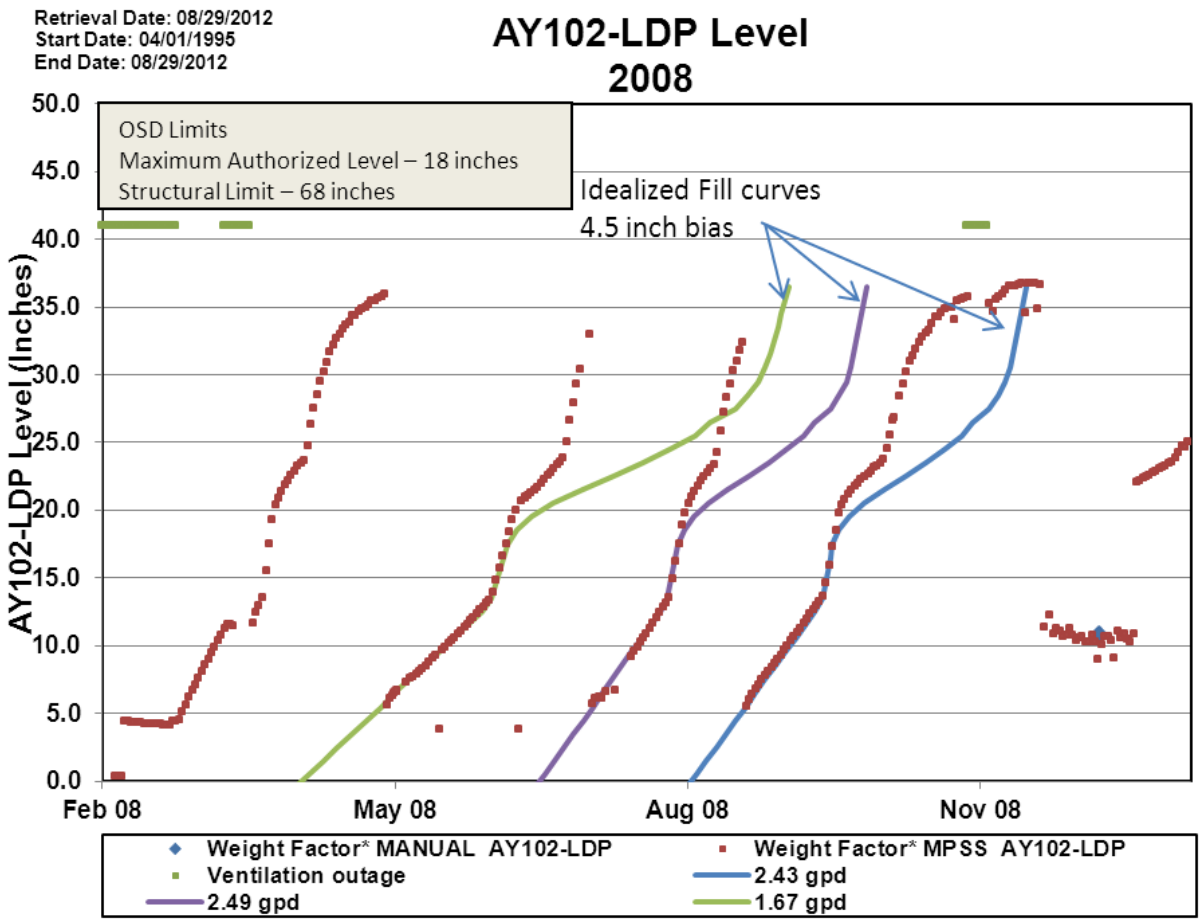
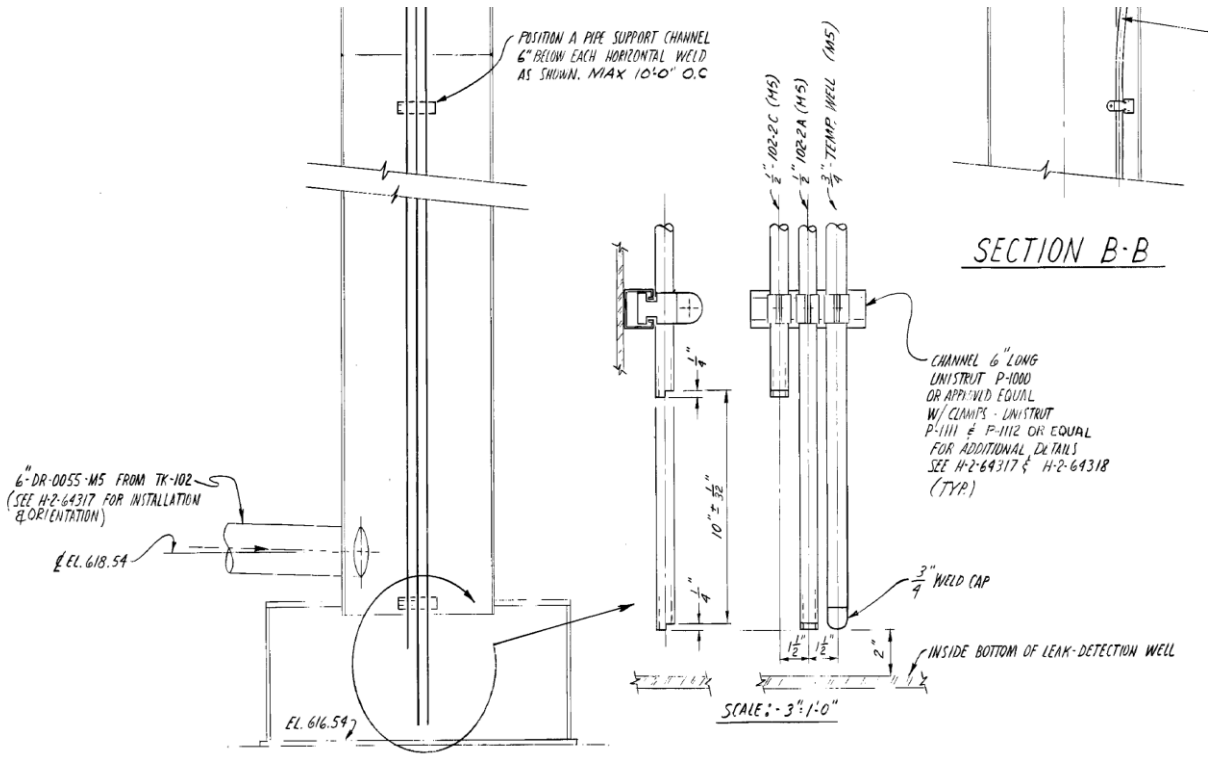


Figure 4-104. Tank AY-102 Leak Detection Pit Level Increase Compared to Ideal Fill Curve-2008

Once the slab drain line begins to fill, the rate should decrease as the drain piping is filled along with the 24-in. riser.

Three idealized fill curves are shown on Figure 4-104, one for each fill cycle. Each ideal curve uses the initial LDP water accumulation rate that was measured in the 47-in. sump section. The first inflection point represents where the 47-in. sump transitions to the 24-in. riser section. A 2-in. negative bias for the idealized fill curve would be expected based on the dip tube offset from the bottom of the sump tank (see Figure 4-105). However, a negative 4.5 in. bias has to be added to each idealized fill curve to get the two lower sections of the idealized fill curve to match the observed level increases.



Source: H-2-64430, 1970, "241-AY Tank Farm Leak Detection Pit Piping Sections and Details (Tank 102)," Sheet 1, Rev. 1, Vitro Hanford Engineering Services, Richland, Washington.

Figure 4-105. AY Farm Leak Detection Pit Sump Tanks and Dip Tube Details Showing 2-in. Offset

Using the offset correction, the match of the ideal fill curve to the actual fill is very good on the two lower portions of the curve, the 47-in. diameter sump and 24-in. diameter riser. The upper portion of the actual fill curve does not match the idealized fill curve and the level rises much faster than the ideal fill curve and drain piping geometry dictate. This could mean the drain piping is partially plugged.

It should also be noted that when the 4.5-in. bias is added to the current level readings for the Tank AY-102 LDP, the result is nearly identical to the level measured with a zip cord during 2012 LDP sampling.

For comparative purposes, a similar comparison was done for Tank AZ-102, the other LDP that showed high rates of ingress during this period. The result is shown in Figure 4-106 for an assumed constant fill rate of 2.9 gal/day.

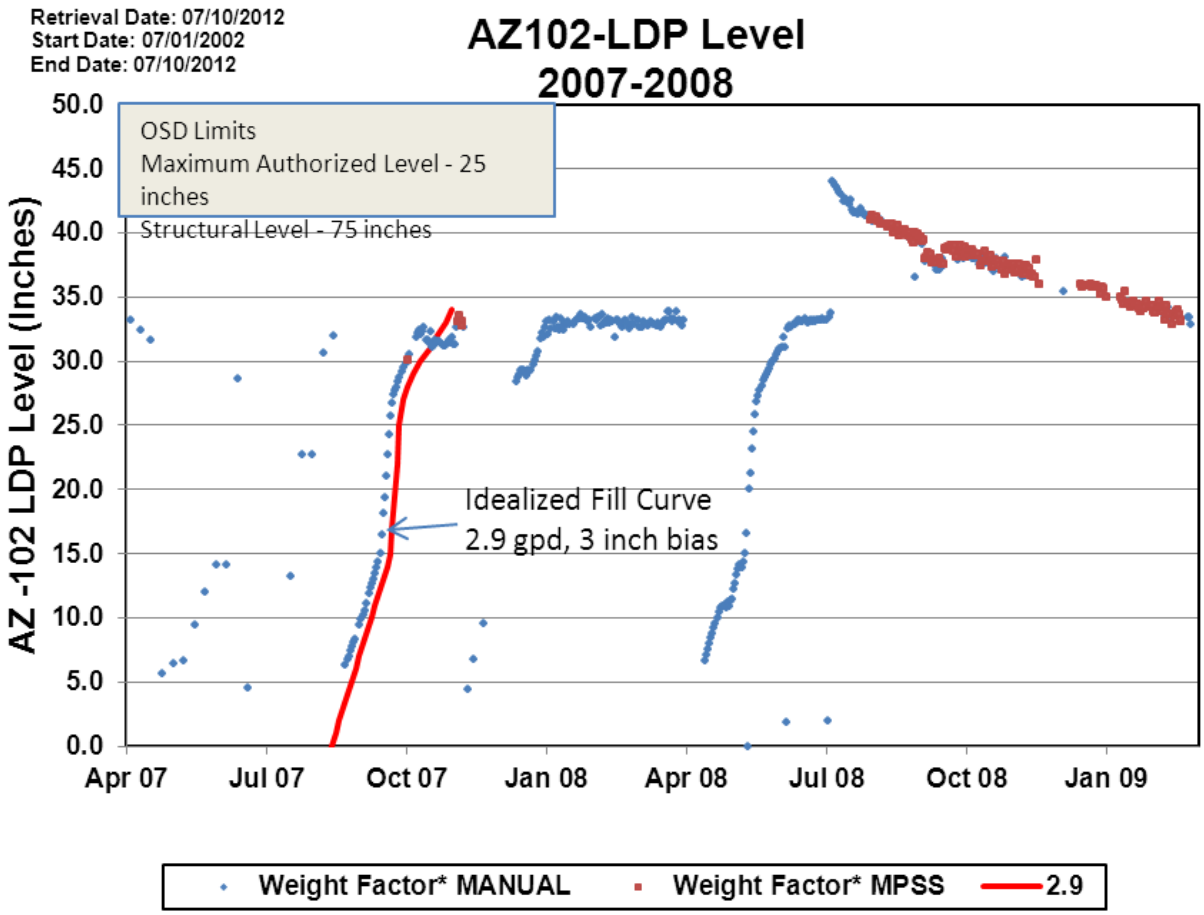


Figure 4-106. Tank AY-102 Leak Detection Pit Level Increase Compared to Ideal Fill Curve-2007-2008

The shape of the Tank AZ-102 idealized fill curve differs from the Tank AY-102 curve because of differences in the LDP geometry. For Tank AZ-102, the vertical distance between the beginning of the 24-in. riser and the drain pipe connection is greater. For Tank AZ-102, the observed fill curve nearly matches the actual fill rate when a 3-in. negative bias is applied.

4.3.7 Inspections of Tank AY-102 Leak Detection Pit

2008 Leak Detection Pit Visual Inspection (from Attachment 2 of WRPS 1203624 [Venetz 2012])

On February 28, 2008 a camera was lowered into the Tank AY-102 LDP riser in order to identify the source of water accumulation and to view the overall condition of the caisson between the at-grade leak detection pump pit and the sump tank, and the foundation drain pipe.

The water source could not be identified. The 2-in. ventilation line that connects near the top of the 24-in. caisson appeared to show some streaking from its penetration point that may be indicative of past water intrusion however, this streak did not appear to be moist during the inspection (see Figure 4-107).

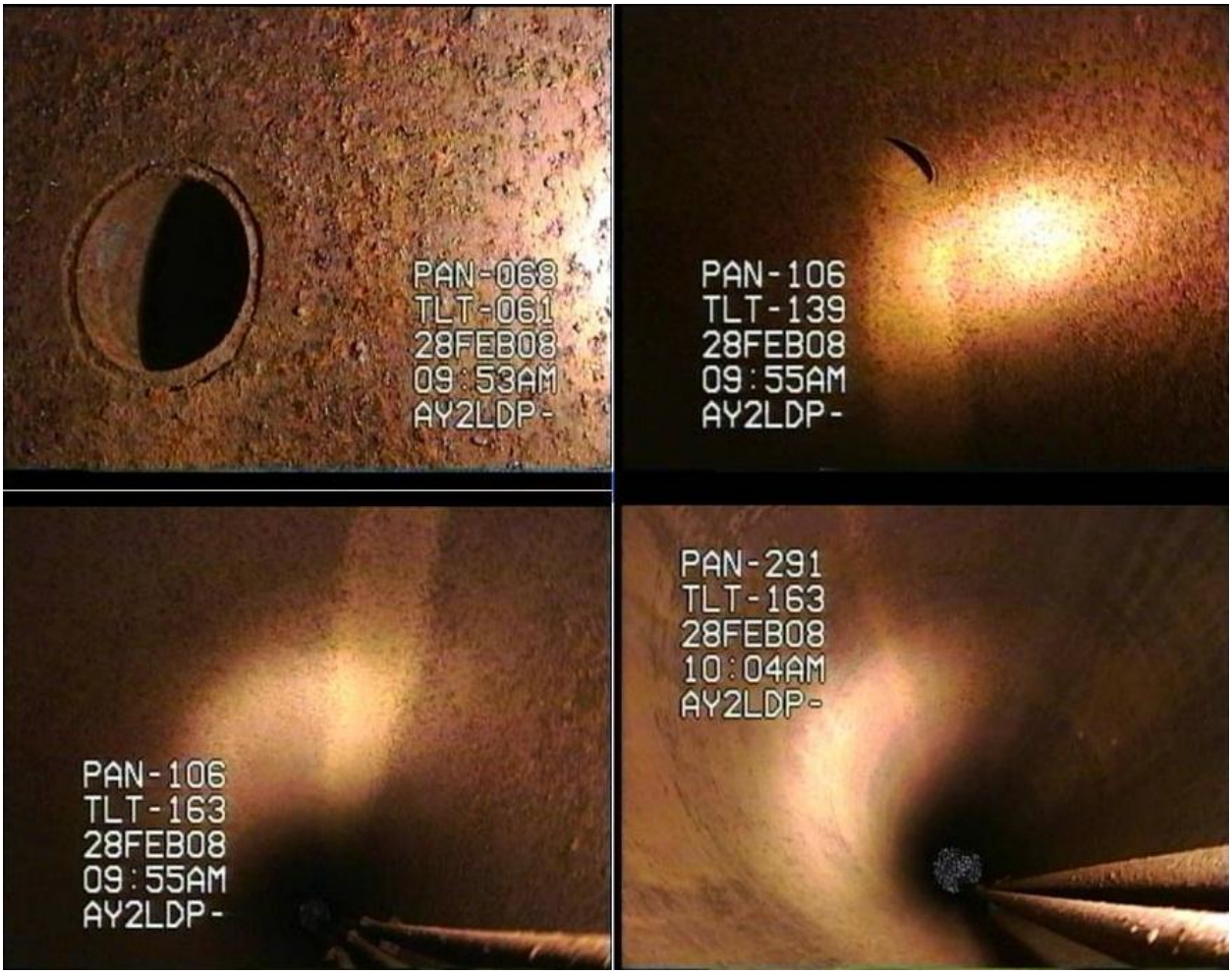


Figure 4-107. Tank AY-102 Leak Detection Pit 2-in. Vent Line (2-in. V-0507-M5) Inspection

The interior surface of the LDP caisson had some corrosion, but the corrosion did not appear to be significant. The integrity of the dip tubes for the weight factor system appeared to be sound with no signs of leakage or condensation out of the reference dip tube located at the top of the 24-in. caisson.

The second area inspected was the 6-in. drain line which carries liquid that may gather at the tank foundation into the LDP. It was thought that there could be a failure in the line at the 41-in. liquid level. The configuration of the drain piping does not allow inspection of that region due to the presence of elbows.

The 6-in. drain appeared to be partially corroded with no signs of severe thinning to the surrounding wall. There was loose debris of unknown origin along the bottom of the drain line (see Figure 4-108). This could potentially be mill scale that has detached from the drain-line or perhaps settlement of debris detached from the lower section of the sump tank that has made its way into the pipe at higher liquid levels. For a drain line which has been submerged for such long durations, the line integrity is in better condition than anticipated.

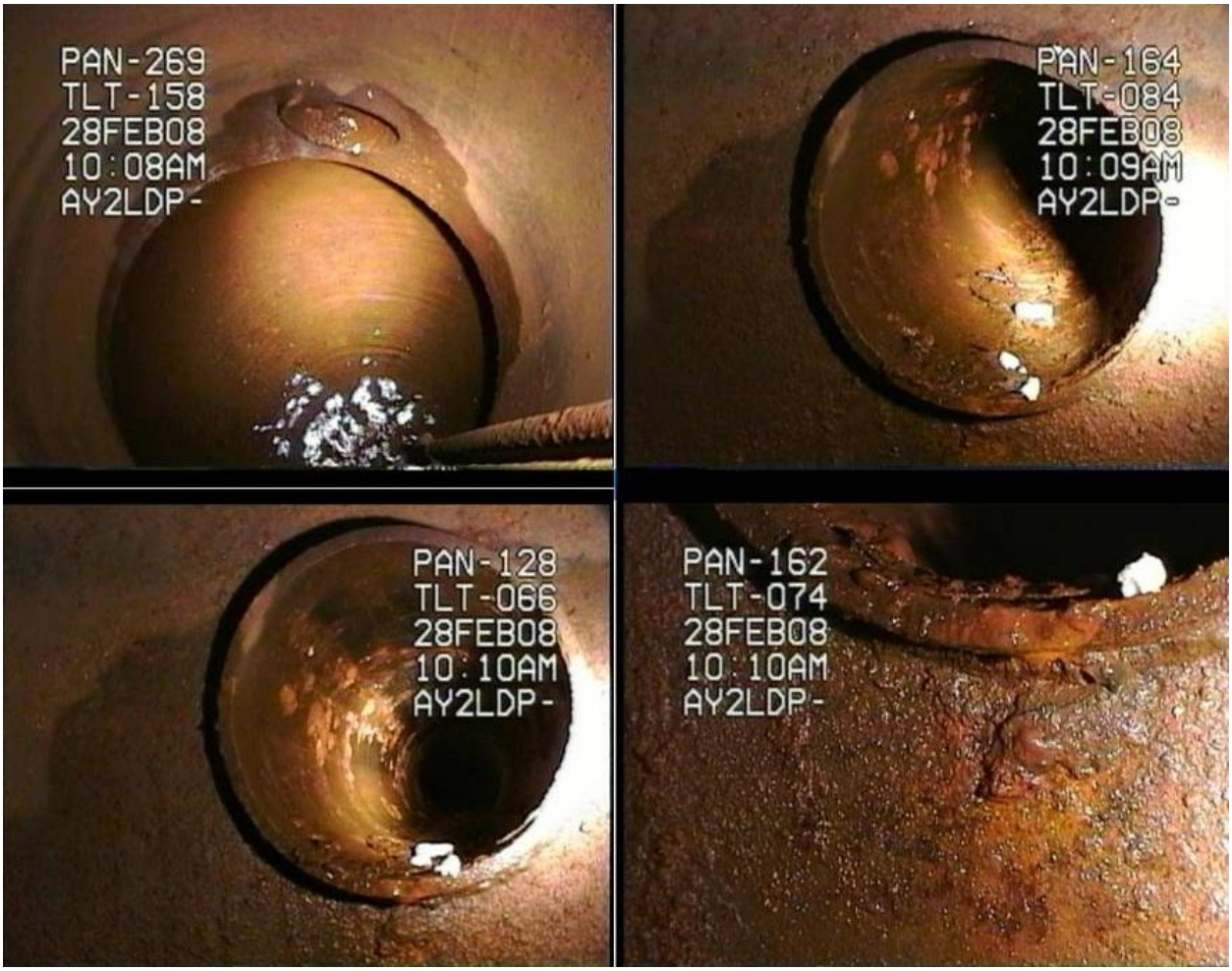


Figure 4-108. Tank AY-102 Leak Detection Pit 6-in. Drain Line Inspection

The 48-in. diameter sump tank at the bottom of the LDP where the majority of the liquid accumulates prior to pumping has been exposed to uninhibited water for very long durations of time (potentially as early as 1970). The amount of corrosion is fairly heavy, however no through wall pitting or penetrations could be detected (see Figure 4-109). Some steel wall thinning has occurred based on the extent of the corrosion. Tubercles have begun to form on the sides of the sump tank. The presence of tubercles is typical of microbial-induced corrosion. The top ring shaped portion of the LDP is in good condition which is attributed to air being trapped as the liquid level increases past the height of the 48-in. diameter sump.

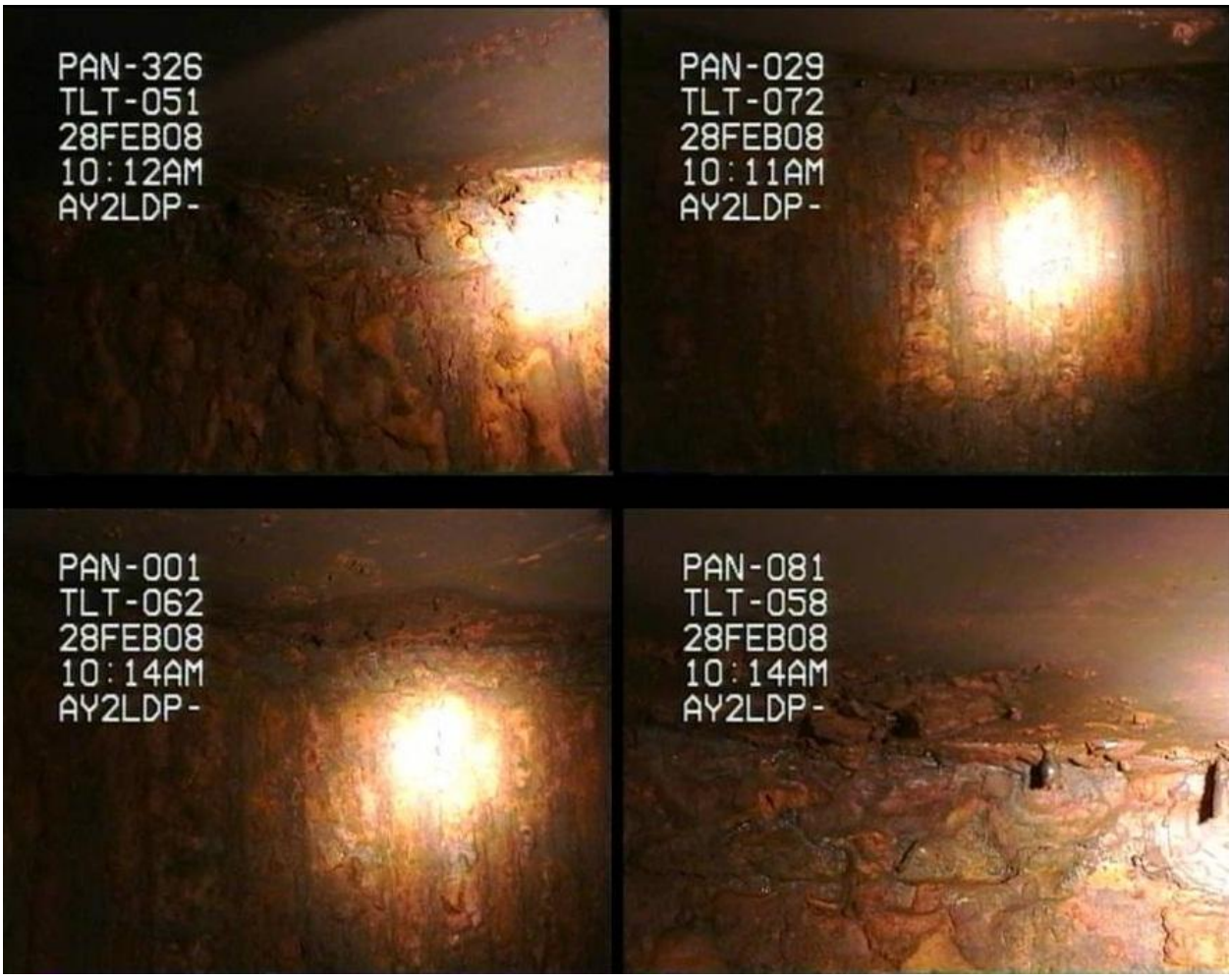


Figure 4-109. Tank AY-102 Leak Detection Pit 48-in. Sump Tank Inspection

2012 Leak Detection Pit Visual Inspection

On September 19, 2012, a camera was lowered into the Tank AY-102 LDP to again attempt to identify the source of water accumulation, and to view the overall condition of the drain line and the sump section. There were clear indications that additional corrosion had occurred on the interior section of the drain. Tubercles have begun to form on the bottom and sides of the drain interior. The presence of tubercles is typical of microbial induced corrosion. Figure 4-110 provides a view of the drain as found in 2008 (Image A) versus 2012 (Image B). Figure 4-111 shows highlighted views of the interior of the drain line. Note that at the end of the viewable drain line in Figure 4-111B, the radius of an elbow can be seen.

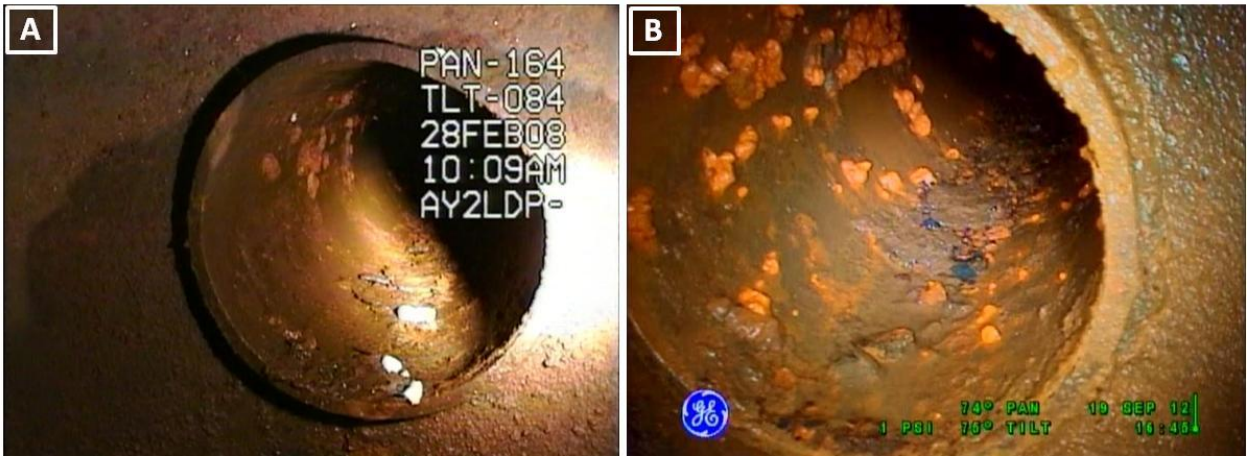


Figure 4-110. Comparison of Tank AY-102 Leak Detection Pit Drain Line Condition in 2008 (A) and 2012 (B)

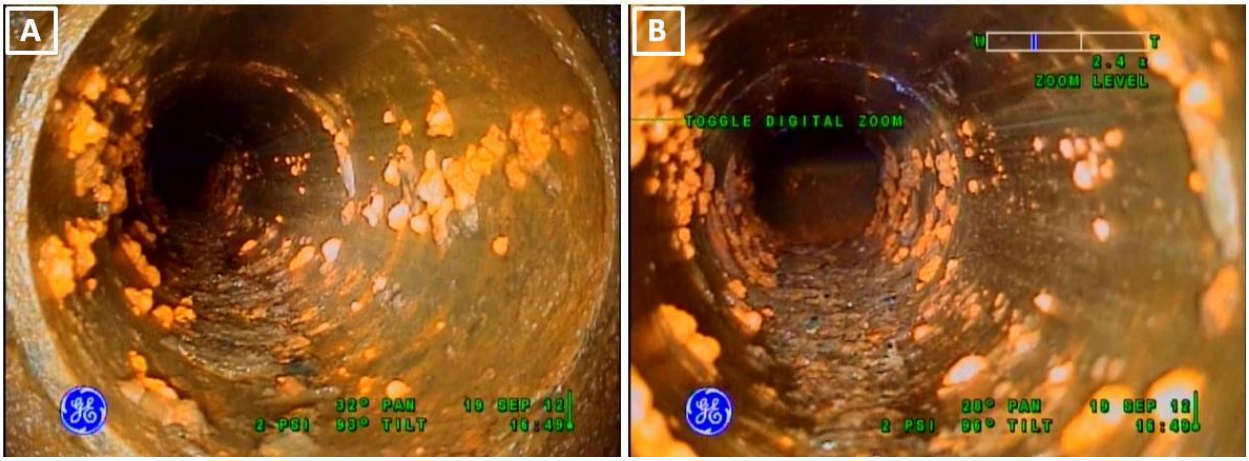


Figure 4-111. Tank AY-102 Leak Detection Pit Drain Line Interior Condition

Figure 4-112 shows a close-up view of the downstream elbow. Note that there appears to be a historic liquid level beach line along the extrados of the elbow. This beach line also seems to correspond with the current stopping point of the concentrated tubercles along the drain line.

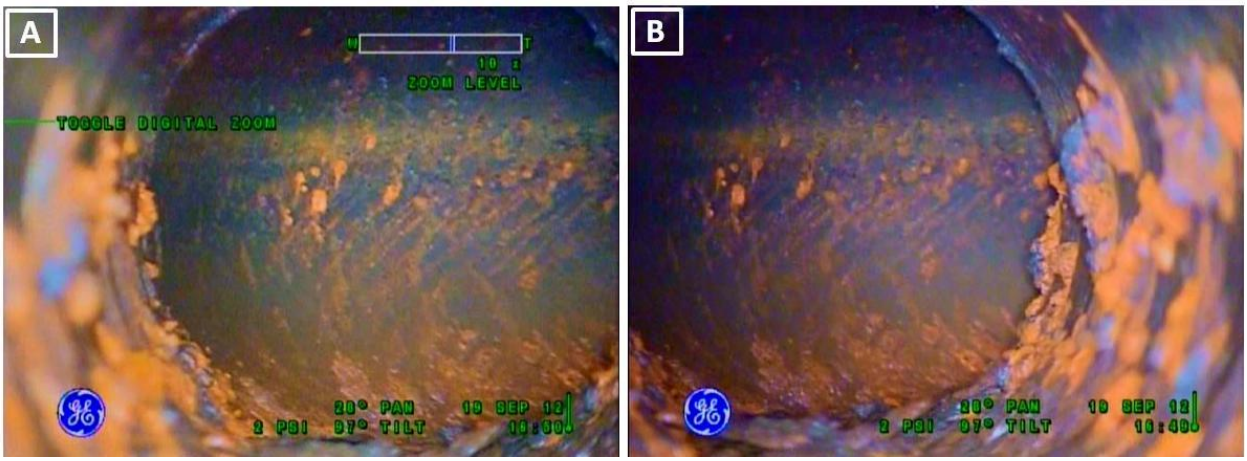


Figure 4-112. Tank AY-102 Leak Detection Pit Drain Line Elbow Condition

Figure 4-113 shows a close-up view of the debris on the bottom portion of the drain line. It is assumed that this debris is either small amounts of dirt, and/or corrosion product.

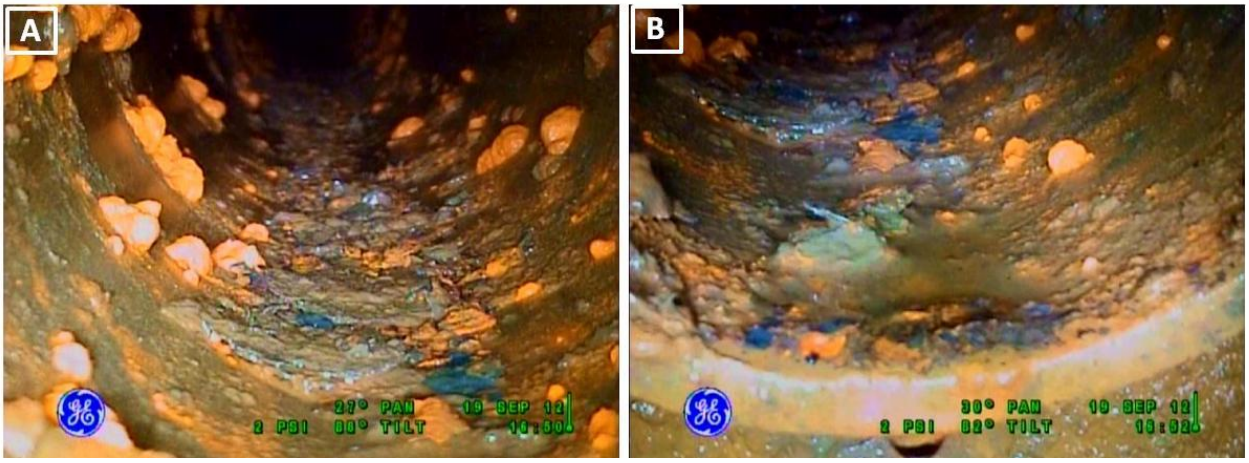


Figure 4-113. Debris along the Bottom of Leak Detection Pit Drain Line

After completing the inspection of the drain line, the camera was lowered toward the 48-in. diameter sump section. Along the 24-in. diameter portion of the well, a few pieces of white material, were observed adhered to the wall. Figure 4-114 provides a close-up view of this white material. It is believed that this material may be part of the alumina-silica ceramic fiber insulation that was installed into the center drain section of the tank foundation during construction and has since been transported into the LDP via the drain line (see drawing H-2-64449, Detail 6, for further description).

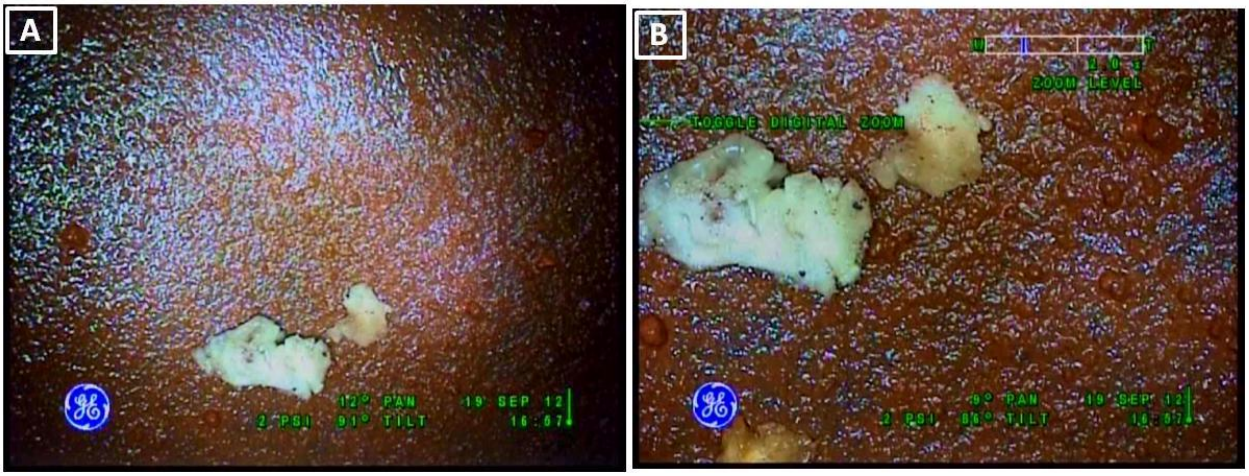


Figure 4-114. White Debris along Leak Detection Pit 24-in. Diameter Pipe Wall

The camera was lowered into the 48-in. diameter sump. No noticeable changes were observed when compared to the 2008 inspection of the same regions. There is still noticeable corrosion product along the sump walls. The top of the sump has limited amounts of corrosion. This is believed to be attributed to the air gap that probably exists between the water and the steel as the liquid increases in height up into the 24-in. diameter section. Figure 4-115 shows views of the sump section from 2012.

As part of the inspection, it was observed that a few hours after the pump down of the LDP sump, the only drips reaching the bottom of the sump were from the drain line. This was to be expected based on the short period of time that had elapsed since the completion of the pump down. The drip rate was estimated to be 10-12 drips per minute (~ ¼ gal per day).

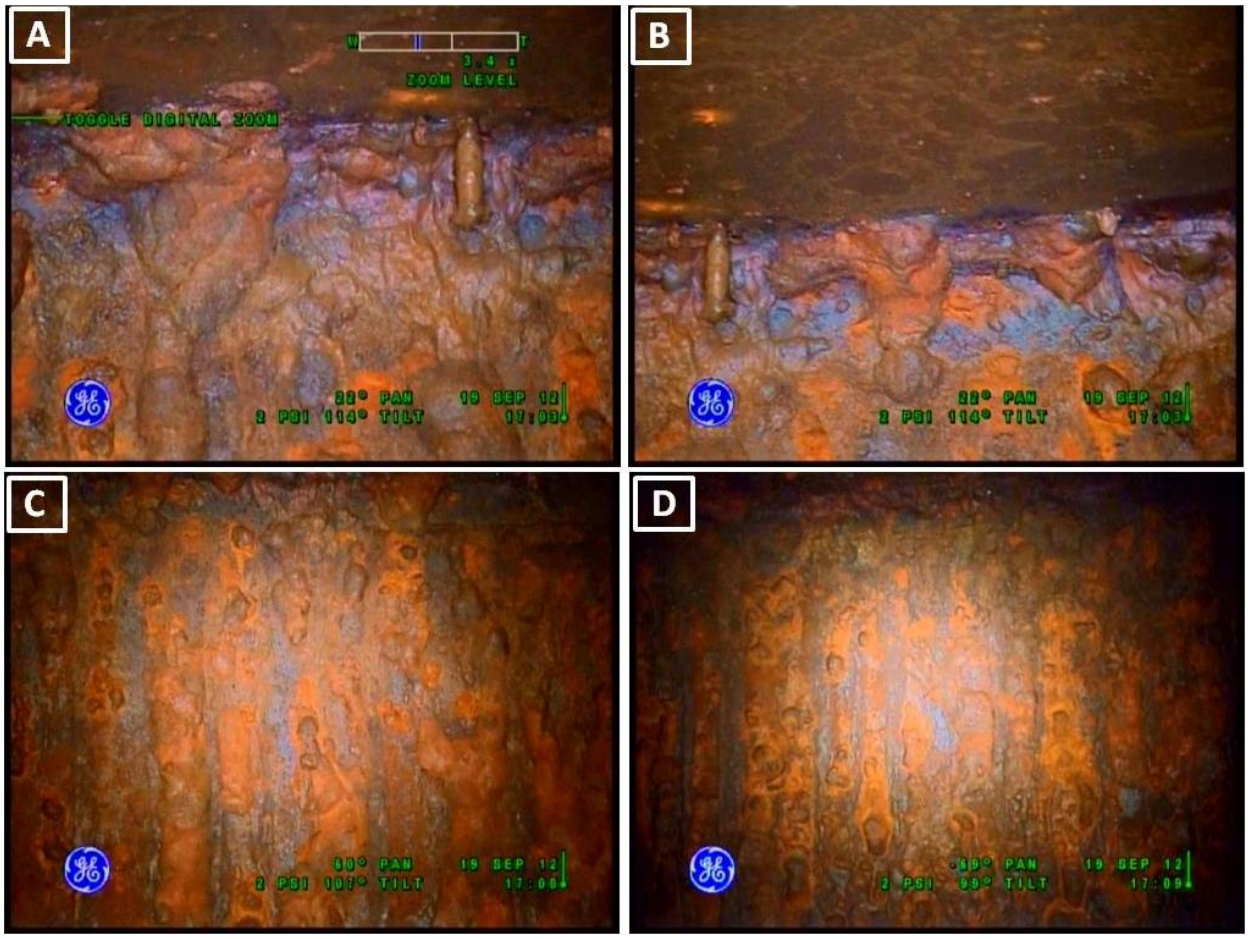


Figure 4-115. Leak Detection Pit 48-in. Diameter Steel Sump Condition

Further observation of the Tank AY-102 LDP took place in the following weeks. On September 24, 2012, a camera was lowered toward the bottom of the LDP. The purpose of the inspection was to attempt to collect evidence on the source of the water intrusion (e.g., leak point in 24-in. diameter well, drips from drain line, etc.). Upon entering the 24-in. diameter section of the LDP, a substantial amount of moisture was visible several feet below the camera (Figure 4-116). This point on the well wall was still greater than 30 ft from the bottom of the LDP.

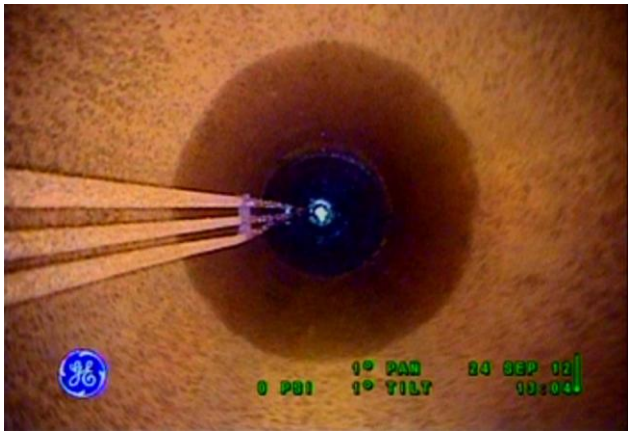


Figure 4-116. Moisture Line on Leak Detection Pit 24-in. Diameter Well Wall Found during Inspection

As the camera was lowered farther towards the bottom, the moisture content and saturated steel walls became more apparent. In the inspection monitoring for locations of dripping liquid, the results were inconclusive. While there were drips coming from the drain line leading toward the tank foundation, there were just as many falling from the bottom of the 24-in. diameter well

wall perimeter with no correlation to the drain line location. Based on the evidence, it was hypothesized that the annulus ventilation system is drawing moist air into the LDP, and as the air is drawn towards the 2-in. vent line towards the top of the pit, it condenses. During the investigation for the cause of the liquid accumulation, the liquid level increased at a rate of 2-3 gal/day, which is consistent with historical increases in the Tank AY-102 LDP.

An additional inspection was conducted on October 18, 2012 to determine whether or not the source of moisture was moist airflow through the 6-in. LDP drain line. A plastic ribbon/flag was placed along the camera and lowered into the LDP. When positioned in front of the drain line, the indicating flag raised up and away from the drain line indicating the airflow. At the time of this test, the annulus ventilation system indicated a -12.0 in. vacuum and the riser at the top of the pit was sealed to maximize the vacuum in the leak detection pit. Figure 4-117 provides the results of the test.

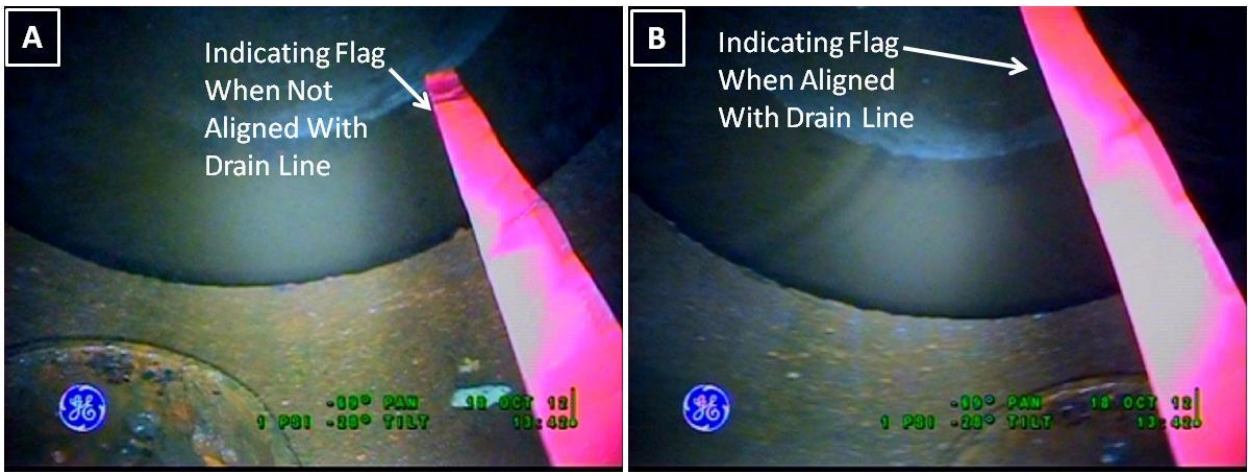


Figure 4-117. Tank AY-102 Leak Detection Pit Drain Line Airflow Test

Based on this evidence there is a high likelihood that air is being drawn from the underside of the tank, however the source is indeterminate.

4.3.8 Occurrence Reports

Seven PERs were found that relate to the Tank AY-102 LDP (see Table 4-33) and LDPs of other DSTs with similar behavior. One of the PERs deals with the vent system and the possible implications involving the LDP liquid level. All of the other PERs are directly related to the LDP liquid level.

Table 4-33. Tank AY-102 Leak Detection Pit Problem Evaluation Request

Tank	PER	Origin	Initial	Description	Final
AW Farm	PER-2004-1059	V	2/24/2004	Open or partially open vent line valve resulting in leak detection pit vacuum possible enhancing water intrusion (AW Farm added for comparison).	3/2/2004
AY Farm	PER-2004-2104	LL	4/13/2004	Leak detection pit liquid level above normal instrument range.	4/16/2004
AY Farm	PER-2004-2923	LL	5/25/2004	Out-of-specification leak detection pit liquid level and failure to reinstall radiological shield plugs after taking radiation readings.	11/30/2006
All Farms	PER-2005-3032	LL	8/19/2005	Delayed pumping of several leak detection pit liquid level above normal operating limits or out of specification.	11/16/2005
241-AZ-102	CH2M-PER-2007-1199	LL	7/12/2007	The AZ-102 leak detection pit liquid level increase. Likely cause is a small water line leak (Tank AZ-102 added for comparison).	4/3/2008
241-AY-102	CH2M-PER-2007-1975	LL	10/30/2007	The AY-102 leak detection pit is increasing by ~1.6 gal/day. The pit has been apparently increasing since the pit was pumped out on 8/14/2007. The current level is now ~33 in., which exceeded the OSD limit of 20 in. on 9/28/2007.	11/3/2008
241-AY-102	WRPS-PER-2010-0350	LL	2/17/2010	241-AY-102 leak detection pits exceeded the maximum authorized limit of 18 in. in January 2009.	8/19/2010

V = vent system configuration.
LL = leak detection pit liquid level control.
OSD = operating specification document.

4.3.9 Conclusions

Water accumulation in the Tank AY-102 LDP and other DST LDPs is a chronic problem. The water level has exceeded the OSD maximum authorized level for many years and exposed the drain piping to standing water for long periods. The LDP level does not appear to have exceeded the structural limit exposing the base concrete or secondary liner bottom to prolonged contact with uninhibited water, based on available LDP liquid level readings. There are however questions about the accuracy of the reported liquid level readings.

Water accumulation in the Tank AY-102 LDP became a more chronic problem after the annulus vacuum was increased and the tank received Tank C-106 sludge in 1998. The LDP level would continually rise to a historic level of 41 in. (39 in. indicated) and appear to stop. The Tank AY-102 LDP foundation drain could have leaked at this historic level; the 41in. liquid-air interface is well upstream of the LDP drain termination and not accessible with existing inspection equipment.

Before 2010, water accumulation in LDP level correlated with annulus ventilation system operation. Since 2010 the LDP liquid level has stabilized at a reported 23 in. Based on zip cord measurements taken during 2012 sampling, the LDP liquid level was about 30 in. and about 2 in. above the top of the drain line inlet to the LDP riser prior to the pump down.

The 2008 and 2012 samples confirm that the pit is filling with water, not tank waste.

There is no evidence that sufficient water has accumulated in the LDP to reach the tank foundation drain slots or the bottom of the secondary liner.

4.4 REGULATORY NOTIFICATIONS

Environmental notifications and environmental log book entries from 1999 through 2012 were reviewed to identify events or conditions that may be associated with suspected waste material in the Tank AY-102 annulus region (see Appendix E). Notifications and log book entries describing Tank AY-102 events were reviewed for leak detection alarms, annulus CAM alarms or samples, tank primary ventilation shutdown, tank annulus ventilation shutdown and annulus stack (A-19) record sampler issues. Approximately 200 Environmental log and notification entries associated with Tank AY-102 during the 1999 to 2012 were screened to identify events or conditions that appeared to be indicative of a contamination event in the annulus or could be a contributing factor to annulus contamination. These notifications and log entries are shown in Table 4-34. In summary, the regulatory notification review found the following:

1. June 6, 2012 – ENRAF 152 (Riser 90) displacer wire broke during repair
2. November 9, 2011 – Tank AY-102 annulus exhauster HEPA filter, 2 of 8 filters failed efficiency test
3. October 26, 2011 – Annulus CAM alarm due to high radiation, preliminary GEA results indicative of radon and ^{137}Cs
4. October 13, 2011 – ENRAF 152 was discovered (on 10/09/2011) reading above expected operating range
5. March 2003 to May 2004 – 12 notifications for Annulus exhauster A-19 shutdowns
6. CY 1999 to CY 2012 – More than 60 notifications for unplanned primary tank exhauster shutdown without log entry of annulus exhauster shutdown

The coincident issues of CAM alarm and ENRAF leak detectors that were identified between October 13, 2011 and October 26, 2012 provide indication of an event within the annulus of Tank AY-102. Other environmental notifications and log entries that provide indications of possible annulus contamination events included:

- 2011 annulus HEPA filter penetration test
- 60+ unplanned shutdowns of the primary exhauster that may have allowed tank vapor movement into the annulus.

The 2004-2012 annulus exhauster notifications were included in this review under the premise that extended periods without annulus exhaust could have led to vapor condensation in the annulus and/or heat stress of the primary tank.

Table 4-34. Environmental Notifications for Tank AY-102 (4 pages)

Date	Notification Number(s) / Log Entry	Description
CY2012	Multiple numbers[b]	Ten logged notifications for A-42 Vent System unplanned shutdown
6/6/2012	TOC-ENV-NOT-2012-0053	Tank AY-102, the AY-102-WSTA-LDT-152 DST annulus ENRAF[a] was identified out of service on 3/10/2012 with a required repair date of 6/8/2012. During planned repairs conducted 5/24/2012 the ENRAF displacer wire broke and the displacer and wire fell into the annular space. A video camera entered into the annulus June 4, 2012, identified the displacer in a location that would interfere with the performance of the ENRAF. The majority of fallen wire was removed but attempts to retrieve or move the displacer from the bottom of the annulus were unsuccessful. Due to the additional recovery actions needed, the ENRAF is expected to be repaired after the 90 day due date of June 8, 2012. The exact completion date is dependent on the ability to move or retrieve the displacer. A discussion was held via phone call between the Base Operations Environmental Compliance for Team AZ and the Ecology DST permit writer late in the day on 06/05/2012 concerning the events leading up to this required notification.
CY2011	Multiple numbers[b]	Eight logged notifications for A-42 Vent System unplanned shutdown
10/13/2011	TOC-ENV-NOT-2011-0012	(AY-102, AY102-WSTA-LDT-152) DST AY-102 annulus ENRAF[a] 152 was discovered reading above the expected operating range on 10/9/2011. The other two annulus ENRAFs were both within the expected operating range and ENRAF 152 was declared out of service. During maintenance and troubleshooting work conducted on 10/12/2011, the ENRAF 152 displacer was discovered to be visually wet and weighing more than expected. Rainwater intrusion is thought to be the cause of the wetness. A video will be taken of the annulus space near this ENRAF and additional maintenance work will be planned to restore the ENRAF to normal operations.
10/26/2011	Log entry	AZ team day shift manager reported the 296-A-19 AY-102 annulus stack was shutdown in response to the AY-102 annulus leak detector CAM alarming. The WRPS radiological control count room located a MO997 performed GEA analysis of the annulus leak detector CAM and preliminary results appear to be radon progeny and ^{137}Cs.

Table 4-34. Environmental Notifications for Tank AY-102 (4 pages)

Date	Notification Number(s) / Log Entry	Description
11/9/2011	TOC-ENV-NOT-2011-0022	296-A-19, 241-AY-102 Annulus, Aerosol testing of the HEPA filter identified two of eight filters providing less than required removal efficiency of 99.95%. The HEPA filters consist of two stages of filters in a 2 high by 2 wide arrangement of individual HEPA filters per stage. One filter in the first stage achieved a 99.86% removal efficiency. One filter in the second stage achieved a 99.944% removal efficiency. No spread of contamination was found following the filter testing. Operations secured the exhauster at 1125 hours and subsequently closed a damper upstream of the HEPA filters. Work documents are being prepared to replace the filters that failed the aerosol test. A review of recent operator rounds showed steady, acceptable, differential pressure readings across each of the HEPA filter stages. A review of the previous aerosol test for these filter stages showed all filters passing at a 99.998% removal efficiency. Background: The 296-A-19 241-AY-102 annulus exhauster provides ventilation of the secondary containment area around the 241-AY-102 underground waste storage tank. Air to the annulus area provides for tank cooling and removal of condensation to minimize corrosion. There is no stored or measurable volume of waste inventory in the annulus.
CY 2010	Multiple numbers[b]	12 Logged notifications for A-42 Vent System unplanned shutdown
CY 2009	Multiple numbers[b]	Eight Logged notifications for A-42 Vent System unplanned shutdown
4/10/2009	WRPS-0900200	Tank AY-102, at 1530 on 4/10/09, the 241-AY-102 annulus leak detector (LDT-151) is out of service. ENRAF[a] and two remaining annulus leak detectors are operating.
CY 2008	Multiple numbers[b]	13 Logged notifications for A-42 Vent System unplanned shutdown
1/28/2008	Log entry	At 1120, WFO called to say that the AY-102, Riser 88, Annulus ENRAF[a] is out of service leaving one serviceable ENRAF.
1/31/2008	Log entry	Notified the AY-102 Annulus Leak Detector 151 is back in normal range and is being declared back in service.
8/13/2008	Log entry	Notified by shift that the AY Annulus 102 Conductivity Probe on Riser 91 was found out of range on height. Range is 0.11 - 0.19, Probe found at 0.20, Probe was taken out of service 90-day clock.
11/24/2008	Log entry	Base Ops Shit Office reports AY-102 Annulus ENRAF, which was restarted to service on 11/21/08, is now reading out of range.
CY 2007	Multiple numbers[b]	Five logged notifications for A-42 Vent System unplanned shutdown
CY 2006	Multiple numbers[b]	Nine logged notifications for A-42 Vent System unplanned shutdown

Table 4-34. Environmental Notifications for Tank AY-102 (4 pages)

Date	Notification Number(s) / Log Entry	Description
CY 2005	Multiple numbers[b]	Eight logged notifications for A-42 Vent System unplanned shutdown
CY 2004	CH2M0401623	One logged notification for A-42 Vent System unplanned shutdown
5/1/2004	CH2M0401332	296-A-19 AY102 annulus power was found off
5/3/2004	CH2M0401334	196-A-19 & 18, AY Annulus shutdown twice due to seismic switch. Will keep shutdown due to need to "jumper" the switch. Engineering is evaluating.
5/4/2004	CH2M0401336	241-A-18 & 19 AY Annulus stacks shutdown due to a faulty seismic switch
5/10/2004	CH2M0401343	296-A-19 Pressure Differential Indicator gauge found out of annual calibration. Emission unit shutdown until calibration can be completed. Last calibration 2/10/03.
5/20/2004	CH2M0401346	296-A-18 & 19 shutdown due to seismic switch trip. 296-A-18 and 296-A-19 exhaust the Tank AY-101 and 102 annulus. No contamination spread.
6/3/2004	CH2M0401348	Notified by shift that 296-A-19 shutdown due to a faulty seismic switch. Exhauster was restarted at 0826. No spread of contamination or personnel.
6/4/2004	CH2M0401613	Notified by shift that 296-A-19 shutdown due to a faulty seismic switch trip. No spread of contamination or personnel.
8/22/2004	CH2M0402274	The 296-A-19 vacuum pump for the AY B Train annulus record sampler went down during rounds on 8/22/04. Called at 1100 hours.
11/15/2004	CH2M0403101	At 2040 the 296-A-19, AY102 annulus exhauster went down. Cause unknown. Exhauster was restarted at 2111. Possible cause seismic controller switch problem.
12/7/2004	CH2M0403105	296-A-19 record sampler was found down due to a tripped breaker. This is a non-designated stack.
12/12/2004	CH2M0403108	296-A-19 annulus exhauster was found shutdown by operators. The shift manager is sending personnel out of investigate cause of shutdown.
CY 2003	Multiple numbers[b]	Six logged notifications for A-42 Vent System unplanned shutdown
3/9/2003	CH2M0205722	Notified by central control and command that 102AY annulus exhauster, 296-A-19, was secured due to noises related to possible bearing or pulley failure.
CY 2002	Multiple numbers[b]	Two logged notifications for A-42 vent system unplanned shutdown
CY 2001	Multiple numbers[b]	Four logged notifications for A-42 vent system unplanned shutdown

Table 4-34. Environmental Notifications for Tank AY-102 (4 pages)

Date	Notification Number(s) / Log Entry	Description
CY 2000	Multiple numbers[b]	Four logged notifications for A-42 vent system unplanned shutdown
CY 1999	Multiple numbers[b]	Two logged notifications for A-42 vent system unplanned shutdown

[a] ENRAF is a registered trademark of Enraf B.V., Delft, Netherlands.
[b] Note: Refer to Appendix E for specific notifications when multiple numbers are indicated.

CAM = continuous air monitor.
CY = calendar year.
DST = double-shell tank.
Ecology = Washington State Department of Ecology.
GEA = gamma energy analysis.
HEPA = high-efficiency particulate air.
WFO = Waste Feed Operations.
WRPS = Washington River Protection Solutions, LLC

5.0 LEAK EVALUATION

Formal leak evaluations are prepared in accordance with TFC-ENG-CHEM-D-42. The process determines the odds that an assumed leaking tank would present the pattern of behavior evident from the data.

To develop the odds that a tank is leaking, in-tank and ex-tank data are analyzed by the leak assessment team, and proposed explanations for the behavior synthesized—the leak and non-leak hypotheses. At the completion of the assessment, the team members' opinions are elicited on the odds of the tank leaking, considering the entirety of the information that has been developed.

The results of the leak assessment are presented to the Washington River Protection Solutions, LLC. Executive Safety Review Board together with the leak integrity recommendation that the tank is sound, or is an assumed leaker. After considering all of the factors reviewed during the leak assessment, the Board either concurs with the recommendation or rejects it. Board concurrence is required to change the leak integrity assignment of a tank.

A formal leak assessment team was established August 10, 2012, to review Tank AY-102 construction and operating histories and determine if the material found on the annulus floor resulted from a primary tank leak. The panel consisted of Engineering, Base Operations, and Environmental Protection individuals representing a broad cross-section of Washington River Protection Solutions, LLC. The team met between August 28, 2012 and October 10, 2012 to gather and analyze information, formulate tank leak and non-leak hypotheses, and reach a consensus on the source of the floor material.

The leak assessment team and supporting technical staff developed the forensic lines of inquiry necessary to understand the construction and operating history of tank AY-102 in the context of the August 2012 discoveries of annulus floor material. In many cases, the line of inquiry did not develop a meaningful relationship to the tank's leak status. However, there were three lines of inquiry that the leak assessment team determined made significant contributions to understanding the tank's current status:

- Tank construction
- The corrosion propensity of the waste sludge at the bottom of the tank
- The composition of samples collected from the annulus floor material.

The most significant elements of all three are discussed below.

Construction History

Tank AY-102 construction records detail a tank plagued by first-of-a-kind construction difficulties and trial-and-error repairs. The result was a tank whose as-constructed robustness was much less than was foreseen by the DST designers.

Bulges created in the secondary liner by welding the thin floor plates and by reworking rejected welds were eventually accepted so construction could proceed. The rigid insulating refractory cast on top of the secondary liner cracked as the bulges moved, leaving the pad bridged in places.

The primary tank floor plate weld rejection rate was 36 percent. Weld maps show welds being reworked as many as four times before passing radiography examination.

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.

After stress relief and the hydrostatic leak check, part of the insulating refractory pad was found to be too damaged to be used. The outside 21 in. of the refractory were excavated from beneath the primary tank and replaced with structural concrete. Pieces of Styrofoam were used to fill gaps between the primary tank bottom and the refractory surface further under the tank when they were found.

The initial pours of the structural concrete filled the area under the primary tank knuckle, but did not flow to the back of the excavation. The slump was increased on later pours to ensure that the primary tank bottom was supported.

Operating History

Between 1977 and 1984, the tank received a variety of supernatant wastes. A thin layer of sludge formed on the tank bottom during 1977 to 1979, and probably 1982 to 1984. The interstitial liquid associated with the sludge may have been mildly corrosive based on derivation of its composition from the limited number of sample analyses that are available. It is possible that the interstitial liquid began to incrementally corrode the tank bottom during this time.

In 1998 and 1999, high-temperature sludge from Tank C-106 was transferred into Tank AY-102. The sludge formed a blanket over the existing sludge and increased its temperature dramatically. It is likely that the corrosion rate accelerated after the temperature increase.

In 2005, a segment of core sample drill string was dropped back into the tank during its removal, and in 2009, the tank bottom was repeatedly bumped during installation of a corrosion probe. Review of these events suggests that neither materially damaged the tank.

Beginning in 2011, a notable change occurred in the annulus CAM alarm behavior. Historically, the CAM alarm was associated with annulus ventilation system restarts and pressure changes. These events often caused legacy contamination deposited from air reversals between the primary tank headspace and the annulus pump pit to become airborne again. The CAM filter paper counts were typically in the 2,000–3,000 cpm range. In October 2011, the behavior of the CAM changed and the count rates soared whenever annulus activities disturbed the floor. This occurred after troubleshooting the ENRAF annulus leak detector on Riser 90 in October 2011; following sample collection of the annulus floor material near Riser 83 in September 2012; and following similar sampling activity near Riser 90 in October 2012.

Annulus Floor Sample Composition

During September and October 2012, samples from both annulus floor locations were collected and analyzed. The material was radioactive and its composition was consistent with Tank AY-102 waste, including a high concentration of potassium. Potassium is a unique chemical marker because it is contained in only a few tanks.

There was consensus agreement among the leak assessment team members that the radioactive material on the annulus floor of Tank AY-102 was the result of waste leaking from a breach in the bottom of the primary tank. The probable leak cause was identified as corrosion at high temperatures in a tank whose waste containment margins had been reduced by construction difficulties. The impacts that the tank bottom may have received from the dropped core sample drill string or the corrosion probe installation were judged to have negligible effect.

6.0 HYPOTHESES

Based on review of the available Tank AY-102 data, the team developed plausible hypotheses for the observed tank behavior.

Leak Hypothesis

The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank.

Non-Leak Hypothesis

The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The source of the dry cascades near Riser 90 is dissolved refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

7.0 CONCLUSIONS

There was consensus among the members of the leak assessment team that the radioactive material discovered on the annulus floor of Tank AY-102 was the result of a waste leak from a breach in the bottom of the primary tank. The estimated leak volume is 190 – 520 gal; a significant portion of the liquid has evaporated, leaving about 20 – 50 gal of drying waste.

It is likely that the leak began sometime after January 2007. The annulus inspection completed in December 2006, and the primary tank wall ultrasonic inspection completed in January 2007 found no evidence of leakage. In both cases, the inspection equipment was removed from the annulus without incident.

In January 2007, Tank AY-102 was filled with supernatant liquid containing a significant concentration of potassium. Potassium is a unique chemical marker in Hanford tank waste because it is contained in only a few tanks. The annulus floor material sample collected near Riser 83 showed an unusually large concentration of potassium.

Tank AY-102 was the first DST constructed at Hanford. Construction difficulties plagued the tank as it was built. These difficulties resulted in a tank whose as-constructed waste containment robustness was much less than intended by the double-shell tank design.

Between 1977 and 1984, the tank received a variety of supernatant wastes. A thin layer of sludge formed on the tank bottom during 1977 – 1979, and probably 1982 – 1984. The interstitial liquid associated with the sludge may have been mildly corrosive based on derivation of its composition from the limited number of sample analyses that are available. It is possible that the interstitial liquid began to incrementally corrode the tank bottom during this time.

In 1998 and 1999, high temperature sludge from Tank C-106 was transferred into Tank AY-102. The sludge formed a blanket over the existing sludge and increased its temperature dramatically. It is likely that the corrosion rate accelerated after the temperature increase.

In 2005, a segment of core sample drill string was dropped back into the tank during its removal, and in 2009, the tank bottom was repeatedly bumped during installation of a corrosion probe. Review of these events suggests that neither damaged the tank

The leak assessment team considered the possibility that Tank AY-102 is an outlier among the Hanford DSTs. Construction difficulties and trial-and-error repairs left the primary tank bottom with residual stresses that could not be forseen by the designers. These provided a fertile incubator for sustained corrosion to take place. With the construction improvements already evident in Tank AY-101 as Tank AY-102 was being completed, and the design changes implemented in the second and subsequent generations of DSTs, it seems unlikely that the other DSTs in similar circumstances would have been similarly affected. Additional Extent of Condition inspections scheduled for the other DSTs will determine the validity of the team's conclusion.

The results of the leak assessment and the panel's recommendation to change the Tank AY-102 leak integrity classification from "sound" to "assumed leaker" were presented to the Executive Safety Review Board on October 19, 2012 (Appendix I). The Board concurred with the classification change.

8.0 REFERENCES

API-936, 2008, *Refractory Installation Quality Control – Inspection and Testing Monolithic Refractory Linings and Materials*, American Petroleum Institute, Washington, D.C.

ARH-205, 1967, *Design Criteria PUREX AY Tank Farm*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-1601, 1973, *Specifications and Standards for the Operation of Radioactive Waste Tank Farms and Associated Facilities*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-1655, 1970, *Hazard Evaluation – PUREX Tank Farm Expansion- Project IAP-614*, Rev. 0, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-1833, 1970, *Investigation of the 241-AY Insulating Refractory Task Force Report*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-2456 A, 1972, *Chemical Processing Division Waste Status Summary January 1, 1972 through March 31, 1972*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-2456 B, 1972, *Chemical Processing Division Waste Status Summary April 1, 1972 through June 30, 1972*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-CD-336 D, 1976, *Production and Waste Management Division Waste Status Summary October 1, 1975 through December 31, 1975*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-CD-702 A, 1976, *Production and Waste Management Division Waste Status Summary January 1, 1976 through March 31, 1976*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-CD-822 MAR, 1977, *Production and Waste Management Division Waste Status Summary March 1977*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-CD-822 APR, 1977, *Production and Waste Management Division Waste Status Summary April 1977*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-CD-822 MAY, 1977, *Production and Waste Management Division Waste Status Summary May 1977*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-CD-822 OCT, 1976, *Production and Waste Management Division Waste Status Summary October 1976*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-LD-208 B, 1975, *Atlantic Richfield Hanford Company Monthly Report August 1975*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-LD-211 B, 1975, *Atlantic Richfield Hanford Company Monthly Report November 1975*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-LD-222 B, 1976, *Atlantic Richfield Hanford Company Monthly Report October 1976*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-LD-229 B, 1977, *Atlantic Richfield Hanford Company Monthly Report May 1977*, Atlantic Richfield Hanford Company, Richland, Washington.

ARH-MA-102, 1972, *241-AY Tank Farm Information Manual*, Atlantic Richfield Hanford Company, Richland, Washington.

Armstrong, W. C., 1970, "Project IAP-614 – PUREX Tank Farm Expansion Post Weld Heat Treating – Tanks 241-AY 101 and 10," (Letter to File, February 2), Atlantic Richfield Hanford Company, Richland, Washington.

Aromi, E. S., 2005, "Contract Number DE-AC27-99RL14047- Revised Tank 241-AY-102 Recovery Plan to Restore Chemistry Control," (Letter Report CH2M-0303535 to R. J. Schepens, U.S. Department of Energy, Office of River of Protection, November 15), CH2M HILL Hanford Group, Inc., Richland, Washington.

ASME, 1965 and 1968, *Boiler and Pressure Vessel Code*, American Society of Mechanical Engineers, New York, New York.

ASME AG-1, 2009, *Code on Nuclear Air and Gas Treatment*, American Society of Mechanical Engineers, New York, New York.

Benton R. W., 1967, "Dissolution of Linde AW 500 Zeolite," (Internal memorandum to P. W. Smith, November 22), Atlantic Richfield Hanford Company, Richland, Washington.

Blaak, T. M., 2000, "Caustic Mitigation Activities at the Hanford Site," (Interoffice memorandum 7KN00-00-TCO-039 to W. E. Bryan, et al., November 2) CH2M HILL Hanford Group, Inc., Richland, Washington.

BNL-52527, 1997, *Guidelines for Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks*, Brookhaven National Laboratory, Upton, New York.

BNWL, 1968, *Evaluation of Kaolite–2200-LI*, Unpublished (RPP-19097, Attachment 5), Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Washington.

BNWL-797, 1968, *Evaluation of Kaolite-20 Insulating Castable*, (RPP-19097, Attachment 3), Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Washington.

BNWL-B-56, 1971, *Evaluation of Kaolite-2000 Insulating Castable*, (RPP-19097, Attachment 7), Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Washington.

BNWL-B-475, 1976, *Computer-Based Structural Investigation of the SY-103 Waste Storage Tank Which Contains an Out-of-Tolerance Bottom Bump*, Atlantic Richfield Hanford Company, Richland, Washington.

Cardwell, C. W., 1968, "Inspection Report – PDM Provo Shops," (Interoffice memorandum to G. Kligfield, December 18), Vitro Hanford Engineering Services, Richland, Washington.

Cardwell, C. W., 1969a, "Installation of Kaolite Insulation," (Letter to H. E. Eager, February 20), Vitro Hanford Engineering Services, Richland, Washington.

Cardwell, C. W., 1969b, "Design Change 2124-17," (Letter to H. E. Eager, April 7), Vitro Hanford Engineering Services, Richland, Washington.

CE-0283, 1967, "Report on a Study of Possible Insulating Materials for Use Between Tank Shells – 241-AY Tank Farm," Vitro Hanford Engineering Services, Richland, Washington.

Choi, S; Crosson, G.; Mueller, K. T.; Seraphin, S.; and Chorover, J., 2005, "Clay mineral weathering and contaminant dynamics in a caustic aqueous system II. Mineral transformation and Microscale Partitioning," *Geochimica et Cosmochimica Acta*, Vol. 69, No. 18, pp. 4437–4451, http://cals.arizona.edu/swes/chorover_lab/pdf_papers/Choi_et_al_2005b.pdf.

Christensen, W. R., 1972, "Monthly Report – January 1972," (Letter 1007190520 to C.J. Francis, January 13), Atlantic Richfield Hanford Company, Richland, Washington.

CML-SSP Working Paper 2001.002, 2001, *Literature Study on Degradation Products of Known Emissions*, Centre of Environmental Science (CML), Leiden University, Leiden, Netherlands.

Congdon, J. W., and Lozier, J. S., 1987, "Inhibition of Washed Sludge with Sodium Nitrite," (Memorandum DPST-87-379 to M. A. Ebra), Savannah River Laboratory, Aiken, South Carolina.

Davis, E. S., 1969, "241-AY Tank Farm Expansion – Welding Quality Control," (Letter to H. E. Eager, June 9), Vitro Hanford Engineering Services, Richland, Washington.

Davis, E. S., 1970, "Willard Smith, Inc. Refractory Tests," (Letter to J. H. Slaughter, U.S. Atomic Energy Commission, October 2), Vitro Hanford Engineering Services, Richland, Washington.

Dodd, R. A., 1994, "Action Plan for Caustic Addition to Tank 241-AY-102," (Memoradum 7CF10-023-094 to N. W. Kirch, September 2), Westinghouse Hanford Company, Richland, Washington.

E-525-TP-1.0, 2004, *Test Plan for Project E-525 DST Transfer System Modifications*, CH2M HILL Hanford Group, Inc., Richland, Washington.

ECN-720173, 2003, "241-AY-102 Annulus Leak Detection using Three ENRAF Level Gauge," Rev. 2, Lockheed Martin Hanford Corporation, Richland, Washington.

ECN-723915, 2006, "DST Isolation Project: Isolate Raw Water to AY0152 and AY-501," Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

EM-RP-WRPS-TANKFARM-2012-0013, 2012, "Video Inspection of Tank 241-AY-102 Identifies Dry Material on Annulus Floor," Washington River Protection Solutions, LLC, Richland, Washington.

Engeman, J. K., Rodgers, M. J., 2007, "Evidence of Annulus Moisture Accumulation in Tanks 241-AY-101 and 241-AY-102," (Interoffice memorandum 7G410-JKE-MJR-007-005 to G. P. Duncan and D. J. Washenfelder, February 8), CH2M HILL Hanford Group, Inc., Richland, Washington.

Ferrera, D. W., 2007, "Contract Number DE-AC27-99RL14047 – Request for Approval of Tanks 241-AY-101 and 241-AY-102 Annulus Corrosion Recovery Plan," (Letter CH2M-0700558 to T. Z. Smith, U.S. Department of Energy, Office of River Protection, March 6), CH2M HILL Hanford Group, Inc., Richland, Washington.

Fulton, J. C., 2007a, "Contract Number DE-AC27-99RL14047 – Submittal of Tanks 241-AY-101 and 241-AY-102 Annulus Corrosion Recovery Plan Intermediate Deliverable 1.E," (Letter CH2M-0700558 R4 to D. L. Noyes, U.S. Department of Energy, Office of River Protection, July 16), CH2M HILL Hanford Group, Inc., Richland, Washington.

Fulton, J. C., 2007b, "Contract Number DE-AC27-99RL14047 – Submittal of Tanks 241-AY-101 and 241-AY-102 Annulus Corrosion Recovery Plan Technical Safety Requirement Deliverable 3," (Letter CH2M-0700558 R5 to D. L. Noyes, U.S. Department of Energy, Office of River Protection, October 25), CH2M HILL Hanford Group, Inc., Richland, Washington.

Fulton, J. C., 2007c, "Contract Number DE-AC27-99RL14047 – Submittal of Tanks 241-AY-101 and 241-AY-102 Annulus Corrosion Recovery Plan Intermediate Deliverable 1.F and Request for Approval of Recovery Plan Revision," (Letter CH2M-0700558 R6 to D. L. Noyes, U.S. Department of Energy, Office of River Protection, November 8), CH2M HILL Hanford Group, Inc., Richland, Washington.

Graves, W. S., 1969a, "PUREX Tank Farm Expansion IAP-614 Minimum Thickness Insulating Concrete," (Letter to C. W. Cardwell, February 14), Vitro Hanford Engineering Services, Richland, Washington.

Graves, W. S., 1969b, "PUREX Tank Farm Addition," (Letter to C. W. Cardwell, March 18), Vitro Hanford Engineering Services, Richland, Washington.

H-2-35299, 1970, "Structural Modification Insulating Concrete Plan & Details," Vitro Hanford Engineering Services, Richland, Washington.

H-2-64307, 1970, "Structural Insulating Concrete Plan and Details," Sheet 1, Rev. 4, Vitro Hanford Engineering Services, Richland, Washington.

H-2-64310, 2008, "Concrete Tank Section and Details," Sheet 1, Rev. 2, Vitro Hanford Engineering Services, Richland, Washington.

H-2-64372, 1970, "Instrumentation Insulating Concrete Plan & Details," Sheet 1, Rev. 3, Vitro Hanford Engineering Services, Richland, Washington.

H-2-64374, 1970, "Instrumentation Concrete Foundation Tank 102 - Plan & Details," Sheet 1, Rev. 3, Vitro Hanford Engineering Services, Richland, Washington.

H-2-64375, 1970, "Instrumentation Concrete Dome Plan & Details," Sheet 1, Rev. 3, Vitro Hanford Engineering Services, Richland, Washington.

H-2-64430, 1970, "241-AY Tank Farm Leak Detection Pit Piping Sections and Details (Tank 102)," Sheet 1, Rev. 1, Vitro Hanford Engineering Services, Richland, Washington.

H-2-64449, 2008, "Tank Elevation and Details," Sheet 1, Rev. 7, Vitro Hanford Engineering Services, Richland, Washington.

H-2-70760, 2003, "Engineering Flow Diagram Valve Pits to 241-AX, AY, and AZ Tanks," Rev. 2, Vitro Engineering Corporation, Richland, Washington.

H-2-77323, 1996, "Abandoned Annulus Vent Piping Tank 241-AY-102," Rev. 2, Kaiser Engineers Hanford Company, Richland, Washington.

H-2-77324, 1996, "Annulus Vent Piping TK-102 241-AY Tank Farm," Rev. 2, Kaiser Engineers Hanford Company, Richland, Washington.

H-2-90252, 1982, "Piping Plan Electrical Plan," Rev. 1, Kaiser Engineers Hanford Company, Richland, Washington.

H-2-90253, 1982, "Piping Plan and Drawing List," Rev. 1, Kaiser Engineers Hanford Company, Richland, Washington.

H-2-94019, 1986, "Piping Supports and Details Line V720," Rev. 1, Kaiser Engineers Hanford Company, Richland, Washington.

H-2-131086, 2012, "Piping Plan AZ Tank Farm," Rev. 4, Washington River Protection Solutions, LLC, Richland, Washington.

H-2-818540, 1998, "Piping Tank 241-AY-102 Sections & Details," Fluor Daniel Northwest, Inc., Richland, Washington.

H-14-003007, 2010, "Electrical (EDS) Panelboard Schedule," Rev. 18, Washington River Protection Solutions, LLC, Richland, Washington.

H-14-010506, 2010, "Dome Penetration Schedules (WST/WSTA) Tank 241-AY-102," Sheets 2 and 4, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

H-14-106417, 2004, "W-211 Initial Tank Retrieval Systems AY Tank Farm 3" PW-404-M9 Installation, Drawing List and Area Map," Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

H-14-106418, 2004, "W-211 Initial Tank Retrieval Systems AY Tank Farm 3" PW-404-M9 Installation, Drawing List and Area Map," Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Hatch, P., 1967, "Trip Report – Savannah River Plant Waste Tank Discussions and ITT Stress Analysis Study," (Interoffice memorandum to G. C. Obert, December 1), Atlantic Richfield Hanford Company, Richland, Washington.

HES QA Report, 1969, Multiple QA Reports January to November, Vitro Hanford Engineering Services, Richland, Washington.

HNF-2317, 1998, *Project W-320 High Vacuum 241-AY-102 Annulus Ventilation System Operability Test Report*, Numatec Hanford Corporation, Richland, Washington.

HNF-3747, 1998, *Tank Leak Assessment Process: Technical Background*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

HNF-4798, 1999, *Tank 241-AY-102 Annulus Continuous Air Monitor High Readings*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

HNF-4818, 1999, *Final Results of Double-Shell Tank 241-AY-102 Ultrasonic Inspection*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

HNF-6047, 2002, *Tank 241-AY-102 Cores 270, 271, 272, and 273 Analytical Results for the Final Report*, Rev. 0A, Fluor Hanford, Inc., Richland, Washington.

HNF-SD-600-FDC-001, 1997, *Functional Design Criteria for the Tank Farm Ventilation Upgrade, Project W-030*, Rev. 4, Numatec Hanford Company, Richland, Washington.

HNF-SD-WM-ER-317, 1997, *Supporting Document for the Historical Tank Content Estimate for AY Tank Farm*, Rev. 1, Fluor Daniel Northwest, Inc., Richland, Washington.

HNF-SD-WM-TSR-006, 2011, *Tank Farms Technical Safety Requirements*, Rev. 7G, Washington River Protection Solutions, LLC, Richland, Washington.

HWS-7789, 1968, *Specification for Primary and Secondary Steel Tanks PUREX Tank Farm Expansion Project IAP-614*, Rev. 2, Vitro Hanford Engineering Services, Richland, Washington.

HWS-7793, 1968, *Procurement Specification for Thermocouple & Strain Gage Assemblies Bldg 241-AY PUREX Tank Farm Expansion Project IAP-614*, Rev. 3, Vitro Hanford Engineering Services, Richland, Washington.

IDMS Accession Number 1007130427, 1973, "Status Report 241-AY Tank Farm 241-AY 11/02/1973 thru 03/30/1975" Atlantic Richfield Hanford Company, Richland, Washington.

ISA-RP1.3, 1959, *Thermocouples and Thermocouple Extension Wires*, Section 1.3, "Terminology, Limits of Error, and Wire Sizes," Instrument Society of America, Pittsburgh, Pennsylvania.

Jansky, M. T., 1981, "Composition of Waste from Tanks 101AY and 102AY," (Internal memorandum 65453-81-130 to M. Teats, April 15), Rockwell International, Richland, Washington.

Jansky, M. T., 1984, "Laboratory Support for Upcoming 242-A Evaporator Campaign Run 84-5," (Internal letter 65453-84-134 to E. G. Gratny, May 10) Rockwell International, Richland, Washington.

Johnson, W. J., 2009, "Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Closure of Technical Safety Requirement Recovery Plan for Water Intrusion into the Annuli of Tanks 241-AY-101 and 241-AY-102," (Letter WRPS-0901335 to S. J. Olinger, U.S. Department of Energy, Office of River Protection, August 14), Washington River Protections Solutions, LLC, Richland, Washington.

Kligfield, G., 1969, "AY Tank Farm Welding," (Letter to B. Kirz, June 10), Vitro Hanford Engineering Services, Richland, Washington.

Lien, D. G., 1967, "Computer Study of AY Tank," (Trip Report to Chicago, Illinois, November 27), Vitro Hanford Engineering Services, Richland, Washington.

Lien, D. G., 1969, "241-AY Tank 102- Insulating Concrete IAP-614," (Interoffice memorandum to W. S. Graves, November 3), Vitro Hanford Engineering Services, Richland, Washington.

Lien, D. G., 1970, "Field Trip to AY Tank Farm," (Letter to G. Kligfield, July 10), Vitro Hanford Engineering Services, Richland, Washington.

Mauss, B. M., 1984, "Chemical Compositions of 102-AY, 101-AW, 105-AN, and 104-AW," (Internal memorandum 65453-84-348 to E. G. Gratny, November 9) Rockwell International, Richland, Washington.

Occurrence Report 74-30, 1974, *Failure to Obtain Routine Monthly Samples in Tank 102-AY*, Atlantic Richfield Hanford Company, Richland, Washington.

Occurrence Report 75-127, 1975, *Misrouting of Process Solution*, Atlantic Richfield Hanford Company, Richland, Washington.

Occurrence Report 76-148, 1976, *Possible Specification Violation: Liquid Level Decrease to Below a Minimum Level*, Atlantic Richfield Hanford Company, Richland, Washington.

OE-03-0009, 2003, *Operability Evaluation for AZ-102 Primary Tank Leak Detection Systems*, CH2M HILL Hanford Group, Inc., Richland, Washington.

Olinger, S. J., 2007, "Contract Number DE-AC27-99RL14047 – Approval of Safety Basis (SB) Amendment-042 to Revise Requirements for Evaluating Annulus Ventilation System Effectiveness in Administrative Control 5.16," (Letter 07-TED-055 to J. C. Fulton, CH2M HILL Hanford Group, Inc., December 21), U.S. Department of Energy, Office of River Protection, Richland, Washington.

OSD-T-151-00007, 2012, *Operating Specifications for the Double-Shell Storage Tanks*, Rev. 10, Washington River Protection Solutions, LLC, Richland, Washington.

OSD-T-151-00017, 1983, *Operating Specifications for the Aging Waste Operations in Tank Farms 241-AY and 241-AZ*, Rev. B-0, Rockwell Hanford Operations, Richland, Washington.

OSD-T-151-00031, 2012, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

PER-2003-3066, 2003, "AZ-102 UT Discovers Concrete Insulation Pad Degraded," CH2M HILL Hanford Group, Inc., Richland, Washington.

PER-2005-1582, 2005, "Lower Half of Drill String Fell into AY-102 When it was Disconnected from the Upper Section," CH2M HILL Hanford Group, Inc., Richland, Washington.

Personal Computer Surveillance Analysis Computer System (PCSACS), Queried October 2, 2012, [Tank 241-AY-102 Temperature Profiles and Waste Levels], Washington River Protection Solutions, LLC, Richland, Washington.

Peterson, M., 1990, "Revised Report on Results of 102-AY Characterization," (Letter Report 9000855 to L. M. Sasaki and A. J. DiLiberto, February 12), Battelle Pacific Northwest Laboratories, Richland, Washington.

PNNL-13571, 2001, *The Expert Panel for Hanford Double-Shell Tank Life Extension*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14706, 2004, *DST Primary Tank Settlement Evaluation*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-21836, 2012, *Characteristics of STP Pre-2004 Archived KE Basin Sludge Samples Before and After Re-Jarring in the RPL – April 2012*, Pacific Northwest National Laboratory, Richland, Washington.

Pourbaix, M., 1974, "Atlas of Electrochemical Equilibria in Aqueous Solutions," National Association of Corrosion Engineers International, Houston, Texas.

PPD-429-DEL, 1971, *Monthly Status and Progress Report March 1971*, U. S. Atomic Energy Commision, Richland, Washington.

PPD-493-4-DEL, 1972, *Monthly Status and Progress Report April 1972*, U. S. Atomic Energy Commission, Richland, Washington.

PPD-493-7-DEL, 1972, *Monthly Status and Progress Report July 1972*, U. S. Atomic Energy Commision, Richland, Washington.

RHO-C-17, 1978, *Additional Analyses of Underground Waste Storage Tanks 241-AW*, Rockwell Hanford Operations, Richland, Washington.

RHO-CD-14 MAY, 1980, *Waste Status Summary May 1980*, Rockwell Hanford Operations, Richland, Washington.

RHO-CD-14 JUNE, 1980, *Waste Status Summary June 1980*, Rockwell Hanford Operations, Richland, Washington.

RHO-CD-14 AUG, 1980, *Waste Status Summary August 1980*, Rockwell Hanford Operations, Richland, Washington.

RHO-CD-14 OCT, 1980, *Waste Status Summary October 1980*, Rockwell Hanford Operations, Richland, Washington.

RHO-CD-14 NOV, 1980, *Waste Status Summary November 1980*, Rockwell Hanford Operations, Richland, Washington.

RHO-CD-14 DEC, 1981, *Waste Status Summary December 1980*, Rockwell Hanford Operations, Richland, Washington.

RHO-CD-213, 1977, *Waste Storage Tanks Status and Leak Detection Criteria, 200 East Area, Volume 1*, Rockwell Hanford Operations, Richland, Washington.

RHO-CD-738-FDL, 1982, *Functional Design Criteria Isolation of Single-Shell Tanks, 100 Areas Project B-181*, Rev. 2, Rockwell Hanford Operations, Richland, Washington (IDMS 1010050556).

RHO-RE-SA-169, 1986, *Sixteen Year of Cesium Recovery Processing at Hanford's B Plant*, Rockwell Hanford Operations, Richland, Washington.

RHO-RE-SR-83-26, 1983, *Process Aids – A Compilation of Technical Letters PUREX and B-Plant Processes, Miscellaneous Studies*, Book A, Volume 15, "Dissolution of Zeolon with Caustic Solutions," pages 337 – 342, Rockwell Hanford Operations, Richland, Washington.

Ritenour, G. P., 2005, "Final Report for Tank 241-AY-102 Cores 318 and 319 in Support of the Corrosion Mitigation and Criticality Programs," (Internal Letter 05-ATL-089 to N. W. Kirch, September 28) Advanced Technologies and Laboratories, Inc., Richland, Washington.

RL-WHC-TANKFARM-1994-0059, 1994, *During a Flush of Waste Transfer Line SL-503, a Leak within the 241-AY-102 02D Sluice Pit was Discovered*, Westinghouse Hanford Company, Richland, Washington.

Routschka, G., 2007, *Pocket Manual Refractory Materials*, Second Edition, McGraw-Hill Companies, Columbus, Ohio.

RP-CHG-TANKFARM-2001-0004, 2001, *Corrosion Observed in Double-Shell Tank 241-AY-101 during Video Inspection and Ultrasonic Testing*, CH2M HILL Hanford Group, Inc., Richland, Washington.

RP-CHG-TANKFARM-2001-0106, 2001, *Corrosion Observed in Double-Shell Tank 241-AY-102 During Video Inspection of the Annulus Section*, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-6012, 2003, *Project W-314, Phase 1 AY Tank Farm Upgrade Acceptance for Beneficial Use*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-7574, 2007, *Double-Shell Tank Integrity Program Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-7625, 2010, *Guidelines for Best-Basis Inventory*, Rev. 10, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-7695, 2001, *Double-Shell Tank Annulus Ventilation Engineering Study*, Rev. 0, CH2M HILL Hanford Company, Inc., Richland, Washington.

RPP-7764, 2002, *Year 2001 Visual Examination of Tank Annuli at Tanks 241-AY-101 and 241-AZ-102*, Rev. 0B, CH2M HILL Hanford Company, Inc., Richland, Washington.

RPP-8887, 2001, *Evaluation of Potential Water Intrusion Sources, Tank 241-AY-101*, Rev. 0, Cogema Engineering Corporation, Richland, Washington.

RPP-9497, 2001, *Year 2001 Visual Examinations of Tank Annuli at Tanks 241-AY-102 and 241-AZ-101*, Rev. 0, CH2M HILL Hanford Company, Inc., Richland, Washington.

RPP-15127, 2007, *System Design Description for AY/AZ Tank Farm Primary Ventilation System (DSA Based)*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15128, 2007, *System Design Description for AY/AZ Tank Farm Annulus Ventilation System (DSA-Based)*, Rev. 1A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15135, 2006, *System Design Description for AY/AZ Tank Farm Double-Shell Tank Waste Storage System (DSA-Based)*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15758, 2003, *Analysis of Corrosion Product Retrieved From The Primary Tank Wall in the Annulus of Tank 241-AY-102*, Rev. 0, CH2M HILL Hanford Company, Inc., Richland, Washington.

RPP-19097, 2003, *Evaluation of Insulating Concrete in Hanford Double-Shell Tanks*, Rev. 0, CH2M HILL Hanford Company, Inc., Richland, Washington.

RPP-19919, 2004, *Campaign Report for the Retrieval of Waste Heel from Tank 241-C-106*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-20260, 2011, *241-AY Tank Farm Historic Dome Load Record Data*, Rev. 0C, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-25782, 2007, *DST Dome Survey Program*, Rev. 0A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-32420, 2007, *Tank 241-AY-101 Annulus Ventilation System Psychrometric Data Evaluation*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-35008, 2007, *AC-5.16 Engineering Evaluation Methodology and Sampling Strategy*, Rev. 0, CH2M HILL Hanford Company, Inc., Richland, Washington.

RPP-42658, 2010, *AZ-702 Ventilation System Bypass Flow Evaluation*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-53434, 2012, *241-AY-102 Annulus Sampling Data Quality Objectives*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-ASMT-27062, 2006, *Stress Corrosion Cracking Evaluation for the Secondary LINER Exposed to In-Specification Waste in a Double-Shell Tank Annulus*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-ASMT-34090, 2007, *Hanford Double-Shell Tank Thermal and Seismic Project – Effects of Dome Rebar and Concrete Degradation*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-ASMT-53794, (2012- To be issued by the end of the first quarter 2013), *Tank 241-AY-102 Supporting Documentation Miscellaneous Reports, Letters, Memoranda, and Data*, Washington River Protections Solutions, LLC, Richland, Washington.

RPP-PLAN-53352, 2012, *Tank AY-102 Annulus Sampling and Analysis Plan*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-25608, 2005, *Hanford Double-Shell Tank Thermal and Seismic Project – Increased Concentrated Load Analysis*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-25731, 2012, *System Health Report for East Base Operations AY/AZ Farms Waste Tank Structures, Mixing and Monitoring Systems for the Fourth Quarter CY2011*, Rev. 27, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-32137, 2007, *Ultrasonic Inspection Results for Double-Shell Tank 241-AY-102 – FY 2007*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-33273, 2007, *241-AY-101/AY-102 Annulus Moisture Intrusion Analysis*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-33284, 2008, *Hanford Tanks AY-102 and AP101: Effect of Chemistry and Other Variable on Corrosion and Stress Corrosion Cracking*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-34311, 2007, *Double-Shell Tank Integrity Inspection Report for 241-AY Tank Farm*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-34311, 2012, *Double-Shell Tank Integrity Inspection Report for 241-AY Tank Farm*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-35923, 2008, *Hanford Tank AY-101: Effect of Chemistry and Other Variable on Corrosion and Stress Corrosion Cracking*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-36150, 2008, *Final Report for the 241-AY-102A Leak Detection Pit Grab Samples in Support of the Waste Compatibility Program*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-37440, 2008, *Tank 241-AY-101 Interim Surface Barrier Feasibility Study*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-40661, 2011, *241-AY-102 Multi-Probe Corrosion Monitoring System: May, June & July 2011 Quarterly Report*, Rev. 29, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-42920, 2009, *2009 Auto-TCR for Tank 241-AY-102*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-44630, 2012, *Derivation of Best-Basis Inventory for Tank 241-AY-102 as of January 1, 2012*, Rev. 3, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-47337, 2011, *Specifications for the Minimization of the Stress Corrosion Cracking Threat in Double-Shell Tank Wastes*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-53511, 2012, *Final Report for Tank 241-AY-102 Annulus Solids Sample Taken in August, 2012*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-SPEC-35429, 2008, *Procurement Specification for the AY-102 Corrosion Probe Assembly*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RSR WTO-022533, 2011, *Radiological Survey Report: Flush AY-102-WSTA-LTD-152 Annulus*, Washington River Protection Solutions, LLC, Richland, Washington.

SAM-76-1, 1976, *Recommended Bottom Flatness Tolerances for Million Gallon Waste Storage Tanks*, Battelle Pacific Northwest Laboratory, Richland, Washington.

Schepens, R. J., 2005, "Contract No. DE-AC27-99RL14047 – Approval to Consolidate Waste Treatment and Immobilization Plant (WTP) Hot Commissioning Feeds Stored in Tanks 241-AP-101 and 241-AY-102," (Letter 05-TPD-082 to E. S. Aromi, CH2M HILL Hanford Group, Inc., September 27), U.S. Department of Energy, Office of River Protection, Richland, Washington.

Schulze, M., 1969a, "AY Tanks IAP-614," (Letter to C. W. Cardwell, February 17), Vitro Hanford Engineering Service, Richland, Washington.

Schulze, M., 1969b, "Subject IAP-614 PUREX Tank Farm Expansion – Insulating Concrete," (Letter to C. W. Cardwell, February 19), Vitro Hanford Engineering Services, Richland, Washington.

Schulze, M., 1969c, "Stress Relieving of TK 102 Tank on 9-30-69," (Letter to File, October 6), Vitro Hanford Engineering Services, Richland, Washington.

Schulze, M., 1970a, "IAP-614-AY Tanks Kaolite," (Interoffice memorandum to G. Kligfield, June 11), Vitro Hanford Engineering Services, Richland, Washington.

Schulze, M., 1970b, "Inspection of Kaolite in TK-101 and Discussion," (Meeting minutes, July 21), Vitro Hanford Engineering Company, Richland, Washington.

Short, A., 1969, "Nick DeStefano Visit to 241-AY Tank Farm – Project IAP-614," (Letter to C. W. Cardwell, June 18), Vitro Hanford Engineering Services, Richland, Washington.

SRNL-STI-2011-00479, 2012, *Effect of Chloride and Sulfate Concentration on Probability Based Corrosion Control for Liquid Waste Tanks – Part IV*, Savannah River National Laboratory, Aiken, South Carolina.

SVF-1342, 2007, *AY102 FY07 Q3 Supernatant PK Vector*, Washington River Protection Solutions, LLC, Richland, Washington.

Tank Waste Information Network System (TWINS), Queried October 2, 2012, [Tank 241-AY-102, Best Basis Inventory], http://twins.pnl.gov/twins.htm.

Tardiff, G. R., 2001, *Evaluation of AY-102 Annulus Cam Readings*, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-43115, 2009, *Summary and Recommendations of the Expert Panel Oversight Committee Meeting on Double-Shell Tank Corrosion Monitoring and Testing Held June 1-3, 2009*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

TFC-ENG-CHEM-D-42, 2012, *Tank Leak Assessment Process*, Rev. B-5, Washington River Protections Solutions, LLC, Richland, Washington.

TFC-ENG-FACSUP-C-10, 2012, *Control of Dome Loading*, Rev. C-19, Washington River Protections Solutions, LLC, Richland, Washington.

TFC-WO-11-5469, 2011, "241-AY Annulus Enraf Cals and Functional Tests," Washington River Protection Solutions, LLC, Richland, Washington.

TFC-WO-12-2156, 2012, "241-AY Annulus ENRAF Cals and Functional Tests," Washington River Protection Solutions, LLC, Richland, Washington.

TO-040-035, 2005-2012, "Exhauster Status Log Sheets," IDMS Accession Number 1109123320, Washington River Protection Solutions, LLC, Richland, Washington.

TOC-ENV-NOT-2011-0012, 2011, "WRPS Environmental Notification TOC-ENV-NOT-2011-0012, AY-102 Annulus ENRAF," Washington River Protection Solutions, LLC, Richland, Washington.

USQ-TF-97-0338, 1997, "Leak Detection Pit Count Rate Meters," Rev. 0, CH2M HILL Hanford, Inc., Richland, Washington.

Venetz, T. J., 2012, "Analysis of DST Leak Detection Pit Levels and Determination of Time to Pump Element," (Interoffice memorandum WRPS-1203624 to D. J. Washenfelder), Washington River Protection Solutions, LLC, Richland, Washington.

WHC-MR-0132, 1990, *A History of the 200 Area Tank Farms*, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-RE-TI-148, 1985, *Metallurgical Analysis of Leak Failure of 241-A-B Valve Pit Jumper*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-W020H-OTP-001, 1992, *Final Energization Survey Report Project W-020H, Priority 1, A-Tank Farm Complex*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-DP-150, 1995, *60-Day Waste Compatibility Safety Issue and Final Results for Tank 241-AY-102, Grab Samples 2AY-95-1, 2AY-95-2, 2-AY-95-3, and 2-AY-95-4*, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-ER-454, 1997, *Tank Characterization Report for Double-Shell Tank 241-AY-102*, Rev. 0B, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-TI-689, 1996, *Waste Status and Transaction Record Summary for the Southeast Quadrant of the Hanford 200 Area*, Rev. 1, Los Alamos National Laboratory, Los Alamos, New Mexico.

Wheeler, R. E., 1974, "Tank Farm Samples," (Internal memorandum to R. L. Wasler, June 25), Atlantic Richfield Hanford Company, Richland, Washington.

Womack, J. C., 1972, "January 1972 Monthly Report," (Internal memorandum 1007190520 to C. J. Francis), Atlantic Richfield Hanford Company, Richland, Washington.

WRPS-PER-2011-2099, 2011, "Water Intrusion into the AY-102 Annulus," Washington River Protection Solutions, LLC, Richland, Washington.

WRPS-PER-2011-2120, 2011, "Create Pre-Planned Work Package to Investigate Annulus Water Intrusion," Washington River Protection Solutions, LLC, Richland, Washington.

WRPS-PER-2012-1363, 2012, "AY-102 Annulus Video Inspection – Potential Intrusion Identified," Washington River Protection Solutions, LLC, Richland, Washington.

WRPS-PER-2012-1438, 2012, "Video Inspection of the Tank 241-AY-102 Identifies Dry Material on Annulus Floor," Washington River Protection Solutions, LLC, Richland, Washington.

WSI, 1970, "PUREX Waste Storage Facility 241-AY Refractory," (Letter to J. Slaughter and B. Kirz, September 25), William Smith Inc., Seattle, Washington.

WSRC-MS-2005-00078, 2005, *Stress Corrosion Cracking of Carbon Steel Weldments*, Savannah River National Laboratory, Aiken, South Carolina.

WSRC-TR-94-0250, 1994, *Recommended Nitrite Limits for Chloride and Sulfate in ESP Slurries (U)*, Westinghouse Savannah River Company, Aiken, South Carolina.

WSRC-TR-90-512, 1990, *Effect of Temperature on the Nitrite Requirement to Inhibit Washed Sludge*, Westinghouse Savannah River Company, Aiken, South Carolina.

Xu, T. and K. Pruess, 2001, *Thermophysical Properties of Sodium Nitrate and Sodium Chloride Solutions and Their Effects on Fluid Flow in Unsaturated Media*, Lawrence Berkeley National Laboratory, Berkeley, California.

Appendix A

TANK LEAK PROBABILITY CALCULATION METHODOLOGY

TANK LEAK PROBABILITY CALCULATION METHODOLOGY

The methodology used to determine the probability of a tank leak is described in HNF-3747, *Tank Leak Assessment Process: Technical Background*. One example to determine the tank leak probability using data such as the ENRAF[6] surface level trends, four probabilities must be known.

(1) $p(\mathrm{L})$ The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

(2) $p(\mathrm{NL})$ The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The $p(\mathrm{NL}) = 1 - p(\mathrm{L})$.

(3) $p(\mathrm{D}|\mathrm{L})$ The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic tank data would be present if the tank was leaking.

(4) $p(\mathrm{D}|\mathrm{NL})$ The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic tank data would be present if the tank was not leaking.

The probabilities (1) – (4) are combined to form likelihood ratios according to the following equations.

(5) $$\Omega_0 = \frac{p(\mathrm{L})}{p(\mathrm{NL})}$$ Equation 1 HNF-3747, p. 15

(6) $$\Omega_1 = \frac{p(\mathrm{L}|\mathrm{D})}{p(\mathrm{NL}|\mathrm{D})} = \frac{p(\mathrm{D}|\mathrm{L})}{p(\mathrm{D}|\mathrm{NL})} \times \frac{p(\mathrm{L})}{p(\mathrm{NL})}$$ Equation 2 HNF-3747, p. 15

(7) $$\Omega_2 = \frac{p(\mathrm{L}|\mathrm{D})}{p(\mathrm{NL}|\mathrm{D})} = \frac{p(\mathrm{D}_{\text{in-tank}}|\mathrm{L})}{p(\mathrm{D}_{\text{in-tank}}|\mathrm{NL})} \times \frac{p(\mathrm{D}_{\text{ex-tank}}|\mathrm{L})}{p(\mathrm{D}_{\text{ex-tank}}|\mathrm{NL})} \times \frac{p(\mathrm{L})}{p(\mathrm{NL})}$$ Equation 3 HNF-3747, p. 16

(8) $$p(\mathrm{L}|\text{combined}) = \frac{\Omega_x}{1+\Omega_x}$$ Equation 4 HNF-3747, p. 27

where:

Ω_0 "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

Ω_1 Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic data examined during the leak assessment.

Ω_2 Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, and the event or discovery that initiated the formal leak assessment; and the diagnostic in-[primary] tank and ex-[primary] tank data examined during the leak assessment.

[6] ENRAF is a registered trademark of Enraf B.V., Delft, Netherlands.

p(L|combined) The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-[primary] tank and ex-[primary] tank data examined during the leak assessment.

In order to determine the probability of a tank leak, either the "prior probability" that the tank was leaking, *p*(L), or the prior probability that the tank was not leaking, *p*(NL), before the event or discovery that initiated the leak assessment, is determined and converted to the "prior" likelihood of a leak. "Likelihood ratios," or Ω's, in HNF-3747, and are the decimal equivalent of "odds."

After the prior likelihood ratio of a leak, Ω_0, is determined, the likelihood ratio is adjusted to take account of the event or discovery that initiated the leak assessment, and the diagnostic data examined during the leak assessment, using the "posterior probability" of the event or discovery, or the diagnostic data, has resulted from a leak, *p*(D|L), and the posterior probability of the event or discovery or the diagnostic data has not resulted from a leak, *p*(D|NL). These are converted to the "posterior" likelihood ratio that the observed event and diagnostic data resulted from a leak.

The product of the prior and the posterior likelihood ratios is the "combined likelihood ratio" that the tank leaked, based on the tank history, and the event or discovery that initiated the leak assessment, and the diagnostic data examined during the leak assessment. The combined likelihood ratio is identified in HNF-3747 as Ω_1 (Equation 6). At the end of the leak assessment the combined likelihood ratio is reconverted to the leak probability, *p*(L|combined).

It is important to note that the combined likelihood ratio can include the product of more than one posterior likelihood ratio if multiple events or discoveries or multiple types of diagnostic data are examined during the leak assessment. The most commonly encountered example of using the product of multiple posterior likelihood ratios to derive a combined likelihood ratio is the presence of both in-tank data and ex-tank data for single-shell tanks – for example the product of waste surface level and drywell radiation profiles posterior likelihood ratios is frequently used to determine the combined posterior likelihood ratio in single-shell tank leak assessments. Equation (7) for Ω_2 illustrates how multiple likelihood ratios from in-tank and ex-tank data are combined to determine the combined posterior likelihood ratio.

A simple example using diagnostic ENRAF surface level data illustrates how the Ω_1 combined posterior likelihood ratio is developed.

Combined Leak Probability, *p*(L|combined), Calculation Example

A single-shell tank is suspected of having a small leak because of its age and operating history. The only data associated with the tank are ENRAF surface level data. The leak assessment panel decides that the prior probability of the tank leaking based solely on the tank's and similar tanks' age, operating histories, and leak integrity status, and not considering the event or observation that initiated the leak assessment, is *p*(L) = 0.40. Therefore, the prior probability of the tank not leaking is *p*(NL) = 1 – *p*(L) = 0.60. Using equation (5), the prior likelihood ratio of the tank leaking before the event or discovery that led to the leak assessment is 0.67.

$$\Omega_0 = \frac{p(\mathrm{L})}{p(\mathrm{NL})} \qquad \text{Equation 5}$$

$$\Omega_0 = \frac{0.40}{0.60}$$

$$\Omega_0 = 0.67$$

Next the leak assessment panel examines the ENRAF surface level data and decides that the data are diagnostic for a leak. If the tank were leaking, the surface level data should show a decrease. In this case, no decrease trend is apparent over the past several years. However, a small leak might not be detectable by the ENRAF. The leak assessment panel decides that the posterior probability of a stable surface level trend from a small leak is 0.40; and that the posterior probability of a stable surface level trend from a non-leaking tank is 0.90. Therefore the posterior likelihood ratio for the surface level trend is 0.44

$$\frac{p(\mathrm{D}|\mathrm{L})}{p(\mathrm{D}|\mathrm{NL})} = \frac{0.40}{0.90}$$

$$\frac{p(\mathrm{D}|\mathrm{L})}{p(\mathrm{D}|\mathrm{NL})} = 0.44$$

During the panel's elicitation, the combined posterior likelihood ratio that the tank leaked is determined using Equation 6. The combined posterior likelihood ratio of is the product of the surface level posterior likelihood ratio and the prior likelihood ratio.

$$\Omega_1 = \frac{p(\mathrm{L}|\mathrm{D})}{p(\mathrm{NL}|\mathrm{D})} = \frac{p(\mathrm{D}|\mathrm{L})}{p(\mathrm{D}|\mathrm{NL})} \times \frac{p(\mathrm{L})}{p(\mathrm{NL})} \qquad \text{Equation 6}$$

$$\Omega_1 = 0.44 \times 0.67$$

$$\Omega_1 = 0.29$$

The combined likelihood ratio that the tank leaked is 0.29.

Next, the panel determines the posterior probability that the tank had a small leak that was not detectable in the stable ENRAF surface level data, using Equation 8.

$$p(\mathrm{L}|\mathrm{combined}) = \frac{\Omega_1}{1+\Omega_1} \qquad \text{Equation 8}$$

$$p(\mathrm{L}|\mathrm{combined}) = \frac{0.29}{1 + 0.29}$$

$$p(\mathrm{L}|\mathrm{combined}) = 0.22$$

The panel determines that the posterior probability that the tank leaked is 0.22, or about two chances in seven.

Reference

HNF-3747, 1998, *Tank Leak Assessment Process: Technical Background*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

Appendix B

LIQUID LEVEL INCREASE 2010-2011 – THERMAL EXPANSION OF THE LIQUID WASTE CALCULATION

Primary and annulus ventilation was off between April 10, 2010 and May 13, 2010. Table B-1 shows waste temperature profiles during this outage (PCSACS 2012):

Table B-1. Waste Temperatures During April 10, 2010 to May 13, 2010 Primary and Annulus Ventilation Outage

Elevation from tank bottom (in.)	Temperature on 4/12/2010 (°F)	Temperature on 4/19/2010 (°F)	Temperature on 4/26/2010 (°F)	Temperature on 5/3/2010 (°F)	Temperature on 5/10/2010 (°F)
319	97.5	97.6	98.2	98.4	101.6
295	97.5	97.7	98.3	98.5	103.8
247	97.5	97.8	98.4	98.6	102.8
235	97.4	97.7	98.3	98.7	102.8
223	97.5	97.6	98.3	99.0	102.8
211	97.5	97.6	98.5	99.2	103.7
199	97.6	97.7	98.5	99.1	103.7
175	97.6	97.7	98.7	99.6	103.2
151	97.7	97.8	98.8	99.8	103.2
127	97.7	97.9	98.9	100.0	103.9
115	97.7	97.9	99.1	100.2	103.9
103	97.7	98.6	99.2	100.4	104.6
79	97.9	98.2	99.4	100.8	104.1
55	98.0	98.5	99.7	100.9	104.4
31	123.1	123.1	125.2	127.4	131.2
19	125.6	126.1	129.3	132.0	136.0
7	125.8	128.5	133.2	136.7	140.9

The measured waste level on April 12, 2010 was 330.85 in. and 331.28 in. on May 5, 2010, an increase of 0.43 in. Thermal expansion of the liquid waste can be estimated based on previous work performed for the Hanford Site. Xu and Pruess (2001) examined the relationship between sodium nitrate concentration, temperature, and density, and found that it fit the following empirical formula:

$$\rho = a_1 - b_1(T - 273.15)$$

where

ρ = density (kg/m^3)
a_1 = concentration dependent parameter (kg/m^3)
b_1 = concentration dependent parameter (kg/m^3·K)
T = waste temperature (°K)

From the TWINS data base (2012), sodium nitrate and sodium nitrite concentrations in the supernatant were 132 and 48.6 kg/m^3, respectively. Sodium nitrate and nitrite concentrations in the sludge interstitial liquid were 0.387 and 7.25 kg/m^3, respectively. Supernatant and interstitial liquid densities were 1,290 and 1,150 kg/m^3, respectively. Summing the sodium nitrate and sodium nitrite concentrations and dividing by the respective densities, mass fractions in the supernatant and interstitial liquid were 0.14 and 0.0066, respectively. From Table 1 of Xu and Pruess (2001), the supernatant a_1 parameter is 1103.8 and b_1 parameter is 0.5421. The interstitial liquid a_1 parameter is 1018.5 and the b_1 parameter is 0.4755.

Sludge weight measurements indicate Tank AY-102 has slightly less than 55 in. of sludge. Averaging the bottom three thermocouple temperatures, sludge temperature on April 12, 2010 was 324.7 K. Averaging the 14 thermocouples in the supernatant, the supernatant temperature was 309.6 K. Similarly, the average sludge temperature on May 10, 2010 was 330.9 K and the average supernatant temperature was 312.9 K.

The supernatant liquid volume fraction is obviously 1.0 and the sludge liquid fraction can be calculated using the water fraction in the interstitial liquid (0.82) and water fraction in the bulk settled solids (0.316) and respective densities (TWINS 2012):

$$\left(\frac{0.316\text{ kg water/kg bulk}}{0.82\text{ kg water/kg interstitial}}\right)\left(\frac{1{,}710\text{ kg bulk/m}^3\text{ bulk}}{1{,}150\text{ kg interstitial/m}^3\text{ interstitial}}\right) = 0.57$$

The calculated supernatant density at 309.6 K is the following:

$$\rho = 1{,}103.8 - 0.5421(309.6 - 273.15) = 1{,}084.0$$

The calculated supernatant density at 312.9 K is the following

$$\rho = 1{,}103.8 - 0.5421(312.9 - 273.15) = 1{,}082.2$$

and the corresponding supernatant expansion is

$$\frac{(1{,}084.0 - 1{,}082.2)}{1{,}084.0} = 0.00166$$

The calculated sludge interstitial liquid density at 324.7 K is the following:

$$\rho = 1{,}018.5 - 0.4726(324.7 - 273.15) = 994.1$$

The calculated sludge interstitial liquid density at 330.9 K is the following

$$\rho = 1{,}018.5 - 0.4726(330.9 - 273.15) = 991.2$$

and the corresponding sludge interstitial liquid expansion is

$$\frac{(994.1 - 991.2)}{994.1} = 0.00296$$

The estimated level rise from thermal expansion of the tank liquid is the following

$$(0.00166)(330.85\text{ in.} - 55\text{ in.}) + (0.00296)(55\text{ in.})(0.57) = 0.55\text{ in.}$$

The measured 0.43 in. generally agrees with the theoretically calculated 0.55 in. and falls well within calculation uncertainties.

Ventilation was also off between October 18, 2010 and January 12, 2011. Table B-2 shows waste temperature profiles for this outage (PCSACS 2012).

Table B-2. Waste Temperatures During October 18, 2010 to January 12, 2011 Primary and Annulus Ventilation Outage

Elevation from tank bottom (in.)	Temperature on 10/18/2010 (°F)	Temperature on 11/8/2010 (°F)	Temperature on 11/29/2010 (°F)	Temperature on 12/20/2010 (°F)	Temperature on 1/3/2011 (°F)
319	104.6	107.1	112.9	113.7	114.6
295	104.9	107.3	111.9	113.6	Not Available
247	104.9	107.5	111.9	113.7	114.8
235	104.7	107.7	112.0	113.6	114.8
223	104.8	107.8	111.9	113.6	114.8
211	104.9	108.0	111.9	113.6	114.8
199	105.2	108.4	112.0	113.7	114.8
175	105.4	108.9	111.9	113.7	114.7
151	105.8	109.0	112.0	113.8	114.8
127	106.1	109.6	112.0	113.8	114.8
115	106.3	109.9	112.1	113.9	114.9
103	106.6	110.6	112.1	113.9	115.0
79	107.0	111.1	112.3	114.1	115.1
55	107.5	110.9	112.4	114.2	115.3
31	133.5	137.7	141.0	143.6	145.0
19	137.6	143.4	146.7	149.8	151.4
7	139.6	149.4	152.4	155.7	157.7

Waste level on October 18, 2010 was 326.72 in. and 327.64 in. on January 3, 2011, a measured increase of 0.92 in. Averaging the bottom three thermocouple temperatures, sludge temperature on October 18, 2010 was 331.43 K. Averaging the 14 thermocouples in the supernatant, the supernatant temperature was 314.05 K. The average sludge temperature on January 3, 2011 was 339.46 K and the average supernatant temperature was 319.18 K.

Following the same process as earlier, the calculated supernatant density at 314.05 K is the following:

$$\rho = 1{,}103.8 - 0.5421(314.05 - 273.15) = 1{,}081.6$$

The calculated supernatant density at 319.18 K is the following

$$\rho = 1{,}103.8 - 0.5421(319.18 - 273.15) = 1{,}078.8$$

and the corresponding supernatant expansion is

$$\frac{(1{,}081.6 - 1{,}078.8)}{1{,}081.6} = 0.00257$$

The calculated sludge interstitial liquid density at 331.4 K is the following:

$$\rho = 1{,}018.5 - 0.4726(\,331.43 - 273.15) = 991.0$$

The calculated sludge interstitial liquid density at 339.4 K is the following

$$\rho = 1{,}018.5 - 0.4726(339.4 - 273.15) = 987.2$$

and the corresponding sludge interstitial liquid expansion is

$$\frac{(991.0 - 987.2)}{991.0} = 0.00383$$

The estimated level rise from thermal expansion of the tank liquid is the following

$$(0.00257)(326.72\text{ in.} - 55\text{ in.}) + (0.00383)(55\text{ in.})(0.57) = 0.82\text{ in.}$$

The measured 0.92 in. agrees nicely with the theoretically calculated 0.82 in. and falls well within calculation uncertainties.

Therefore, the two periods of increasing liquid level are an effect of thermal expansion as opposed to any other reason.

Appendix C

TANK AY-102 ENRAF LEAK DETECTOR LIQUID LEVEL 2004-2011

The annulus ENRAF liquid level data, from 2004 to present, obtained from Surveillance Data Display System (SDDS) and PCSACS was reviewed. Figure C-1 shows the liquid level data for the three annulus ENRAFs from July 2004 through December 2004. Liquid level readings were below 0.25 in. and no issues reported were found.

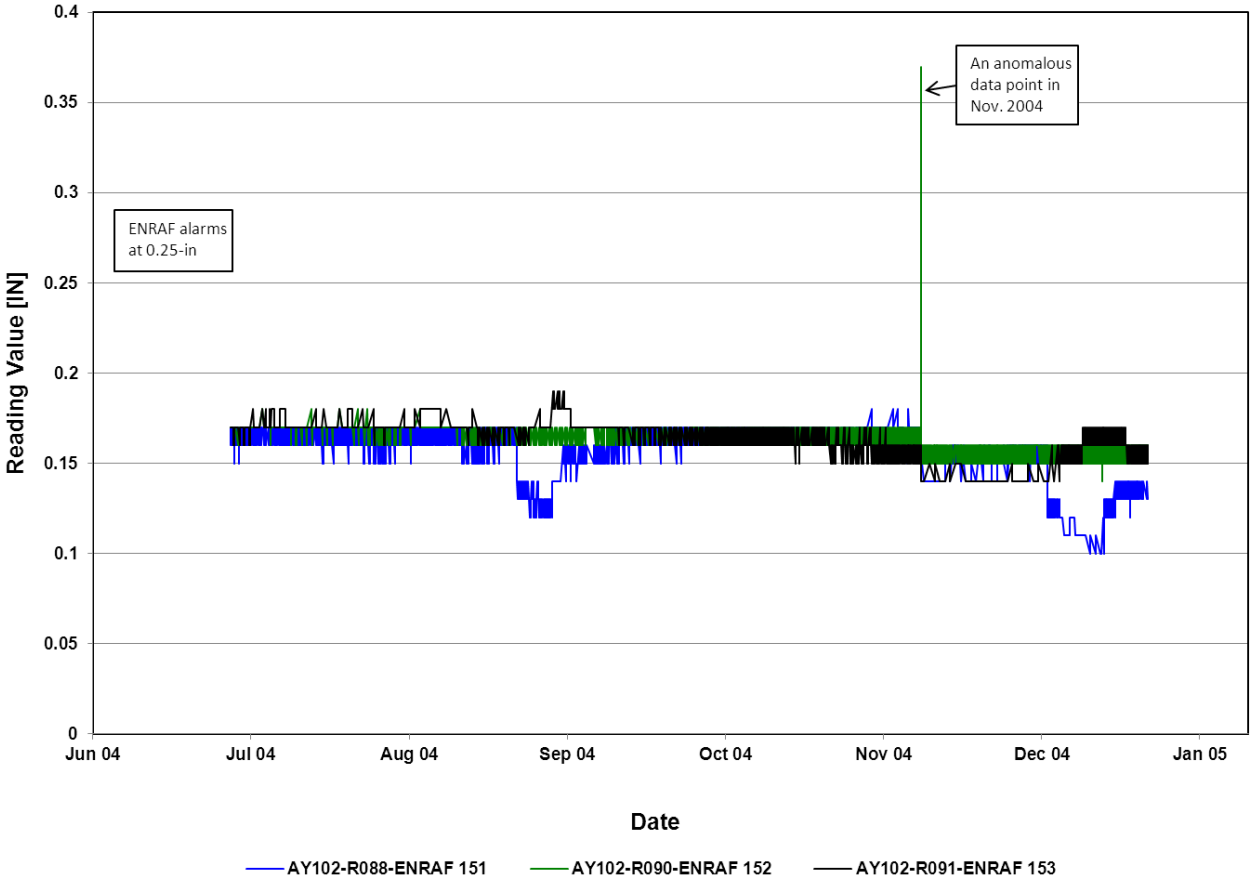


Figure C-1. Tank AY-102 Annulus ENRAFs Liquid Levels 2004

Figure C-2 shows the liquid level data for the three annulus ENRAFs for 2005. Liquid level readings were below the 0.25-in. specification except for three readings. On October 13, 2005, three readings were above 0.25 in., two for Riser 90 (ENRAF 152) and one for Riser 91 (ENRAF 153). It is assumed these were erroneous data points as levels returned to normal within hours.

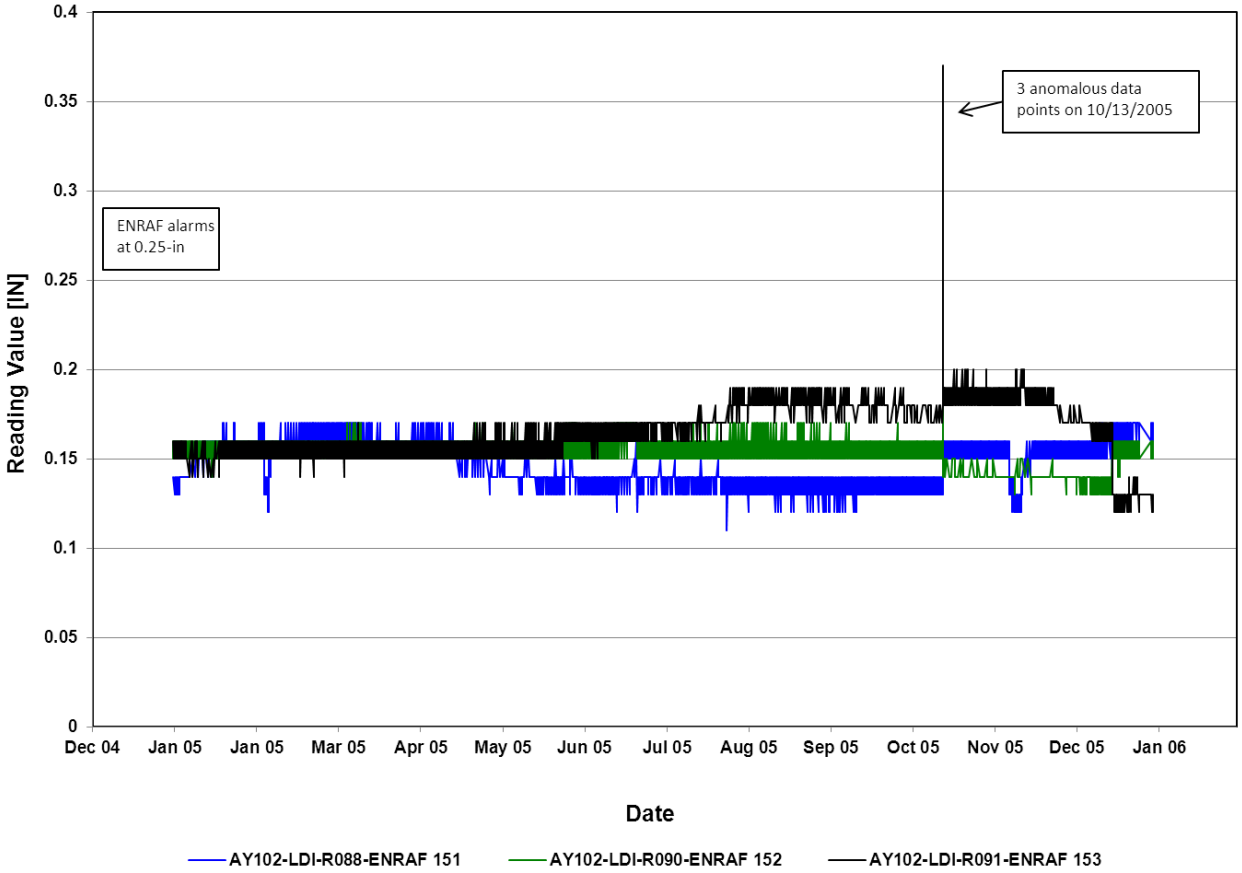


Figure C-2. Tank AY-102 Annulus ENRAFs Liquid Levels 2005

Figure C-3 shows the liquid level data for the three annulus ENRAFs for 2006. Liquid level readings of the annulus ENRAFs were below the 0.25-in. specification except for three readings. On September 6, 2006, three readings were above 0.25 in. for each annulus ENRAF. It is assumed these were erroneous data points due to possible electrical errors as levels returned to normal within hours.

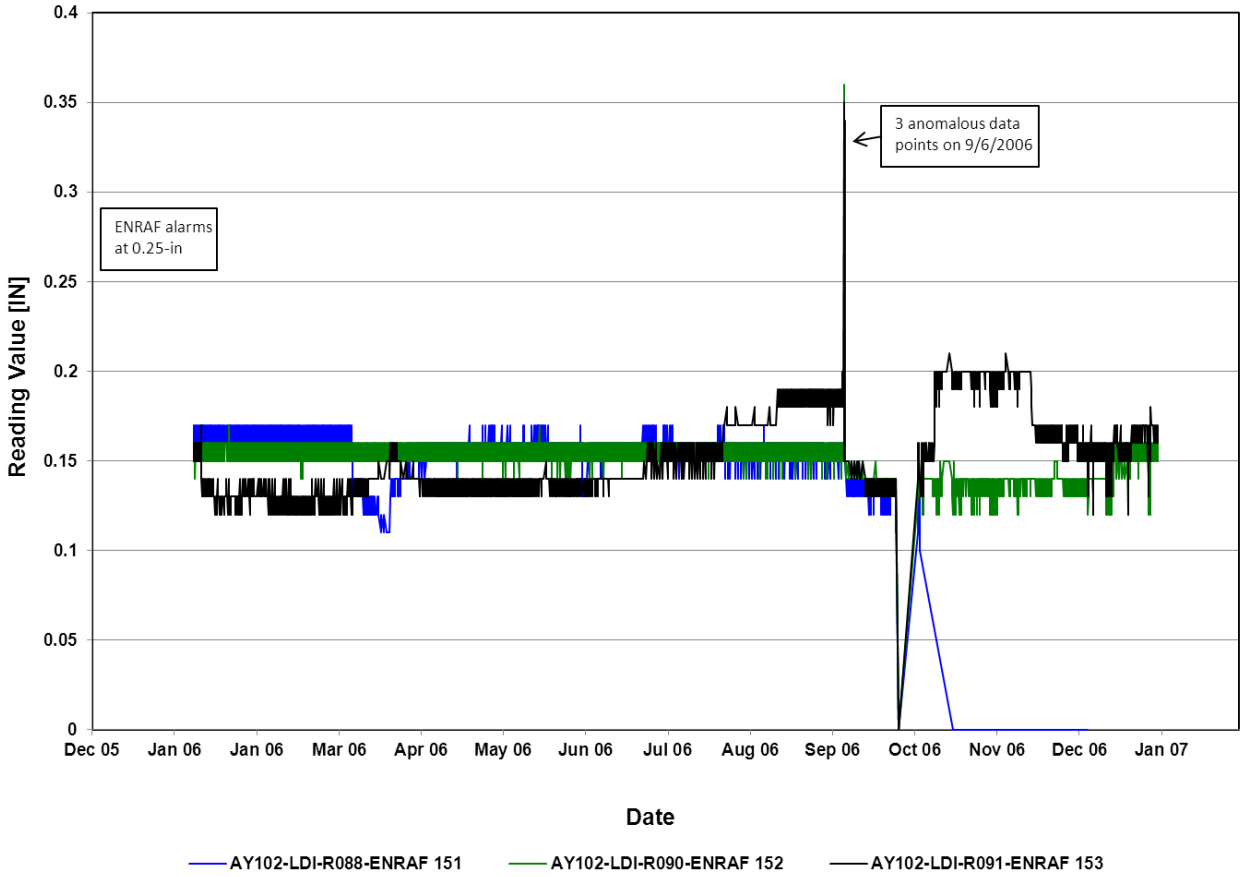


Figure C-3. Tank AY-102 Annulus ENRAFs Liquid Levels 2006

Figure C-4 shows the liquid level data for the three annulus ENRAFs for 2007. There were two instances were liquid level readings were above 0.25 in. The first was in January 2007 at Riser 88 (ENRAF 151) which was reported to be reinstalled on January 8, 2007 after being removed to support UT inspection (CH2M-PER-2007-0138). The second instance was reported on August 13, 2007 when two readings at Riser 90 (ENRAF 152) were above 0.25 in. These were assumed to be erroneous data as liquid level readings returned to normal levels within hours.

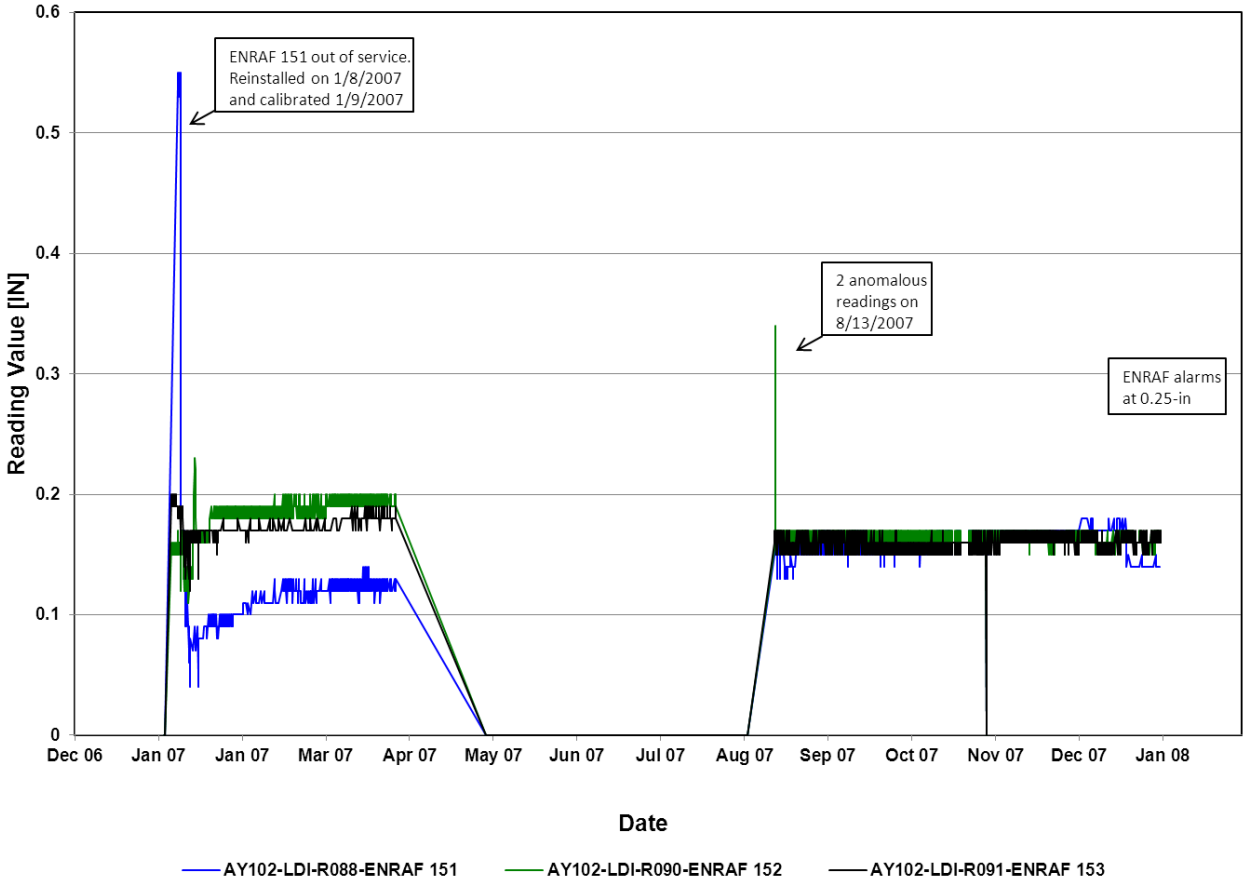


Figure C-4. Tank AY-102 Annulus ENRAFs Liquid Levels 2007

Figure C-5 shows the liquid level data for Riser 88 and Riser 90 annulus ENRAFs. On May 6, 2008, there appears to be one anomalous data point at Riser 90 (ENRAF 152) as liquid levels returned to normal within hours.

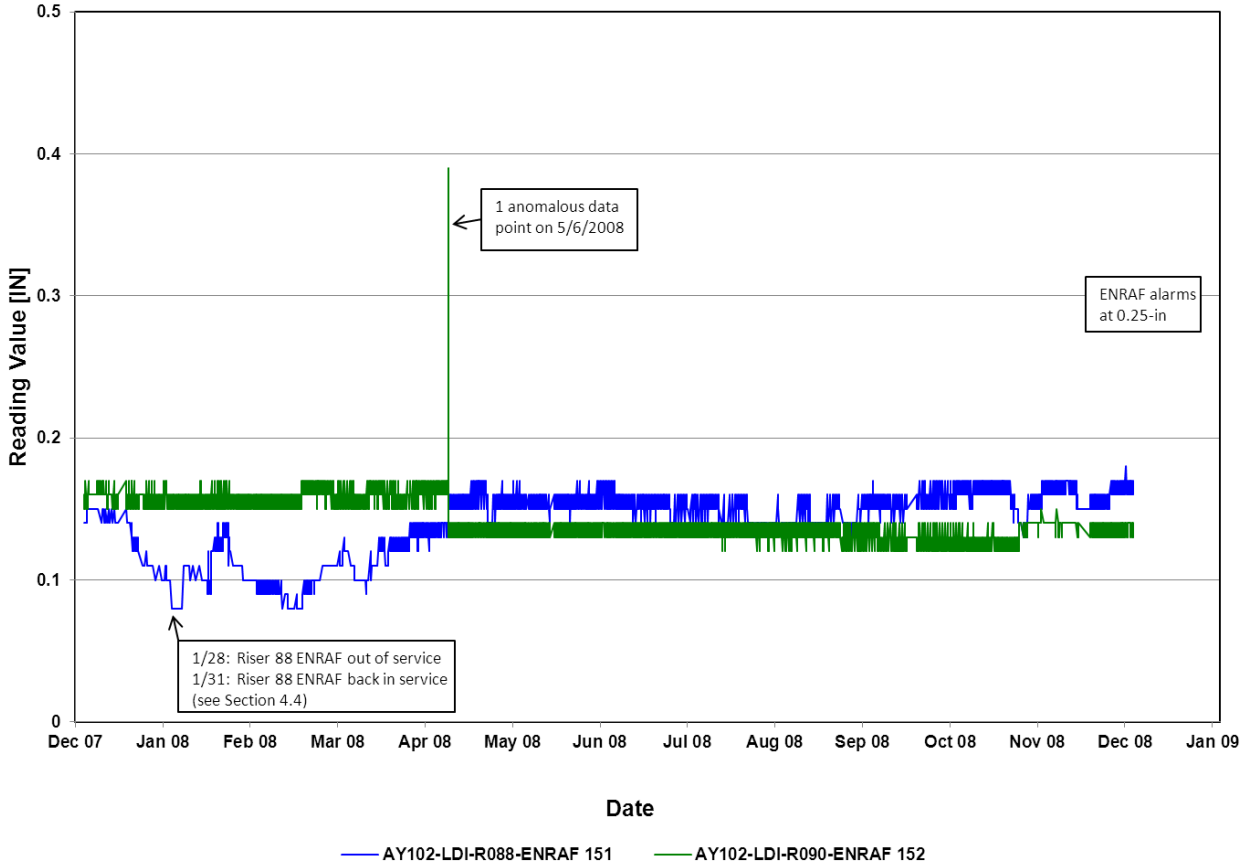


Figure C-5. Tank AY-102 Risers 88 and 90 Annulus ENRAFs Liquid Levels 2008

Figure C-6 shows the annulus ENRAF liquid level data for Riser 91 (ENRAF 153) in 2008. Beginning on January 16, 2008, the reading was reported to be suspect for ENRAF 153 with a PCSACS comment that the ENRAF needed to be re-zeroed (PCSACS comment). On February 14, 2008 ENRAF 153 was taken out of service, and a few days later flushed with approximately 60 gal of water (PCSACS comment). The next ENRAF 153 record is June 19, 2008 when a work package (WFO-WO-08-1135) was written to fix the ENRAF. In July 2008, it appears ENRAF 153 was fixed as liquid level readings decreased from approximately 2.7 in. to 0.14 in. However, on August 13, 2008 it was reported that ENRAF 153 was found out of range and was taken out of service (see Section 4.4). There were additional comments in PCSACS stating this ENRAF was still drifting and needs to be re-zeroed through October.

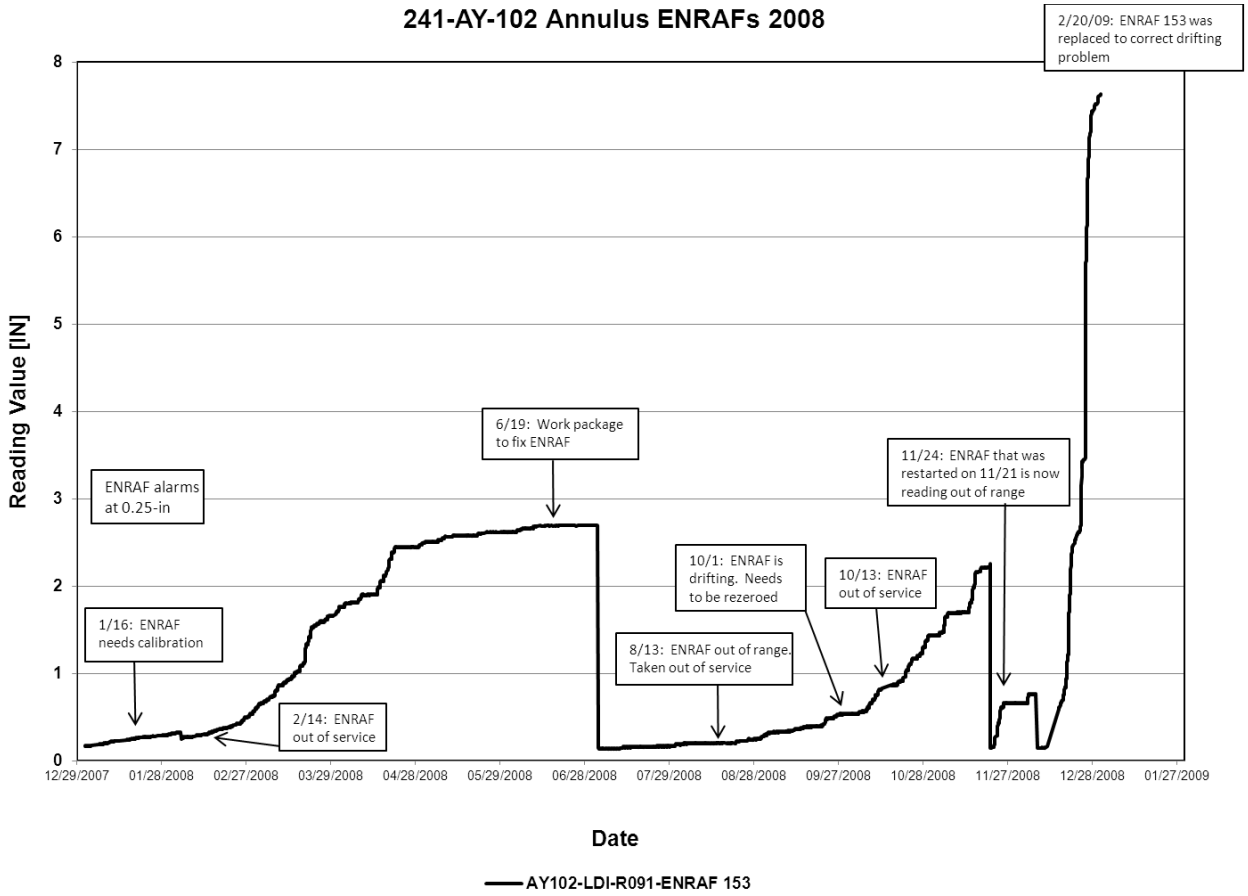


Figure C-6. Tank AY-102 Riser 91 Annulus ENRAFs Liquid Levels 2008

ENRAF 153 appears to have been re-zeroed on November 21, 2008. One environmental log dated November 24, 2008 stated, "Base Ops Shift Office reports AY102 Annulus ENRAF, which was restarted to service on 11/21/08, is now reading out of range" (see Section 4.4). It is assumed this entry is referring to ENRAF 153 as the other two annulus ENRAFs appeared to be in working condition during this time. The next record comment is February 20, 2009 which states that ENRAF 153 was replaced to correct the drifting problems (PCSACS comment). Thus, it appears any ENRAF 153 readings above the 0.25-in. specification in 2008 were assigned to instrument failure.

Figure C-7 shows the liquid level data for the three annulus ENRAFs for 2009. All readings were below the 0.25-in. specification except for three readings. On July 28, 2009, three readings were above 0.25 in. for ENRAF 153. It is assumed these were erroneous data points because the level returned to normal within hours. ENRAF 153 was replaced on February 20, 2009.

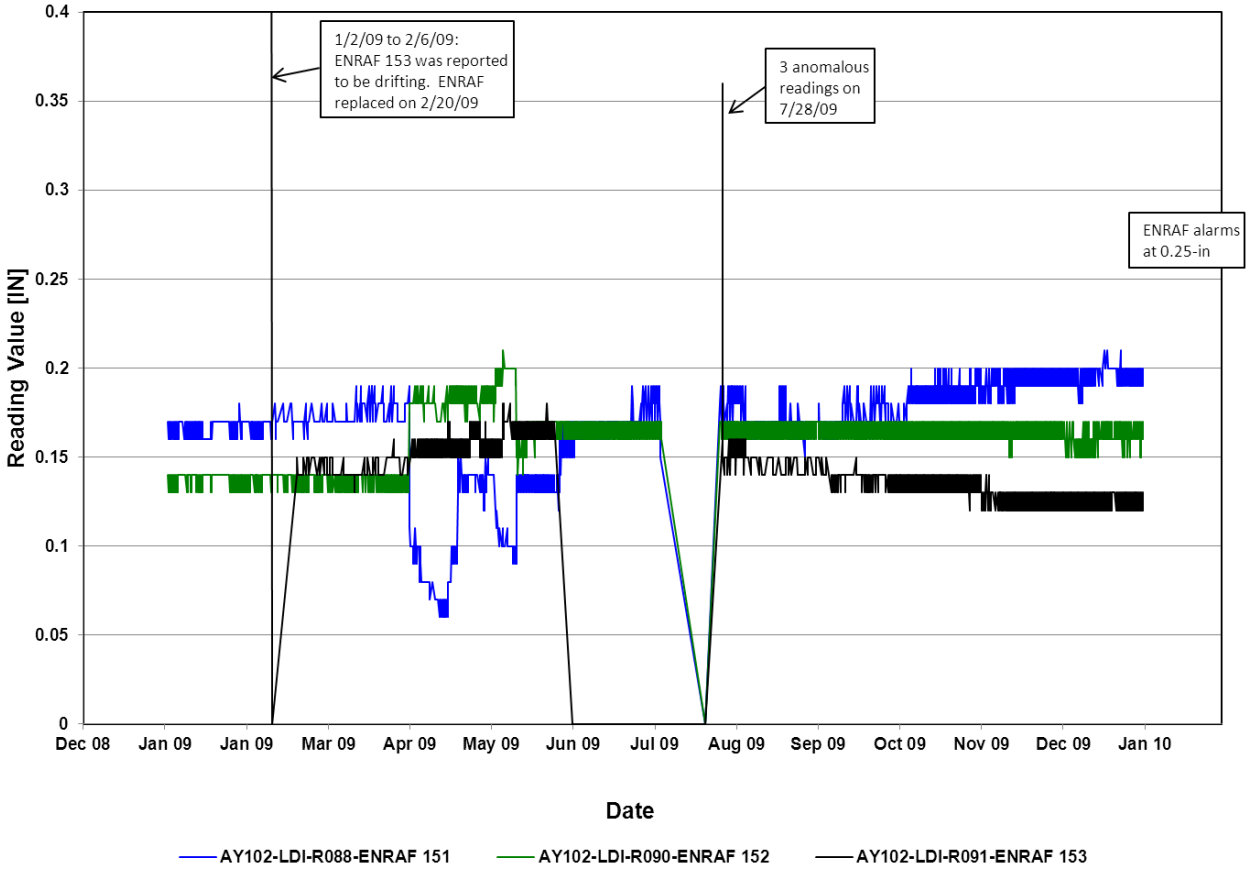


Figure C-7. Tank AY-102 Annulus ENRAFs Liquid Levels 2009

Figure C-8 shows the liquid level data for the three annulus ENRAFs for 2010. Liquid level readings were below the 0.25-in. specification for the available data.

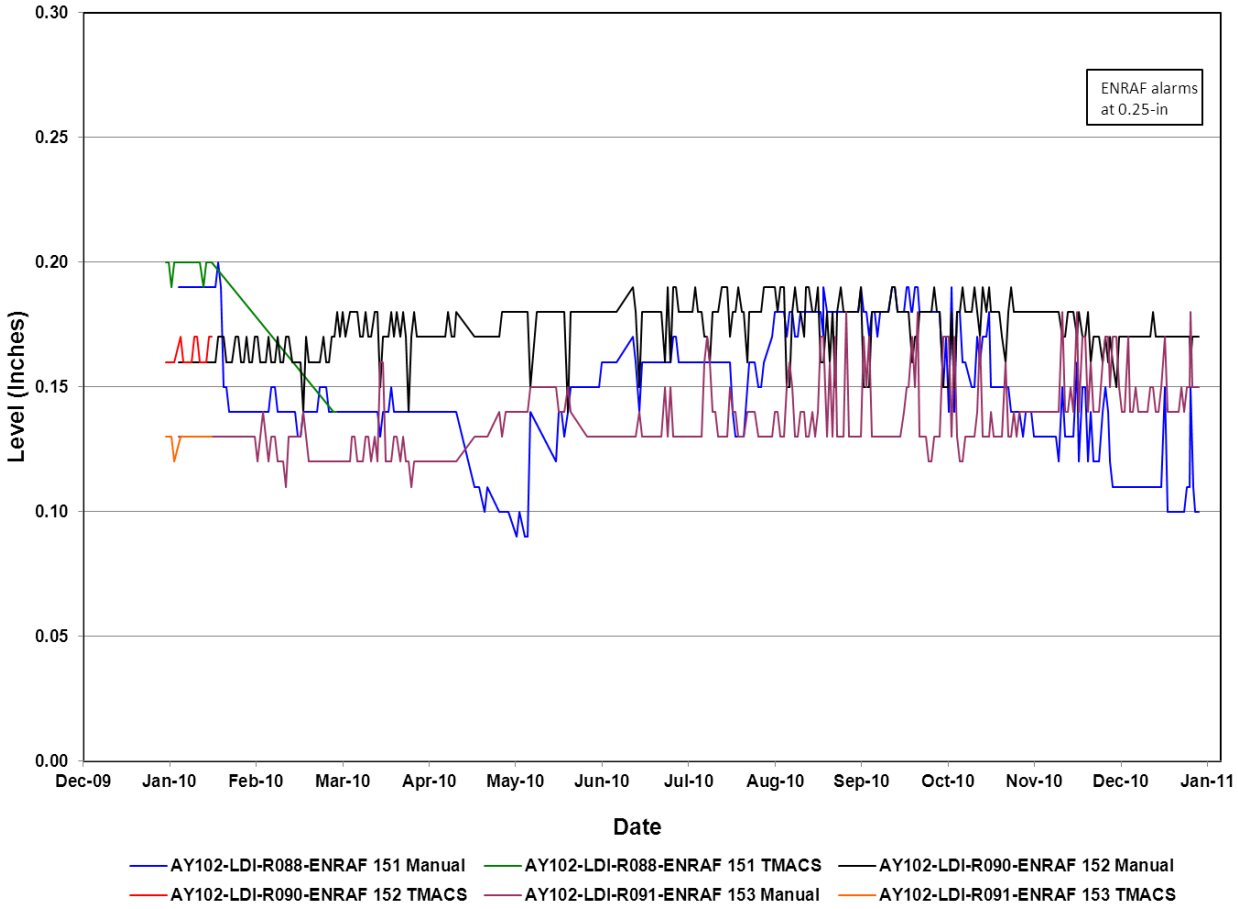


Figure C-8. Tank AY-102 Annulus ENRAFs Liquid Levels 2010

Figure C-9 shows the liquid level data for the three annulus ENRAFs for 2011. ENRAFs 151 and 153 levels were below the 0.25-in. specification from March through December 2011.

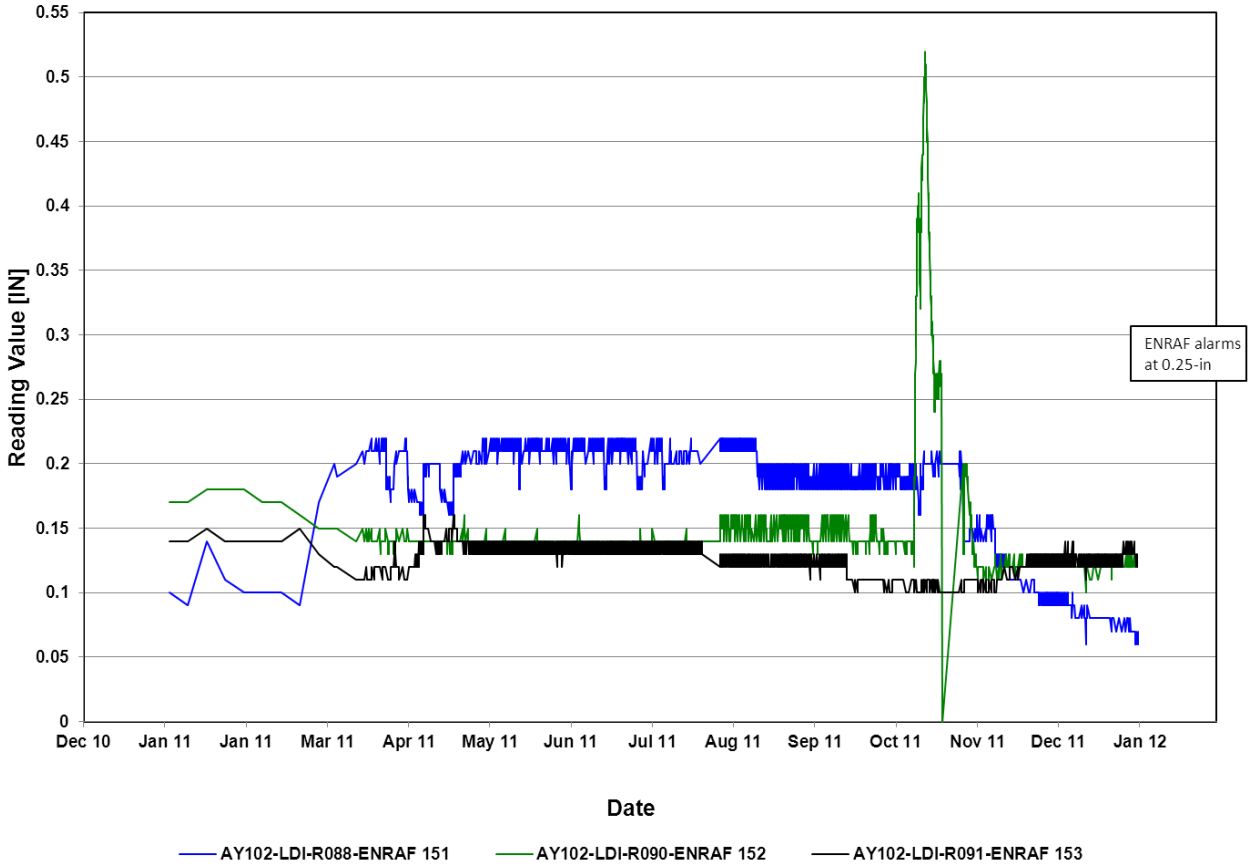


Figure C-9. Tank AY-102 Annulus ENRAFs Liquid Levels 2011

Appendix D

TANK AY-102 CONTINUOUS AIR MONITOR SAMPLE RESULTS

Table D-1. Tank AY-102 CAM Sample Results March 2005- September 2012 (4 pages)

Location Code	Count Room Sample ID	Sample Number	Sample Collection Period (Date and Time)		Samples Activity (Net Counts)		Rotameter			Volume (cu ft)	Concentration				
			On	Off	Alpha	Beta	On	Off	Units		a (mCi/cc)	a DAC	b (mCi/cc)	b DAC	TOTAL DAC
E146	N/A	S643804	03/19/05 09:08	04/21/05 12:53	0.00	38.57	2.1	1.7	cfm	88717.2	0.00E+00	0.00E+00	1.71E-14	1.71E-06	1.71E-06
E146	N/A	S653019	04/21/05 12:53	07/09/05 08:38	0.00	21.30	2.1	1.7	cfm	212024.9	0.00E+00	0.00E+00	3.85E-15	3.85E-07	3.85E-07
E146	N/A	S662455	09/06/05 12:46	10/12/05 09:17	0.40	30.37	2.0	1.7	cfm	93146.2	1.90E-16	3.80E-05	1.46E-14	1.46E-06	3.95E-05
E146	N/A	S672983	10/31/05 08:41	12/27/05 09:25	9.43	50.30	2.1	1.9	cfm	159865.1	2.60E-15	5.20E-04	1.19E-14	1.19E-06	5.21E-04
E145	N/A	S657675	12/27/05 9:25	1/12/06 14:56	0.00	38.30	2.00	1.84	cfm	44116.1	0.00E+00	0.00E+00	3.35E-14	3.35E-06	3.35E-06
E146	N/A	S689757	9/5/06 13:17	9/18/06 10:49	0.00	17.80	1.94	1.89	cfm	34966.0	0.00E+00	0.00E+00	1.93E-14	1.93E-06	1.93E-06
E146	N/A	S695969	9/18/06 10:56	9/27/06 10:36	1.93	173.83	2.04	1.75	cfm	24108.0	3.59E-15	7.18E-04	2.71E-13	2.71E-05	7.45E-04
E146	N/A	S700795	9/27/06 10:36	10/14/06 8:41	0.00	81.13	1.97	2.00	cfm	47549.4	0.00E+00	0.00E+00	6.38E-14	6.38E-06	6.38E-06
E146	N/A	S701510	10/18/06 13:35	10/31/06 13:56	0.00	69.70	2.04	1.53	cfm	32888.9	0.00E+00	0.00E+00	8.14E-14	8.14E-06	8.14E-06
E146	N/A	S704689	10/31/06 13:58	11/14/06 9:26	0.97	27.40	2.05	0.00	cfm	20041.6	2.12E-15	4.24E-04	5.03E-14	5.03E-06	4.29E-04
E146	N/A	S706772	11/14/06 9:27	11/22/06 8:35	0.00	24.90	0.00	1.84	cfm	10372.7	0.00E+00	0.00E+00	9.24E-14	9.24E-06	9.24E-06
E146	N/A	S708181	11/22/06 8:40	12/12/06 12:52	0.00	129.03	2.06	1.81	cfm	55268.2	0.00E+00	0.00E+00	8.73E-14	8.73E-06	8.73E-06
E146	N/A	S709582	12/12/06 13:06	12/27/06 13:24	0.00	153.23	1.89	1.69	cfm	38044.1	0.00E+00	0.00E+00	1.51E-13	1.51E-05	1.51E-05
E146	N/A	S707860	12/27/06 13:25	1/6/07 10:42	0.00	48.23	1.86	1.09	cfm	20645.7	0.00E+00	0.00E+00	8.65E-14	8.65E-06	8.65E-06
E146	N/A	S689746	1/6/07 10:42	1/10/07 10:05	0.43	35.43	2.01	1.40	cfm	9593.3	2.04E-15	4.08E-04	1.40E-13	1.40E-05	4.22E-04
E146	N/A	S711834	1/10/07 10:06	1/24/07 9:56	0.00	407.90	2.00	1.53	cfm	34965.4	0.00E+00	0.00E+00	4.43E-13	4.43E-05	4.43E-05
E146	N/A	S707856	1/24/07 9:57	2/6/07 12:59	0.00	181.13	1.94	1.83	cfm	35029.8	0.00E+00	0.00E+00	1.98E-13	1.98E-05	1.98E-05
E146	N/A	S715112	2/6/07 13:01	2/21/07 8:57	0.00	234.50	1.95	1.89	cfm	40312.5	0.00E+00	0.00E+00	2.16E-13	2.16E-05	2.16E-05
E146	N/A	S717938	2/21/07 8:58	3/22/07 10:40	0.40	50.03	1.94	0.00	cfm	39921.8	4.60E-16	9.20E-05	4.82E-14	4.82E-06	9.68E-05
E146	N/A	S719035	3/22/07 10:41	4/4/07 10:24	0.47	22.27	0.00	0.00	cfm	0.0	2.30E-13	4.60E-02	9.63E-12	9.63E-04	*0.00E+00*
E146	N/A	S707855	4/4/07 10:25	6/21/07 9:46	0.43	41.57	0.00	2.00	cfm	110388.7	3.46E-14	6.92E-03	3.07E-11	3.07E-03	*0.00E+00*
E146	N/A	S719808	7/24/07 13:33	8/7/07 13:03	0.00	41.33	1.95	0.00	cfm	19296.0	0.00E+00	0.00E+00	8.52E-13	8.52E-05	8.52E-05
E146	N/A	S737094	8/7/07 13:04	10/18/07 10:21	0.00	0.00	0.00	1.80	cfm	91595.2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E146	N/A	S749326	10/18/07 10:23	3/19/08 8:29	0.00	0.00	0.00	0.00	cfm	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E146	N/A	S747694	3/19/08 8:29	6/12/08 9:33	0.40	13.73	0.00	2.00	cfm	120400.1	1.46E-13	2.92E-02	4.65E-15	4.65E-07	*0.00E+00*
E146	N/A	S758046	6/12/08 9:33	6/25/08 10:37	0.50	25.10	2.00	1.93	cfm	36288.5	6.12E-16	1.22E-04	2.84E-14	2.84E-06	1.25E-04
E146	N/A	S760452	7/9/08 8:55	7/22/08 9:27	1.90	1360.80	1.97	2.05	cfm	37056.3	2.22E-15	4.44E-04	1.47E-12	1.47E-04	5.91E-04
E146	N/A	S761819	7/22/08 9:28	8/7/08 12:44	2.40	445.37	2.16	2.10	cfm	48658.6	2.15E-15	4.30E-04	3.70E-13	3.70E-05	4.67E-04
E146	N/A	S763295	8/7/08 12:45	8/20/08 12:59	0.43	22.87	2.11	2.05	cfm	38310.0	4.94E-16	9.88E-05	2.41E-14	2.41E-06	1.01E-04
E146	N/A	S765006	8/20/08 13:00	9/4/08 9:16	3.90	1317.10	2.18	2.10	cfm	44973.7	3.80E-15	7.60E-04	1.19E-12	1.19E-04	8.79E-04
E146	N/A	S765686	9/4/08 9:17	9/16/08 9:47	5.90	1386.10	2.16	2.08	cfm	36078.7	4.26E-15	8.52E-04	1.58E-12	1.58E-04	1.01E-03
E146	N/A	S767407	9/16/08 9:49	10/2/08 9:39	0.00	37.77	2.11	2.05	cfm	47095.1	0.00E+00	0.00E+00	3.32E-14	3.32E-06	3.32E-06

Table D-1. Tank AY-102 CAM Sample Results March 2005- September 2012 (4 pages)

Location Code	Count Room Sample ID	Sample Number	Sample Collection Period (Date and Time)		Samples Activity (Net Counts)		Rotameter			Volume (cu ft)	Concentration				
			On	Off	Alpha	Beta	On	Off	Units		a (mCi/cc)	a DAC	b (mCi/cc)	b DAC	TOTAL DAC
E146	N/A	S768946	10/2/08 9:39	10/15/08 8:58	0.00	47.40	2.11	1.95	cfm	37279.3	0.00E+00	0.00E+00	4.77E-14	4.77E-06	4.77E-06
E146	N/A	S770521	10/15/08 8:58	10/30/08 10:29	0.50	283.47	2.00	2.07	cfm	43397.3	5.04E-16	1.01E-04	2.64E-13	2.64E-05	1.27E-04
E146	N/A	S771529	10/30/08 10:29	11/11/08 12:42	0.93	1136.93	2.11	1.93	cfm	34581.5	1.20E-15	2.40E-04	1.35E-12	1.35E-04	3.75E-04
E146	N/A	S772732	11/11/08 12:42	12/11/08 9:28	2.47	853.43	2.00	2.01	cfm	84773.8	1.29E-15	2.58E-04	4.11E-13	4.11E-05	2.99E-04
E146	N/A	S749658	12/11/08 9:28	12/22/08 12:47	0.00	62.43	0.00	2.00	cfm	15768.7	0.00E+00	0.00E+00	1.61E-13	1.61E-05	1.61E-05
E146	N/A	S778987	12/22/08 12:47	2/18/09 9:41	0.93	19.70	0.00	0.10	cfm	4166.7	1.00E-14	2.00E-03	1.96E-13	1.96E-05	2.02E-03
E146	N/A	S781016	3/5/09 10:08	3/18/09 9:25	1.97	531.73	1.90	1.88	cfm	34704.6	2.48E-15	4.96E-04	6.21E-13	6.21E-05	5.58E-04
E146	N/A	S782719	3/18/09 9:26	4/24/09 9:42	4.93	1814.03	1.91	2.00	cfm	102437.7	2.07E-15	4.14E-04	7.24E-13	7.24E-05	4.86E-04
E146	N/A	S784347	4/24/09 9:45	6/11/09 10:29	1.00	2309.97	2.13	2.01	cfm	140756.6	3.03E-16	6.06E-05	6.02E-13	6.02E-05	1.21E-04
E146	N/A	S787429	6/11/09 10:29	6/23/09 9:04	0.00	1004.83	2.10	2.07	cfm	35247.4	0.00E+00	0.00E+00	1.07E-12	1.07E-04	1.07E-04
E146	N/A	S791637	6/23/09 9:11	7/9/09 9:38	0.00	831.00	2.16	2.08	cfm	48077.9	0.00E+00	0.00E+00	6.46E-13	6.46E-05	6.46E-05
E146	N/A	S788634	7/9/09 9:39	7/20/09 6:27	0.47	677.73	2.11	2.10	cfm	32383.9	6.37E-16	1.27E-04	7.96E-13	7.96E-05	2.07E-04
E146	N/A	S794626	7/20/09 6:27	8/5/09 9:15	0.00	0.00	2.13	1.97	cfm	46774.6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E146	N/A	S796778	8/5/09 9:17	8/20/09 8:54	0.00	575.73	2.16	2.08	cfm	44972.3	0.00E+00	0.00E+00	4.79E-13	4.79E-05	4.79E-05
E146	N/A	S796824	8/20/09 8:56	9/3/09 9:34	0.00	874.50	2.13	2.00	cfm	41005.9	0.00E+00	0.00E+00	8.15E-13	8.15E-05	8.15E-05
E146	N/A	S800939	9/17/09 9:16	10/1/09 10:27	0.00	261.40	1.89	2.07	cfm	39382.3	0.00E+00	0.00E+00	2.49E-13	2.49E-05	2.49E-05
E146	N/A	S800978	10/1/09 10:27	10/15/09 10:29	0.00	141.13	2.07	0.00	cfm	20516.0	0.00E+00	0.00E+00	2.57E-13	2.57E-05	2.57E-05
E146	N/A	S810992	10/15/09 10:30	12/27/09 8:18	0.00	0.00	0.00	0.00	cfm	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E146	N/A	S809027	12/27/09 8:19	1/20/10 9:55	0.93	717.10	0.00	2.01	cfm	34242.3	5.80E-16	1.16E-04	3.83E-13	3.83E-05	1.54E-04
E146	N/A	S813471	1/20/10 9:55	2/4/10 13:55	0.50	2577.63	2.00	2.00	cfm	42943.9	5.13E-16	1.03E-04	2.28E-12	2.28E-04	3.31E-04
E146	N/A	S815473	2/4/10 13:55	2/18/10 14:07	0.00	575.20	2.10	1.93	cfm	39961.6	0.00E+00	0.00E+00	5.50E-13	5.50E-05	5.50E-05
E146	N/A	S817202	2/18/10 14:08	3/4/10 8:20	0.50	807.77	2.08	1.94	cfm	39151.0	5.66E-16	1.13E-04	7.86E-13	7.86E-05	1.92E-04
E146	N/A	S804825	3/4/10 8:21	3/18/10 12:31	0.50	164.77	2.07	1.94	cfm	40232.4	1.26E-15	2.52E-04	3.57E-13	3.57E-05	2.88E-04
E146	N/A	S820589	3/18/10 12:33	4/1/10 9:26	0.00	701.77	2.01	1.90	cfm	38389.1	0.00E+00	0.00E+00	6.95E-13	6.95E-05	6.95E-05
E146	N/A	S803015	4/1/10 9:26	5/26/10 13:07	1.90	674.20	2.00	1.84	cfm	149918.4	5.41E-16	1.08E-04	1.65E-13	1.65E-05	1.25E-04
E146	N/A	S826843	5/26/10 13:07	6/8/10 12:52	0.40	417.20	2.16	2.05	cfm	38710.4	4.27E-16	8.54E-05	3.84E-13	3.84E-05	1.24E-04
E146	N/A	S830265	6/8/10 12:53	6/23/10 8:35	0.90	284.37	2.20	2.01	cfm	44167.8	8.51E-16	1.70E-04	2.59E-13	2.59E-05	1.96E-04
E146	N/A	S831691	6/23/10 8:36	7/12/10 1:55	0.93	268.97	2.07	1.83	cfm	51684.1	7.85E-16	1.57E-04	2.09E-13	2.09E-05	1.78E-04
E146	N/A	S833386	7/12/10 1:55	7/28/10 8:54	0.00	201.57	2.07	1.94	cfm	46242.6	0.00E+00	0.00E+00	1.76E-13	1.76E-05	1.76E-05
E146	N/A	S749758	7/28/10 8:55	8/10/10 10:29	0.47	213.07	2.10	1.75	cfm	35606.6	5.63E-16	1.13E-04	2.37E-13	2.37E-05	1.36E-04
E146	N/A	S836113	8/10/10 10:31	8/25/10 8:34	0.00	15.00	2.18	1.86	cfm	42664.3	0.00E+00	0.00E+00	1.46E-14	1.46E-06	1.46E-06
E146	N/A	S838696	8/25/10 8:34	9/24/10 8:14	0.00	479.33	2.10	1.88	cfm	84480.0	0.00E+00	0.00E+00	2.27E-13	2.27E-05	2.27E-05

Table D-1. Tank AY-102 CAM Sample Results March 2005- September 2012 (4 pages)

Location Code	Count Room Sample ID	Sample Number	Sample Collection Period (Date and Time)		Samples Activity (Net Counts)		Rotameter			Volume (cu ft)	Concentration				
			On	Off	Alpha	Beta	On	Off	Units		a (mCi/cc)	a DAC	b (mCi/cc)	b DAC	TOTAL DAC
E146	N/A	S841629	2/17/11 9:14	3/7/11 12:56	0.50	523.33	0.00	1.68	cfm	21589.2	9.95E-16	1.99E-04	9.62E-13	9.62E-05	2.95E-04
E146	N/A	S850672	3/7/11 13:01	3/30/11 12:27	2.50	903.33	2.01	1.76	cfm	61316.0	1.76E-15	3.52E-04	5.87E-13	5.87E-05	4.11E-04
E146	N/A	S855941	3/30/11 12:27	4/13/11 13:24	0.00	444.83	1.98	1.94	cfm	38957.5	0.00E+00	0.00E+00	4.61E-13	4.61E-05	4.61E-05
E146	N/A	S862842	5/12/11 13:10	5/24/11 9:16	0.93	510.00	2.00	1.81	cfm	31925.4	1.26E-15	2.52E-04	6.65E-13	6.65E-05	3.19E-04
E146	N/A	S864701	5/24/11 9:19	6/8/11 10:29	0.93	479.50	1.94	1.91	cfm	41011.7	9.90E-16	1.98E-04	4.92E-13	4.92E-05	2.47E-04
E146	N/A	S866284	6/8/11 10:30	6/23/11 9:47	0.43	444.50	2.16	2.00	cfm	44082.9	5.86E-16	1.17E-04	5.81E-13	5.81E-05	1.75E-04
E146	CR11-01897	S845318	6/23/11 9:49	7/6/11 8:53	0.96	361.19	2.00	1.89	cfm	35689.7	1.34E-15	2.68E-04	3.57E-13	3.57E-05	3.04E-04
E146	CR11-01897	S852925	8/4/11 9:06	8/18/11 10:30	0.00	303.19	2.18	1.89	cfm	40502.2	0.00E+00	0.00E+00	2.62E-13	2.62E-05	2.62E-05
E146	CR11-01897	S872326	8/18/11 10:33	8/31/11 12:33	0.96	205.19	2.20	2.02	cfm	39082.4	1.23E-15	2.46E-04	1.86E-13	1.86E-05	2.65E-04
E146	CR11-01897	S871493	8/31/11 12:34	9/14/11 10:29	0.00	211.19	2.11	1.72	cfm	37720.4	0.00E+00	0.00E+00	1.99E-13	1.99E-05	1.99E-05
E146	CR11-01992	S875082	9/14/11 10:29	10/3/11 9:03	0.37	267.33	2.11	1.84	cfm	52958.3	3.51E-16	7.02E-05	1.80E-13	1.80E-05	8.82E-05
E146	CR11-02077	S875035	10/3/11 9:05	10/21/11 9:24	2.95	8657.41	2.20	2.00	cfm	53553.9	2.67E-15	5.34E-04	5.66E-12	5.66E-04	1.10E-03
E146	CR11-02070	S875083	10/21/11 9:26	10/26/11 13:47	9.75	18270.00	2.20	2.00	cfm	15404.0	3.06E-14	6.12E-03	4.14E-11	4.14E-03	1.03E-02
E146	CR11-2174	S881311	10/26/11 13:47	11/14/11 14:05	0.58	816.70	2.20	0.00	cfm	29608.3	9.66E-16	1.93E-04	9.74E-13	9.74E-05	2.91E-04
E146	CR12-00061	S875087	12/27/11 14:15	1/18/12 10:00	1.37	2059.71	0.00	2.00	cfm	30895.4	2.15E-15	4.30E-04	2.33E-12	2.33E-04	6.63E-04
E146	CR12-00171	S886979	1/18/12 10:01	2/1/12 12:54	0.00	815.58	2.1	2.0	cfm	41280.0	0.00E+00	0.00E+00	7.03E-13	7.03E-05	7.03E-05
E146	CR12-00171	S889488	2/1/12 12:54	2/15/12 14:09	2.35	1377.78	2.08	2.00	cfm	40583.7	2.76E-15	5.52E-04	1.15E-12	1.15E-04	6.67E-04
E146	CR12-00228	S889530	2/15/12 14:18	2/29/12 13:24	5.75	4232.58	2.20	2.01	cfm	41609.8	6.87E-15	1.37E-03	3.59E-12	3.59E-04	1.73E-03
E146	CR12-00316	S891918	2/29/12 13:25	3/21/12 12:19	0.77	1821.00	2.20	1.95	cfm	61555.9	5.96E-16	1.19E-04	1.05E-12	1.05E-04	2.24E-04
E146	CR12-00604	S892803	3/21/12 12:20	4/11/12 13:39	1.36	813.97	2.20	1.79	cfm	59467.0	1.13E-15	2.26E-04	4.82E-13	4.82E-05	2.74E-04
E146	CR12-00736	S896529	4/11/12 13:39	5/18/12 9:46	1.16	937.00	2.20	1.88	cfm	106392.1	5.32E-16	1.06E-04	3.19E-13	3.19E-05	1.38E-04
E146	CR12-00982	S900002	5/18/12 9:47	6/29/12 12:32	1.95	1028.35	1.93	1.83	cfm	112091.1	8.49E-16	1.70E-04	3.33E-13	3.33E-05	2.03E-04
E146	CR12-01194	S904011	6/29/12 13:01	8/13/12 9:15	27.74	1369.68	2.26	1.65	cfm	124114.6	1.10E-14	2.20E-03	4.02E-13	4.02E-05	2.24E-03
E146	CR12-01211	S904057	8/13/12 9:17	8/15/12 13:47	0.00	21.80	2.00	2.00	cfm	2836.0	0.00E+00	0.00E+00	2.70E-15	2.70E-07	2.70E-07
E146	CR12-01386	S904054	8/15/12 13:47	8/24/12 9:07	0.16	90.03	2.00	2.00	cfm	24932.6	3.05E-16	6.10E-05	1.31E-13	1.31E-05	7.41E-05
E146	CR12-01438	S905762	8/24/12 9:09	9/7/12 13:44	0.96	307.86	2.00	1.90	cfm	39176.7	4.39E-16	8.78E-05	2.91E-13	2.91E-05	1.17E-04
E146	CR12-01574	S905881	9/7/12 13:46	9/16/12 7:55	0.14	11.40	2.2	1.7	cfm	24173.2	2.79E-16	5.58E-05	1.71E-14	1.71E-06	5.75E-05
E146	CR12-01575	S905880	9/16/12 7:55	9/21/12 9:09	0.54	49.00	2.2	1.6	cfm	13766.5	1.94E-15	3.88E-04	1.31E-13	1.31E-05	4.01E-04
E146	CR12-01573	S905886	9/21/12 9:10	9/27/12 12:52	0.16	8229.97	2.1	1.8	cfm	16815.4	4.67E-16	9.34E-05	1.75E-11	1.75E-03	1.8E-03
E146	NA	S907964	09/27/12 12:54	10/05/12 10:45	NA	NA	NA	NA	NA	21670.1	NA	NA	NA	NA	NA

Table D-1. Tank AY-102 CAM Sample Results March 2005- September 2012 (4 pages)

Location Code	Count Room Sample ID	Sample Number	Sample Collection Period (Date and Time)		Samples Activity (Net Counts)		Rotameter			Volume (cu ft)	Concentration				
			On	Off	Alpha	Beta	On	Off	Units		a (mCi/cc)	a DAC	b (mCi/cc)	b DAC	TOTAL DAC
E146	CR12-01717	S908928	10/05/12 10:47	10/16/12 21:00	12.96	18729.37	2.3	1.8	cfm	33160.2	1.90E-14	3.80E-03	2.04E-11	2.04E-03	5.84E-03
E146	CR12-01744	S892845	10/16/12 21:00	10/17/12 21:15	1.14	17203.84	1.9	2.0	cfm	2789.4	1.92E-16	3.84E-05	2.11E-12	2.11E-04	2.49E-04
E146	CR12-01771	S900047	10/17/12 21:15	10/18/12 12:20	1.96	37588.37	2.1	2.0	cfm	1824.0	5.16E-14	1.03E-02	7.38E-10	7.38E-02	8.41E-02

Net counts are above 1,000 cpm

NA = Not available

Appendix E

TANK AY-102 REGULATORY NOTIFICATIONS 2000-2012

Table E-1. 2000 Environmental Notifications (2 pages)

Date	Time Logged	Notification Number	Description
2/14/2000	1655	No CNS Number[1]	296-A-19, AY102 tank annulus ventilation stack record sampler was discovered out of service. The air pump had failed. Air pump was replaced, system placed back in service 2/15/00 at 0950 hours.
2/23/2000	1759	No CNS Number[1]	During equipment checks in the 296-A-42, 702AZ stack monitoring cabinet, a record sampler low flow alarm and CAM high Rad alarm sounded. Both alarms sounded when the cabinet door was opened. Both alarms reset. The record sampler was offline for 30 seconds.
3/29/2000	0913	No CNS Number[1]	At 296-A-42, a tagout was hung at 0913 to secure power to the 101AY record module for maintenance. The outage had been approved by WDOH, the isolation point selected for AY101 resulted in the AY102 record fan also tripping unexpectedly. Power to AY102 record fan restored at 1120. The tagout is being modified to secure power to AY101 only.
3/30/2000	1130	No CNS Number[1]	296-A-42 B Train HEGA filter failed its aerosol test. The A Train HEGA was placed in service. No Release.
7/4/2000	1054	CHG0003487	AY102 recire fan was making excessive noise and had to be shutdown. The recire module was placed in bypass mode per approved procedures. There was no loss of ventilation to the AY or AZ tank farms as a result of this event.
9/3/2000	1000	CHG0004427	Daily check of minor stack 296-A-19, 102AY annulus exhauster found the record sampler off line due to tripped breaker. Breaker reset and record sampler returned to service.
10/10/2000	1139	CHG0005543	The 296-A-42 exhauster experienced an unplanned shutdown at 1139 on 10/10/00. The cause of the loss of ventilation is unknown at this time. The ventilation system was restarted at 1143 on 10/10/00. 241-AZ and AY tank pressures did not go positive during the ventilation outage, and there was no indication of an environmental release.
10/12/2000	1426	CHG0005545	Aerosol test on 702AZ HEPA System failed its periodic test. A Train was locked out and B Train was put into service, environmental notified on 10/12/00 at 1945.
11/9/2000	2300	CHG0005555	At 2300 hours on 11/9/00, operations started receiving continuous "Fault Alarms" for the 702AZ chiller that was shutting it down. Tried to restart, but could not keep chiller running for more than 10 minutes at a time. Chiller was off at 0005 on 11/10/00.
11/27/2000	1607	CHG0006487	296-A-42 online for tripped due to control system communication error.
12/3/2000	1330	CHG0006492	Air samples obtained during jumper replacement activities on the 241-AZ-01B Pit indicated 0.14 DAC Beta-Gamma above ground, 3 DAC alpha. Suspected cause is naturally occurring radon. Update - 12/4/00 0845- Alpha and beta-gamma activity for this sample have decayed to <0.1 DAC, confirming initial high counts as being due to radon.
12/8/2000	0040	CHG0006495	The heater for the HEPA filters on the 296-A-42, 702AZ chiller shutdown at 0040. The heater was back online at 0215.
12/9/2000	2018	CHG0006908	At 2018, operations lost the fan for the 702AZ building and the backup fan did not start automatically. The backup fan was placed in manual mode and started without incident. No release was reported.

Table E-1. 2000 Environmental Notifications (2 pages)			
Date	**Time Logged**	**Notification Number**	**Description**
12/12/2000	2018	CHG0006910	At 2000 the fans at 702AZ automatically switched from the primary to the backup fan. At 2018 an operator was doing a system configuration in the control room when there was an unplanned shutdown of the backup fan. Cause at this time for the shutdown is unknown. No indication of any Rad release. Fan was restarted at 2030.

[1] Note: Per reporting procedure prior to April 2000, correspondence numbering system (CNS) numbers were not required on Environmental notification checklist. They were maintained by reporting date.

Table E-2. 2001 Environmental Notifications (2 pages)			
Date	**Time Logged**	**Notification Number**	**Description**
1/11/2001	2305	CHG0006915	296-A-42, 702AZ Primary stack continuous air monitor failed. NOC requires WDOH notification. Also, informed WDOH that a measurement of a Blue Max exhauster air flow showed ~1600 ft^3/min when flow indicator on Blue Max showed ~1,000cfm. When damper adjusted for <1,000 ft^3/min, flow indicator on Blue Max essentially read zero.
1/16/2001	1005	CHG0100330	An unplanned shutdown of 296-A-42 recirculation module fan and a change in HEPA filter banks occurred while preparing to replace a failed stack monitoring CAM.
1/25/2001	0505	CHG0100332	296-A-42, 702AZ ventilation system experienced an unplanned shutdown due to a spurious beta CAM high radiation alarm. Local indication at eh CAM showed <10 ft^3/min activity and there was no detectable activity on either the CAM filter paper or the record sampler filter paper. The system was restarted at 0620.
1/29/2001	1400	CHG0100333	296-A-42, 702AZ B Train high efficiency gas absorber failed its periodic aerosol test. Ventilation was shifted to the A Train, and the B Train is being tagged out pending replacement of the high efficiency gas absorber.
2/6/2001	1401	CHG0100335	Unplanned switch in 296-A-42 operating fan. No loss of flow or monitoring.
3/31/2001	1500	CHG0101005	Air sample for pit work in tent at the 241-AZ-102-02A pit read 0.3DAC for field readings. Radon expected. 4/2/01 ~40hour after initial field readings, air sample shows <0.1 DAC
4/10/2001	1500	CHG0101915	Air sample obtained during AZ-02A pit upgrade work under project W-314 had elevated Beta/Gamma at 0.25 DAC, background alpha. Suspect radon.
6/20/2001	1100	CHG0101929	241-AY-101 and 241-AY-102 annulus leak detection CAMs were found to be vented to the CAM cabinet instead of back to the exhaust duct.
7/16/2001	1640	CHG0103045	The 241-AY-101 recire system was placed in bypass to perform maintenance. The 296-A-42 emission unit remained in operation while this maintenance is being performed. The recire system is part of the abatement controls.
7/27/2001	1400	CHG0103408	During pit work at the 241-102-AZ-02A central pump pit, an elevated concentrate air sample was detected. Level was 0.17 DAC, no evidence of contamination spread outside the pit work was conducted under the W-314 notice of construction.
8/2/2001	0715	CHG0104042	At AZ-02A, a cartridge HEPA filter (mask type) assembly failed while being used to defuse/filter the exhaust of an Air Powered sander. The cartridge failed in the vicinity of the joint between the portion holding the HEPA filter and the portion containing the exhaust area. The cartridge is used, as a best management practice, to diffuse/filter the exhaust while the sander is used in a radiologically contaminated area. AZ-02A pump pit, per the project W-314 NOC, the work was in a PTRAEU exhausted containment tent.
8/17/2001	1600	CHG0104052	241-AZ-01A pump pit, notified by Radon at 2351 on 8/17/01 of work area air sample results. 9.4 DAC alpha, 0.3 DAC Beta Gamma. No spread of contamination to personnel or equipment.
8/18/2001	2300	CHG0104053	241-AZ-01A pump pit, notified of work area air sample results. 12.65 DAC alpha, less than reportable Beta Gamma. No spread of contamination to personnel or equipment.
8/25/2001	0600	CHG0104392	241-AZ-01A pump pit air sample taken during project W-314 activity pit contamination tent showed 7.3 DAC alpha, <0.1 DAC beta/gamma. No radioactive contamination spread detected.

Table E-2. 2001 Environmental Notifications (2 pages)			
Date	**Time Logged**	**Notification Number**	**Description**
9/14/2001	1130	CHG0104395	241-AZ-02A pit, upon shutdown of PTRAEU operations at AZ-02 pit, it was discovered that the air sample at the exhauster outlet was not operating. The air sampler is the periodic confirmatory measurement. The PTRAEU operated for ~1 hour 15 minutes. Air sampler was started with PTRAEU and operated for 4 - 5 minutes. Pit air samples showed no activity above background.
10/22/2001	1232	CHG0104401	The 702AZ chiller shutdown on chiller fault. The loss of chiller caused a 296-A-42 stack CAM failure due to overheating. The chiller was restarted at 1248 and the CAM returned to service.
10/31/2001	1700	CHG0106139	296-A-19, notified by shift that record sampler was found offline by HPT doing rounds. Breaker was found tripped.
11/25/2001	0900	CHG0106143	296-A-19, notified by shift that record sampler was found off during HPT doing rounds. Breaker was found tripped. Breaker was reset and sampler was turned back on.

Table E-3. 2002 Environmental Notifications (2 pages)			
Date	**Time Logged**	**Notification Number**	**Description**
2/3/2002	1140	CHG0200163	Notified by shift that 296-A-42 exhauster A Train failed its halide test. B Train passed and is online.
2/19/2002	1831	CHG0200167	1831 a power pole overturned causing a fire and interrupting power to the evaporator and A, AX, AY farms. Lost power to annulus ventilation and leak detectors in AY101 and AY102. All other systems were not operating at the time, A & AX Evaporator. All primary exhausters and monitoring equipment continued to function. Restored power and restored leak detection at 2036, no Rad release.
4/24/2002	1600	CHG0201160	Notified by operations that 296-A-42 record sampler "O" Ring was broken. New "O" Ring has been ordered and may take up to a week for delivery and installation. We will be using the CAM for record keeping.
5/6/2002	1715	CHG0201162	Two personnel were slightly contaminated (4250 dpm/100cm square and 300dpm/100cm square, no alpha) on their face and their hair during the removal of the drill string from 241-AY-102. The drill had been partially removed from the tank and was positioned for disassembly. The disassembly was being performed in an open top bullpen used as a wind barrier. To disassemble the drill string, the contaminate bag must be opened to allow the installation of a strap wrench. During the evolution, swirling wind caused the movement of radioactive contamination within the bullpen. The rubber matting serving as a work place floor was contaminated to a level or 200,000dpm/100cm square. Contamination levels of 6000 dpm/100cm^2 were detected on the inner bullpen wall. Wind speed at the time of the activity was 10 to 13 mph.
5/12/2002	1340	CHG0201163	AY102 record sampler, annulus, shutdown due to malfunctioning vacuum pump.
5/27/2002	1530	CHG0201170	Notified by shift that 102AY annulus record sampler shutdown due to the vacuum pump electrical breaker tripping
6/9/2002	1235	CHG0201176	The AY102 Annulus Record Sampler Vacuum Pump failed at 0128 on 6/9. CAM is functional.
6/11/2002	1530	CHG0201177	When the drill string was removed from the AY102 tank, the work place air sample was 0.16 DAC/38. The drill string was fully contained in sleeving. Cross-contamination is suspected as field smear of work area did not indicate a spread of contamination occurred.
6/19/2002	1500	CHG0202958	Late notification on 6/19/02 at 1500 the 702AZ B Train HEGA Filter failed its halide test. The A Train was online at the time and is still currently running.
8/11/2002	1824	CHG0202966	An electronics card failure caused the 702AZ ventilation system to shutdown at 1824 on 8/11/02. Repairs made and unit restored at 1838.
9/22/2002	1000 & 1035	CHG0202972	The 296-A-42 Primary chiller shutdown twice, cause of the shutdowns is unknown. Chiller was offline for 10 minutes after each shutdown.
10/23/2002	0840	CHG0202853	702AZ A Train HEGA filter failed halide test at 1500 on 10/22/02. System switched to B Train until filter is replaced.
12/12/2002	0815	CHG0202862	At 0815 the vacuum pump for the 296-A-19 record sampler was found to be not operating. Apparently the vacuum pump sieged during operation, the continuous air monitor shows o release occurring
12/26/2002	1819	CHG0202864	296-A-42, 702AZ record sampler/CAM vacuum pump discovered to be shutdown. The backup vacuum pump did not auto start. Backup vacuum pump started manually at 1855, shutdown occurred at 1819.

Table E-4. 2003 Environmental Notifications

Date	Time Logged	Notification Number	Description
2/25/2003	0030	CH2M0205720	296-A-42, 702AZ, CAM/Record sampler vacuum pump failed at 0030. 296-A-42 manually shutdown.
3/9/2003	0337	CH2M0205722	Notified by central control and command that 102AY annulus exhauster, 296-A-19, was secured due to noises related to possible bearing or pulley failure.
3/12/2003	1230	CH2M0205723	Notified by CCC that 702AZ B Train has been shutdown due to failed HEGA filter halide test. HEGA filter will be replaced and retested.
4/1/2003	1025	CH2M0300544	702AZ,296-A-42 record sampler lost at 1025 due to maintenance personnel accidently tripping the vacuum pump control switch with the lower part of the body. Restarted at 1035.
4/19/2003	1530	CH2M0300551	Electrical power interruption/surge caused shutdown of 296-A-20, 296-A-27, 296-A-28, 296-A-40, 296-A-41 and train shift at 296-A-42. All restored. No Release.
5/7/2003	1415	CH2M0300545	296-A-42 was operating on the A Fan / A Filter. The central system attempted to auto shift to the B Train. The attempted auto shift resulted in both fan A and fan B running. Both fans shutdown on suspected high DP. B Train was started manually, restored ventilation.
6/10/2003	0850	CH2M0301891	While maintenance was performing calibration of the outlet temperature transmitters for 296-A-42, the exhauster shutdown. Work package instructions were not specific enough to ensure proper system alignment while performing the maintenance activity to prevent shutdown. Exhauster was restarted at 0905, no contamination to equipment or personnel.
6/18/2003	1020	CH2M0301894	296-A-42, 702AZ, A Train HEGA failed aerosol testing initially intended to shutdown complete unit. Change made to switch to B Train.
8/11/2003	0633	CH2M0301902	296-A-42, 241AY/AZ, at 0633 the 296-A-42 exhaust system shutdown on A Train HEGA low DP. The system was restarted at 0640, no contamination spread or released.
9/8/2003	0840	CH2M (number incomplete)	296-A-19, AY102 annulus record sampler went down

Recommend Further Eval

Table E-5. 2004 Environmental Notifications (2 pages)

Date	Time Logged	Notification Number	Description
1/6/2004	0930	CH2M0400009	296-A-19, AY102 annulus unplanned shutdown due to power loss to electrical supply breaker. Will correct power supply problem and restart exhauster.
1/13/2004	1620	CH2M0400011	The 296-A-42 B Train failed its HEGA filter halide test on 1/13/04
2/10/2004	1422	CH2M0400018	296-A-42, 702AZ ventilation replacement HEGA filter failed halide test; 702AZ primary tank B Train. A Train returned to service. Filter was installed on 2/10/04 to replace HEGA filter that failed annual Halide aerosol test.
5/1/2004	1200	CH2M0401332	296-A-19 Ay102 annulus power was found off
5/3/2004	0910	CH2M0401334	196-A-19 & 18, Ay Annulus shutdown twice due to seismic switch. Will keep shutdown due to need to "jumper" the switch. Engineering is evaluating.
5/4/2004	0900	CH2M0401336	241-A-18 & 19 AY Annulus stacks shutdown due to a faulty seismic switch
5/10/2004	1422	CH2M0401343	296-A-19 Pressure Differential Indicator gauge found out of annual calibration. Emission unit shutdown until calibration can be completed. Last calibration 2/10/03.
5/20/2004	0842	CH2M0401346	296-A-18 & 19 shutdown due to seismic switch trip. 296-A-18 and 296-A-19 exhaust the 241-AY-101 and 102 annulus. No contamination spread.
6/3/2004	0800	CH2M0401348	Notified by shift that 296-A-19 shutdown due to a faulty seismic switch. Exhauster was restarted at 0826. No spread of contamination or personnel.
6/4/2004	0830	CH2M0401613	Notified by shift that 296-A-19 shutdown due to a faulty seismic switch trip. No spread of contamination or personnel.
6/29/2004	1530	CH2M0401623	On 6/29/04 at 1430 the flow rate for 296-A-42 was observed to be 1200 ft^3/min (0.57cms). This is above the July 10, 1998 (AIR 98-708) limit and condition #18 of 0.5cms (1059 ft^3/min). This occurred during the A Train HEPA filter change out (wp:2E-04-01062, Replace First Stage HEPA Filter in 241-AZ-102). The flow is normally maintained to keep a vacuum on the plenum. The high flow alarm (set at 900 ft^3/min) did alarm. The alarm response procedure (Respond to Monitor Control System Graphic #18 Primary Vent Stack Alarms, ARPT-T-251-00018) list the alarm set point as 920scfm. The data collected after the fact shows that the 1059 ft^3/min NOC limit was exceeded at 1402 (1174.94 scfm) and continued to be over the NOC limit until 1430 (904.84 scfm). A total of 28 minutes with the highest value being 1194.92 scfm at 1416.
8/22/2004	0800	CH2M0402274	The 296-A-19 vacuum pump for the AY B Train annulus record sampler went down during rounds on 8/22/04. called at 1100 hours.
11/15/2004	2214	CH2M0403101	At 2040 the 296-A-19, AY102 annulus exhauster went down. Cause unknown. Exhauster was restarted at 2111. Possible cause seismic controller switch problem.
12/7/2004	1300	CH2M0403105	296-A-19 record sampler was found down due to a tripped breaker. This is a non-designated stack.
12/12/2004	2030	CH2M0403108	296-A-19 annulus exhauster was found shutdown by operators. The shift manager is sending personnel out to investigate cause of shutdown.

Recommend Further Eval

Table E-6. 2005 Environmental Notifications (2 pages)			
Date	**Time Logged**	**Notification Number**	**Description**
1/4/2005	1100	CH2M-0403939	296-A-42 stack CAM was found to not have isokinetic flow at 1100 hours. No tank input, pumping, or mixing was occurring.
1/5/2005	1543	CH2M-0404050	The 296-A-42, 702AZ, B Train HEGA filter failed its halide test. Exhauster shutdown until aerosol testing of A Train can be performed.
1/10/2005	0800	CH2M-0500085	296-A-42, 702AZ, B Train filters; including a HEGA that had failed a halide test on 1/7/05, was inadvertently placed in service. This occurred while using a control system "macro" command to switch from the B Train fan to A Train fan. An A Train fan and A Train filter was the desired end point. A control system reset occurred during the fan transfer, this resulted in a B Fan and filter alignment. Manual actions taken to establish B Fan and A filter alignment.
4/24/2005	1325	CH2M-0501251	Notified by shift office that 296-A-19, AY-102 Annulus, record sampler was found off during routines. No spread of contamination to equipment or personnel
5/21/2005	0225	CH2M-0501260	During troubleshooting of the 296-A-42 CAM Flow indication 296-A-42 was inadvertently tripped. Restarted at 0245, CAM and record sampler functioning normally
6/7/2005	1410	CH2M-0501265	Notified by shift that 296-A-42 record sampler was found off due to a failed vacuum pump. No contamination spread.
6/14/2005	0914	CH2M-0501268	Power to the 200 East DST farms was lost at 0914 for an known reason. The affectively shutdown 11 stacks. Power was restored at 0940. prior to restart of exhauster of each farm was radiologically surveyed. The restart times for each system are listed herein.
6/21/2005	1930	CH2M-0501576	Power to the 200 East DST farms was lost at 1930 due to high winds creating a ceramic crossover with the breaker associated with pole #6. Electrical power was restored at 2330. No waste disturbing activities were ongoing and each tank farm was radiologically surveyed prior to exhauster restart, the restart times are listed herein.
8/2/2005	1330	CH2M-0501586	record sampler at 296-A-42 was found inoperable at 1330.
9/14/2005	1929	CH2M-0502389	At approximately 1929, on September 14, 2005, the 296-A-42, 702AZ ventilation system CAM tripped due to a high exhaust temperature, 110 degrees. Review of the 702AZ temperature data indicates the cause of the high exhaust temperature to be a shutdown of the chiller, due to unknown cause at 1630 on 9/14/05. Review of the 702AZ HEPA and HEGA differential pressure data indicates that the differential pressure s have increased slightly. The HEPA filter differential pressure is being monitored every two hours. During the period in which the ventilation system is operational without a CAM, the record sampler filter paper is being surveyed every eight hours.
9/26/2005	1546	CH2M-0502392	296-A-42, 702AZ, chiller listed abatement control, for the 241AY/AZ primary tank ventilation system unexpectedly shutdown. The primary ventilation system was manually shutdown to prevent any moisture carry-over due to the chiller not working.
10/1/2005	1425	CH2M-0502395	Notified by shift that during Ops 5 routines, 296-A-19 record sampler was found off. Cause was a vacuum pump filter
10/16/2005	1055	CH2M-0502397	Chiller for 702AZ primary ventilation system went down at 1055. This caused an increase in stack temperature which shutdown the stack CAM. The chiller was restarted by 1059 and later the ventilation was secured for planned maintenance at 1350. Record sampler was not affected by initial chiller shutdown.

Table E-6. 2005 Environmental Notifications (2 pages)			
Date	**Time Logged**	**Notification Number**	**Description**
12/15/2005	0710	CH2M-0503301	Due to a "Phase-to-ground fault" occurring at or near the canister storage building, all power was lost for a short time in East Tank farms. Primary and Annulus exhausters at AN, AP, AW, and AY/AZ farms and 702AZ building shutdown. All exhausters were restarted by 1025. no spread of contamination to equipment or personnel.
12/15/2005	1405	Ch2M-0503302	Operations found the 702AZ chiller shutdown,. Chiller may have been affected by the power loss that happened in the morning, chiller was restarted.

Table E-7. 2006 Environmental Notifications			
Date	**Time Logged**	**Notification Number**	**Description**
2/15/2006	1029	CH2M-0600024	296-A-42, 702AZ, B train HEGA failed halide test. 296-A-42 currently running on A Train
2/18/2006	2235	CH2M-0600025	296-A-42, 702AZ, at 2035 it was discovered the 296-A-42 chiller had shutdown. System temperature reading 99 degrees, CAM not effected
2/20/2006	1407	CH2M-0600458	296-A-42 chiller was found shutdown at 0040, chiller was restarted at 0145, max stack temperature 110 degrees, chiller is currently in operation.
4/24/2006	0830	CH2M-060475	296-A-42, 702AZ, Multiple occurrences (5) of chiller tripping off on low suction pressure during 4/22 - 4/23 time period. One instance resulted in loss of stack CAM due to elevated stack temperature
5/4/2006	1330	CH2M-0600479	296A-42, 702AZ, Notified by shift that 702AZ chiller was found shutdown. No apparent cause for the shutdown, chiller was restarted at 1620
6/3/2006	0700	CH2M-0601285	296A-42, 702AZ, Operational problems including possible moisture noted at 1410. Problem investigation completed between 1725 and 2052. Investigation included by passing HEME, then chiller, then condenser over a 2-hour period while watching indicators. At 2052 system was put back in full operation, no bypass, looks like HEME may be blocked. Investigation will continue with engineer review of data.
8/2/2006	1250	CH2M-0601302	296-A-42, 702AZ, the 296-A-42, 702AZ exhauster was placed into CAM by-pass for planned maintenance activities. It is anticipated to be restarted in approximately 24 hours.
9/30/2006	0849	CH2M-0601721	296A-42, 702AZ, CAM declared out of service due to fluctuating flow, low flow alarm. Begin 72 hour clock system still in operation. No waste activities planned.
10/6/2006	1424	CH2M-0601723	296-A-42, During testing the B Train first stage (upstream) HEPA filter and the HEGA filter failed the Aerosol and Halide tests respectively. Returned the A Train filter back to service.
10/6/2006	2350	CH2M-0601726	296-A-42, Unplanned shutdown of exhauster on low CAM flow, resulting from A stack temperature signal spike. Exhauster restarted at 0100 10/7/06. Investigation of periodic low CAM flows continuing throughout weekend. Exhauster manually shutdown on 10/8/06 13:43 hours due to loss of stack temperature signal. Loose wire identified on 10/9/06 and exhauster started at 1007 hours.
10/9/2006	1417	CH2M-0601727	296A-42, 702AZ, Chiller used for emission control, tripped, cause not determined; unit reset and restarted. Exhauster continued to operate, but CAN flow did isolate for brief period at stack temperature increase.
11/9/2006	2120	CH2M-0601854	296A-42, 702AZ, at 2120 the ventilation automatically shutdown during a CAM functional test. The unplanned shutdown lasted only minutes before the exhauster was restarted around 2122
12/19/2006	0110	CH2M-0601869	At 0110 on 12/19/06, all operating stacks lost electrical power and were restarted.

Table E-8. 2007 Environmental Notifications (2 pages)			
Date	**Time Logged**	**Notification Number**	**Description**
1/3/2007	1120	CH2M-0700005	296-A-42, 702AZ A Train HEGA filter failed challenge test. B train placed in service.
1/5/2007	2310	CH2M-0700011	Heavy wind induced spike on tank farm electrical system caused the following exhausters to shutdown: 296-A-42, 296-A-40, 296-A-27, 296-S-25, 296-A-18, 296-A-19, and 296-A-20. All exhaust systems successfully restarted.
1/8/2007	1310	CH2M-0700012	241-AY-102 ENRAF 151, one of three annulus leak detectors, was removed from service on October 5, 2006 to support UT inspection and video of 241-AY-102 for integrity assessment. In accordance with the Settlement Agreement and Stipulated Order of Dismissal, PCHB NOS 98-249 and 98-250, Ecology must be notified of any DST leak detection devise out of service for more than ninety (90) days and the notification must include a schedule for return to service of the devise. ENRAF 151 exceeded the ninety (90) day criteria on January 3, 2007. The ENRAF has been reinstalled on the annulus riser, but has not been fully secured, has not had power restored, and has not been functionally tested. Reinstallation of ENRAF 151 is expected by January 19, 2007. Since October 5,2006, three of the four required AY102 leak detection devices have functional.
5/23/2007	1100	CH2M-0700681	At 1047, the 296-A-42, 702AZ Exhauster was found with the record sampler Out OF Service. The mastron is showing "reading unreliable". Troubleshooting will be performed.
6/4/2007	834	CH2M-0700683	On 6/4/07 at 0834 hours the 296-A-42 exhauster shutdown due to unknown causes. The exhauster was restarted at 0839. No waste disturbing activities were ongoing during the exhauster shutdown in the Ay/AZ tanks.
6/19/2007	1225	CH2M-0700689	On 6/8/07 the annual ammonia sampling of the AY/AZ primary stack, 296-A-42, was completed. The measure concentration of ammonia at the stack was 107ppm. This result was used to calculate an emission rate of 0.217lb/hr. To confirm this measure re-sampling of the AY/AZ primary stack was performed on 6/18/07. Sampling using a field instrument and a dragger tube from the same sample port on the stack confirmed the earlier stack ammonia concentrations (115ppm/0.234lb/hr., and 100ppm 0.0203lb/hr, respectively.
6/27/2007	1102	Ch2M-0700691	The 296-A-42, 702AZ Exhauster failed its annual HEGA filter test on A Train. Operations have switched to the B Train. A work package will be developed to replace the failing HEGA filter.
8/23/2007	1247	CH2M-0701026	The primary condenser was out of service due to an unplanned shutdown of the chiller pumps. The chiller provides the cooling media, glycol, to the primary condenser. After resetting the chiller pump, it was returned to service. During the time period the chiller/condenser was out of service, the stack continuous air monitor was automatically isolated due to high stack temperature. The continuous air monitor was also returned to service after reset of the chiller pump.
11/1/2007	1245	CH2M-0702567	Minor emission point 241-AY-101 annulus ventilation system 296-A-18 record sample loop instruments overdue for calibration. The annual calibration of the record sample loop was due on October 26,2007. The calibration was performed on October 31, 2007 and November 1, 2007.
11/7/2007	1832	CH2M-0702568	On 11/07/07 swing shift the 296-A-42 exhauster B train failed its halide test of its HEGA filter. With results of the testing the operations switched to the A train of this system

Table E-8. 2007 Environmental Notifications (2 pages)			
Date	**Time Logged**	**Notification Number**	**Description**
12/25/2007	1055	CH2M-0702576	At 0845, the chiller for the 296-A-42, AY/AZ Exhauster shutdown causing a HI-HI Temperature alarm which shuts down flow to the CAM. The chiller was restarted and the alarm reset at 0915. The CAM is operating properly.

Table E-9. 2008 Environmental Notifications (4 pages)

Notif PDF	Date	Time Logged	Logbook Volume	Page Number	Notification Number	Description
	1/17/2008	1410	ENV-03	3		At 130 hrs the 296-A-19 exhauster shutdown for maintenance
	1/20/2008	2005			CH2M-0800170	On 1/20/08 at 2055 hours the 296-A-42 exhaust stack was shutdown due to operations was unable to keep the 702AZ chiller running. The chiller shut down on interlock due to low suction pressure alarms for both chiller compressors. Refrigeration Equipment Services (RES) determined that the equipment problem was caused by the chiller control voltage transformer, which they replaced on 1/21/08. The exhauster was brought online on 1/21/08 at 1610 hours.
	1/21/2008	1615	ENV-03	4		The 296-A-42, 702-AZ exhauster stack was taken down on 1/20/08, (not reported to me on 1/20/08) at 2009 hrs with a chiller problem. The circuits had maintenance done and the exhauster was restarted at 1510 hours.
	1/21/2008	1530	ENV-03	4		The WFO Shift Office called with more information on the Chiller Problem at 296-A-42. this was decided to not be planned maintenance (chiller pumps failed) at the exhaust stack was near its high temperature interlock. Because WDOH is off on 1/21/08, I will notify WDOH on the morning of 1/22/08.
	1/28/2008	1120	ENV-03	5		At 1120, WFO called to say that the AY-102, Riser 88, Annulus ENRAF is out of service leaving one serviceable ENRAF
	1/31/2008	1256	ENV-03	6		Notified the AY-102 Annulus Leak Detector 151 is back in normal range and is being declared back in service.
	2/27/2008	2000	ENV-03	10	CH2M-0800176	At 1800 the "Chiller" was found down on 296-A-42 and restarted. Notification via email was sent on 2/28/08 at 1220hrs CH2M-0800176
	3/15/2008	1755	ENV-03	16	CH2M-0800260	Notified by shift that 702AZ Chiller, 296-A-42, was found down to a "fault" condition, was immediately restarted, CNS:0800260
	3/17/2008	1635	ENV-03	16		Notified by shift that 26-A-19, 241-AY-102 Annulus Record Sampler was found down due to a failed vacuum pump
	3/26/2008	2000	ENV-03	18		Notified by shift manager that the 702AZ Chiller found in Fault condition at 1940. No cause apparent. Latest of several shutdowns. Restarted at 1950. Advised shift manager that WDOH will be notified in morning of unplanned shutdown of emissions control; advised that new policy required management notification per TFC-OPS-OPER-D-01, “Courtesy Call Outside Agency.”
	3/26/2008				CH2M-0800264	The chiller for 296-A-42 was found shutdown at 1940 hours, due to a "fault" condition. No specific cause for the "fault" condition was identified. Operations restarted the chiller at 1950 hours. The chiller is part of the recirculation system condenser emissions control equipment.
	3/26/2008	0718				WDOH notified of 296-A-42 chiller unplanned shutdown. CNS: CH2M-0800264

Table E-9. 2008 Environmental Notifications (4 pages)

Notif PDF	Date	Time Logged	Logbook Volume	Page Number	Notification Number	Description
		0719				Informed shift office of WDOH notification and that shift manager had made SOEN page on 3/26/08
	4/21/2008	1645	ENV-03	21		Notified AY/AZ Primary 296-A-42 Chiller self-secured discovered at 1555. Self-restarted at 1600. Ops performing temporary rounds every 2 hours, stack temperature did not alarm, no off-site notification required. Not listed on table 1, TFC-ESHQ-ENV-FS-C-01
	6/19/2008	1024			CH2M-0800278	241-AY-102 annulus ENRAF (AY102-WSTA-LDT-1 53) went out of service on February 21, 2008 based on Operating Rounds. Investigation into the ENRAF problem show that the plummet is resting at approximately +2.56 inches above the annulus floor. Pursuant to the Settlement Agreement and Stipulated Order of Dismissal (PCHB No 98-249; No. 987-250) notification is required to Ecology if: "Downtime for repair of a Leak Detection system device discovered to be inoperable or requiring repair shall not normally exceed (90) days. Ecology must be notified of any leak detection device out of service for more than ninety (90) days. This notification must include a schedule for repair and return to service of the device as soon as possible." The planned corrective maintenance activities included putting a camera down an adjacent riser during the week of June 23, 2008. Based on the results of this investigation repair or replacement of the ENRAF device will be completed with an estimated completion date of July 28, 2008.
	7/2/2008	1514	ENV-03	30		Notified 296-A-42 A Train HEGA failed annual halide testing. Email notification required to WDOH. Switched to B Train.
	7/2/2008				CH2M-0800282	The A Train HEGA failed its annual halide testing and will be replaced. Operation of the 296-A-42 Ventilation system has switched to B train.
	8/13/2008	1525	ENV-03	34		Notified by shift that the AY Annulus 102 Cond Probe on Riser 91 was found out of range on height. Range is 0.11 - 0.19, Probe found at 0.20, Probe was taken out of service 90-day clock.
	9/20/2008	1255	ENV-03	36		1255 Notified by shift that 296-A-42, 702AZ, was shutdown due to Two (2) fan mounting brackets on the chiller being broken. This is a reportable to WDOH per our notification procedure. CNS: CH2M-0800292
	9/20/2008	1130			CH2M-0800292	The 296-A-42 stack was shutdown at 1220 due to fan problems on the chiller unit. Two Chiller fan mounting brackets broke causing the fan unit to hang at a 30 degree angle instead of horizontally. The water chiller is listed on Table 1 of the notification procedure as part of the abatement technology. Replacement of bolts is currently in planning. Ventilation unit will be restarted upon completion of repairs,
	9/22/2008	0902	ENV-03	37		Notification on 296-A-42 shutdown sent out

Table E-9. 2008 Environmental Notifications (4 pages)

Notif PDF	Date	Time Logged	Logbook Volume	Page Number	Notification Number	Description
	10/6/2008	0748	ENV-03	39		Notified by Base Ops shift manager of 0740 discovery of 296-A-19, AY102, record sampler vacuum pump shutdown
X	10/6/2008	1011	ENV-03	39	WRPS-0800004	296-A-19, 241-AY-102, During routine rounds, the record sampler for the 241-AY-102 annulus exhauster was found out-of-service due to a shutdown vacuum pump. The cause for the vacuum pump shutdown is being investigated.
	10/16/2008	0810	ENV-03	43		Notified by shift that Exhauster 296-A-42, 702AZ, shutdown unexpectedly. Maintenance to troubleshoot, CNS: WRPS-0800009
X	10/16/2008	0823	ENV-03	43	WRPS-0800009	296-A-42, 241-AY/AZ, Exhauster shutdown unexpectedly. Maintenance will troubleshoot and re-start.
	10/21/2008	0815	ENV-03	44		Notified by shift that gauge PDTAZ109-1 on the HEME Filter on 296-A-42, 702AZ, failed calibration, non-recordable.
	10/8/2008	1538	ENV-03	45		Notified by shift that the Quarterly Stack Flow Calibration for 702AZ, 296-A-42, was missed.
	10/30/2008	1735	ENV-03	46		Call from Steve Ringo, shift office, power restored to AY/AZ Exhauster at 1550 hours.
	11/7/2008	0621	ENV-03	46	WRPS-0800011	Notified by shift that stack 296-A-42 was shutdown at 0230 due to chiller not being able to maintain operation. Reportable per section 45 major stack chiller H2O pump listed on table 1. WRPS-0800011 to WDOH. Notification sent 0657 hours
X	11/7/2008				WRPS-0800011	296-A-42, 241-AY/AZ, Operation of the chiller system on the ventilation system could not be maintained, it kept switching itself off. The AY/AZ ventilation system was then manually shutdown by operations at 0230 to allow trouble shooting. 296-A-42 is a major stack and the chiller is listed as part of the control technology per the FF-01.
	11/18/2008	0223	ENV-03	49		Shift office notified that 702AZ Primary was shutdown for maintenance, the shutdown occurred around 0052, a determination will be made as to whether or not notification will be required to WDOH. This will be based upon whether the maintenance activity can be performed within 8 hours from the time of shutdown, or if it can be determined that this shutdown was a "planned" shutdown.
	11/18/2008			49	Work Package 4R-6-1992/C	Spoke with the facility manager, 702AZ, and determined that the exhauster shutdown that occurred on 11/08/08 at 0052 hours was planned. The daily release sheet for 11/08 shows the maintenance activity, chiller repair as priority #8, work p[package #4R-6-1992/C

Table E-9. 2008 Environmental Notifications (4 pages)

Notif PDF	Date	Time Logged	Logbook Volume	Page Number	Notification Number	Description
	11/18/2008	0945	ENV-03	50		Shift office reported that the AY Annulus Exhauster, 296-A-19, had been secured at 0945 and the C-110 portable exhauster has been secured at 0924. Both shutdowns were considered as planned due to maintenance activities. No notification is planned at this time.
	11/21/2008	1110	ENV-03	50		296-A-42, 702AZ, exhauster restarted from maintenance activities, AY-102 Annulus ENRAF restarted to operation
	11/24/2008	1130	ENV-03	51		Base Ops Shit Office reports AY102 Annulus ENRAF, that was restarted to service on 11/21/08, is now reading out of range.
	12/19/2008	1415	ENV-03	55	Recorded as "Informa-tion Only"	Reported by Kyle Meyer, 702AZ Record Sample, HPTs went into 702AZ CAM Room to change record sample/CAM filter paper at 1415 hours. There was liquid dripping in front of the CAM Cabinet from nozzle "G" on the overhead exhaust duct (where liquid was coming out of the duct on 12/18/08 *See Spill Log). The samplers were NOT in question as the sample papers being wet. The samples are continuing to operate satisfactory. The sample papers are now scheduled to be changed Monday, 12/22/08. This will make the change out 2 weeks and 2 days, maybe more. No Notification Required.

Recommend Further Eval

Table E-10. 2009 Environmental Notifications (2 pages)

Notif. PDF	Date	Time Logged	Logbook Volume	Page Number	Notification Number	Description
X	1/5/2009				WRPS-0900002	296-A-42 702-AZ (241-AY/AZ) Record sampler filter paper for 296-A-42 EU was noted as wet during sample exchange 12/3 and 12/22
X	1/21/2009				WRPS-0900011	296-A-42 (241-AY/AZ) 241-AY-102 Evaporative tower fan reported out of service
	1/24/2009	0910	ENV03	66		Shift manager reported the 241-AY-102 VTA Annulus Record Sampler had no flow. No notification to WDOH
	1/31/2009	2206	ENV03	69		Shift office notified shutdown of 702AZ Primary Exhauster, B Train, because of chiller malfunctioning. Notification will be made to WDOH in accordance with notification procedure.
X	1/31/2009				WRPS-0900023	296-A-702-AZ Primary Exhauster (296-A-42) B Train. Chiller was malfunctioning and couldn't be repaired, causing shutdown of primary exhauster.
	2/1/2009	0705	ENV03	69		notification to WDOH was made regarding shutdown of 702AZ Primary Exhauster, B Train, CNS: WRPS-0900023
	2/2/2009	1115	ENV03	69		Shift office notified that Annulus Exhauster for AY-101, AY102 and AZ Tanks were shutdown due to high radiation CAM Alarms. High Rad Alarms are likely due to the Primary Exhauster being shutdown. Note: the high radiation alarms were from the annulus leak detectors in AY101 and AZ102.
	2/3/2009		ENV03	70	Follow-up	Preformed follow-up on high rad alarms noted on 2/2/09 (*see entry page 69-for 0115 hours), according to Kyle Meyers, the primary count on CAM filters for the annulus leak detectors in AY101 and AZ102 indicated Radon. The results from the count room were 0.92 and 0.20 (respectively). The DAC fraction indicates that the alarms were set off due to atmospheric Radon. No Notifications required.
	2/7/2009	1430	ENV03	73		Notified the AY102 ENRAF is to move to a different riser to support corrosion probe installation. ENRAF is anticipated to be back in service by 2/11/09. Not reportable to WDOE
	4/1/2009	2021	ENV03	86		Late entry: Druch (?) used to calibrate 296-A-42, 241-AY/AZ Primary Ventilation record sampler loop and HEME DPR. Not Reportable
	4/6/2009	0817	ENV03	86		Planned outage for 296-A-42 and 296-A-18, 296-A-19, 296-A-20 for replacement of chiller. No Primary or Annulus Ventilation in AY/AZ Farms.
	4/10/2009	1530	ENV03	87		BOSO reported that AY102 Annulus leak detector, LDT151, is out of service. Notification: WRPS-0900200
X	4/10/2009				WRPS-0900200	241-AY-102, at 1530 on 4/10/09, the 241-AY-102 annulus leak detector (LDT-151) is out of service. ENRAF and 2 remaining annulus leak detectors are operating.
	4/16/2009	1435	ENV03	87		702AZ Ventilation facility manager (Woehle) reported the efforts are underway to start the 702AZ. Subsequent to the Chiller being replaced

Table E-10. 2009 Environmental Notifications (2 pages)

Notif. PDF	Date	Time Logged	Logbook Volume	Page Number	Notification Number	Description
X	8/14/2009				WRPS-0900601	296-A-42, 241-AY/AZ, Unplanned shutdown of 241-AY/AZ primary tank ventilation exhauster occurred while preforming maintenance on the system. No release occurred. Restarted exhauster at 1324 hours.
X	12/7/2009				WRPS-0901211	296-A-19, 241-AY-102 Annulus Exhauster. The 241-AY annulus exhauster record sampler is out of service due to a failed vacuum pump. The exhauster continues to operate. There is NO waste disturbing activities ongoing in the 241-AY-102 tank. No radiological or contamination was spread outside the exhauster.
X	12/30/2009				WRPS-0901217 Rev. 1	296-A-43, 702 AZ primary exhauster had an unplanned shutdown at approximately 0110, 12/30/09. The exhauster was immediately restarted. The cause of the shutdown is unknown.

Event
Recommend Further Eval

Table E-11. 2010 Environmental Notifications (2 pages)			
Notif. PDF	**Date**	**Notification Number**	**Description**
X	1/27/2010	WRPS-1000065	While validating the semi-annual air operating permit report for the second half of calendar year 2009 personnel identified that record samples collected during the period did not meet the monitoring requirements specified in the Hanford Site Radioactive Air Emissions License,#FF-01, for "4 week sample/year." nor did the record samples collected during the first half of calendar year 2009
X	4/8/2010	WRPS-1000710	On 04-08-10, at 1019, the 296-A-42 (241-AY/AZ-A-Train Primary Exhauster) had an unplanned shutdown while performing a train swap from B-Train to A- Train. The 296-A-42 B-Train was re-started at 1025.
X	4/10/2010	WRPS-1000714	On 04-10-10, at 2020, the 296-A-42 (241-AY/AZ Tank Primary Exhauster) CAM failed due to no flow. The Exhauster was shutdown at 2110 due to no-compliant sampling system.
X	5/15/2010	WRPS-1000722	Malfunction alarm received for the Beta CAM. Investigation revealed a high inlet temperature exhaust stream due to chillers being down. The exhauster was shut down until maintenance could make repairs. The chillers were repaired and the exhauster was restarted at 1440hrs. All alarms cleared and operating normally.
X	5/17/2010	WRPS-1000723	Unplanned shut down of the 241-AZ Annulus exhauster. During operational rounds the exhauster was found to be shut down. The exhauster was returned to service 2040hrs on 05-14-2010 and was operating normally.
X	7/31/2010	WRPS-1001158	All DST Farm Primary Exhausters and the 296-S-21 Stack lost power and had an unplanned outage due to a lightning storm. Power was reported lost at 0116 hours. Crews worked over the weekend to restart the exhausters. Power was returned to all DST Farm Primary and the S-21 Exhausters by 1350 hours on 08/01/10, with the exception of AW Farm exhausters. As of 1015 hours on 8/2/10, only the AW farm was still without power. 296-A-44 (241-AN A train) restarted 8/1 @ 1510 hrs. 296-A-45 (241-AN B train) restarted 8/1 @ 1510 hrs. 296-A-46 (241 AW A train) power still down as of 8/2 @ 1015 hrs. 296-A-47 (241 AW B train) power still down as of 8/2 @ 1015 hrs. 296-S-21 restarted 7/31 @ 0925 hrs.
X	7/31/2010	WRPS-1001159	An intensive lightning storm knocked out power to the DST Tank Farms in both the 200 East and 200 West Areas. Crews worked through the weekend restoring power leak detection capabilities to all Tank farms by 1550 hrs. on 8/1/10, with the exception of AW Tank farm. In addition, crews were unable to access the SY-101 Tank to take a reading due to construction activities for the SY Transfer Lines upgrade project. Crews continue to work to reestablish leak detection capabilities for these two areas.
X	8/10/2010	WRPS-110060	During internal requirement reviews WRPS identified a potential compliance deficiency for operation of 296-A-42 without required abatement equipment associated with the evaporative cooling towers. The condition evaluation is still ongoing and WRPS is working on corrective actions for the equipment. WRPS would like an opportunity to discuss this situation with WDOH.
X	8/16/2010	WRPS-1001161	Notified by shift that 296-A-42 shutdown due to a Stack CAM Low Flow Alarm. Exhauster was restarted at 1500.
X	8/17/2010	WRPS-1001163	Notified by shift that 296-A-42 shutdown due to a Stack CAM Low Flow Alarm. Maintenance is troubleshooting.
X	8/17/2010	WRPS-1001164	Notified by shift that 296-A-42 shutdown due to a Stack CAM Low Flow Alarm. The recurring issue at this time is pointing to circuitry in the CAM. Maintenance continues to troubleshoot.

Table E-11. 2010 Environmental Notifications (2 pages)			
Notif. PDF	**Date**	**Notification Number**	**Description**
X	8/20/10 & 8/21/10	WRPS-1001165	(296-A-42) 702-AZ Exhauster found shutdown on 8/20/10 at 1445 hours, the system was restarted and returned to service at 1523 hours. No contamination was found. Cause unknown. (296-A-42) 702-AZ Exhauster shutdown on 8/21/10 at 1630 hours, the system was restarted and returned to service at 1644 hours. No contamination was found. The "Keep Alive" alarm indication was "in" at time of the shutdown.
X	8/23/2010	WRPS-1001166	702-AZ Exhauster shutdown on 8/23/10 at 1622 hours, the system was restarted and returned to service at 1638 hours. No contamination was found.
X	8/24/2010	WRPS-1001168	702-AZ Exhauster shutdown on 8/24/10 at 1323 hours, the system was restarted and returned to service at 1430 hours. No contamination was found. System is being switched to manual mode in an attempt to minimize the unplanned shutdowns suspected to be caused by the age of the electronic control system.
X	9/12/2010	WRPS-1001169	Three unplanned shutdowns of the 296-A-42 Exhauster (241-AY/AZ Primary Tank Ventilation) occurred: 1300 hours - unplanned shutdown with no specific cause identified. A CAM spike is suspected. Exhauster restarted at 1315 hours. 1840 hours - Unplanned shutdown with suspected cause a faulty heater valve operation. Exhauster restarted at 2136 hours. 21501 - Unplanned shutdown due to false high radiation alarm on continuous air monitor. Field count of continuous air monitor filter paper showed no elevated counts. When a restart was attempted continuous air monitor alarm locked in. Exhauster remains shutdown for investigation and repair on continuous air monitor.
X	10/7/2010	WRPS-1002311	All 200-E DST Farm Primary Exhausters lost power and had an unplanned outage due to a power outage. Power was reported lost at 1630 hours on 10/7/10. Power was returned within a few minutes, but went down again at 1830 hours. Power restored at 2100 hours on 10/7/10. The AW ventilations system has been restored. Maintenance and trouble-shooting ongoing for all other ventilation systems. Below is a recap of ventilation systems status: 296-A-42 (241-AY/AZ & 702-AZ) Power still down as of 10/8 @ 1500 hours. 296-A-44 (541-AN A Train) power still down as of 10/8 @ 1500 hours. 296-A-45 (241-AN B Train) power still down as of 10/8 @ 1500. 296-A-46 (241-AW A Train) restarted 10/8 @ 1430. 296-A-47 (241 AW B Train) restarted 10/8 @ 1430.
X	12/28/2010	WRPS-1002334	296-A-42 702-AZ, Quarterly ANSI N13.1 inspection of the 702-AZ exhauster systems has been delayed due to ongoing upgrades to the control system. ANSI N13.1 inspection will be completed as the project upgrades are completed and turn-over for operational use. The record sampler is operational and will be used when the exhauster is operating.

Table E-12. 2011 Environmental Notifications (2 pages)			
Notif. PDF	**Date**	**Notification Number**	**Description**
X	2/15/2011	WRPS-1100370	East area DST primary exhausters and C farm had an unplanned shutdown due to an electrical power outage near the A Farm complex area. Power was reported lost at 0030 hrs. on 2/15/11. Power was restored at approximately 0830 hours. Primary tank farms ventilation systems have been returned to operation. Primary Ventilation System 396-A-42 (241-AY/AZ Primary A Train) returned to active ventilation at 1344, 396-A-45 (241-AN Primary B-Train) at 1250, 296-A-46 (241-AW Primary A train) at 1204, 296-A-40 (241-AP primary A train) at 1306, and 396-P-47 (POR-08, C farm) at 1010. 296-A-41 (241 AP annulus A train) restart at 1310, 296-A-18/19/20 (AY/AZ annulus preparing for restart, 296-A-43 secured for Ops Accept Tests, 296-A-28 (241AW A train) restart at 1428, and 296-A-30 restart is in process.
X	3/22/2011	WRPS-1100382	The 296-A-42 primary exhaust system A-Train HEPA filters were last aerosol tested February 22, 2010 and are overdue for this annual test at this time. The A-Train has been non-operational due to project upgrades and operational acceptance testing. The 296-A-42 primary exhaust system is currently operating on the B-Train. The A-Train will be started to facilitate necessary repairs to the heater followed by the HEPA aerosol testing.
X	4/2/2011	WRPS-1100385	On 04/02/2011 at 0753 hrs., the 296-A-42 (AY/AZ Tank Primary Exhauster) shutdown due to a failure of the CAM. Maintenance personnel are currently evaluating the CAM to determine a course of action. The exhauster will be restarted once this evolution is complete and the CAM is operational.
X	5/14/2011	WRPS-1100390	Loss of electrical power due to lightning causes unplanned shutdown of tank farm exhausters (Early morning and early evening of 5/14). Also results in loss of record sampling at 222-S labs while exhauster operates on diesel drive. No release of contamination identified during surveys of the facilities. 296-A-40 241-AP Primary - Shutdown at 0115 and restarted at 1100 296-A-41 241-AP Annulus - Shutdown at 0115 and restarted at 1100 296-A-42 241-AY/AZ Primary{aka 702-AZ} - Shutdown at 0115 and restarted at 0700 296-A-18 241-AY-101 Annulus - Shutdown at 0115 and restarted at 1305 296-A-19 241-AY-102 Annulus - Shutdown at 0115 and restarted at 1305 296-A-20 241-AZ Annulus - Shutdown at 0115 and restarted at 1305 296-A-43 702-AZ Building - Shutdown at 0115 and restarted at 1045 296-A-28 241-AW Annulus - Shutdown at 0115 and restarted at 1130 296-S-21 Record sampler - Shutdown at 0115 and restarted at 0850 296-A-28 241-AW Annulus - Shutdown at 2037 and restarted at 2058 296-A-20 241-AZ Annulus - Shutdown at 2048 and restarted at 2053 **296-S-25 241-SY "A-Train" - Shutdown at 0730 and restarted at 0930 **Found down at 0720 on rounds – believed caused by 0115 electrical power loss.
X	10/13/2011	TOC-ENV-NOT-2011-0012	(AY-102, AY102-WSTA-LDT-152) Double-shell Tank 241-AY-102 annulus ENRAF 152 was discovered reading above the expected operating range on 10/9/2011. The other two annulus ENRAFs were both within the expected operating range and ENRAF 152 was declared out of service. During maintenance and troubleshooting work conducted on 10/12/2011, the ENRAF 152 displacer was discovered to be visually wet and weighing more than expected. Rainwater intrusion is thought to be the cause of the wetness. A video will be taken of the annulus space near this ENRAF and additional maintenance work will be planned to restore the ENRAF to normal operations.

Table E-12. 2011 Environmental Notifications (2 pages)

Notif. PDF	Date	Notification Number	Description
X	11/9/2011	TOC-ENV-NOT-2011-0022	296-A-19, 241-AY-102 Annulus, Aerosol testing of the HEPA filter identified 2 of 8 filters providing less than required removal efficiency of 99.95%. The HEPA filters consist of two stages of filters in a 2 high by 2 wide arrangement of individual HEPA filters per stage. One filter in the first stage achieved a 99.86% removal efficiency. One filter in the second stage achieved a 99.944% removal efficiency. No spread of contamination was found following the filter testing. Operations secured the exhauster at 1125 hours and subsequently closed a damper upstream of the HEPA filters. Work documents are being prepared to replace the filters that failed the aerosol test. A review of recent operator rounds showed steady, acceptable, differential pressure readings across each of the HEPA filter stages. A review of the previous aerosol test for these filter stages showed all filters passing at a 99.998% removal efficiency. Background: The 296-A-19 241-AY-102 annulus exhauster provides ventilation of the secondary containment area around the 241-AY-102 underground waste storage tank. Air to the annulus area provides for tank cooling and removal of condensation to minimize corrosion. There is no stored, or measurable volume, of waste inventory in the annulus.
X	12/6/2011	TOC-ENV-NOT-2011-0030	Unplanned Shutdown 296-A-42, 702-AZ, 241-AY/AZ Tank Exhauster. Notified by Central Shift Manager that the 241-AY/AZ Tank Exhauster, 702-AZ (296-A-42) experienced an unplanned shutdown. Cause for the unplanned shutdown of the 241-AY/AZ Primary Exhauster, 702-AZ was due to a momentary failure of a control card. The 241-AY/AZ Primary Exhauster, 702-AZ was restarted at 0810 hrs. A sweep of the farm for contamination was conducted and no contamination was found.
X	12/7/2011	TOC-ENV-NOT-2011-0032	Unplanned Shutdown 296-A-42 & 296-A-20, 241-AY/AZ Tank & AZ Annulus Exhauster. Notified by Central Shift Managers that both the 241-AY/AZ Tank Exhauster, 702-AZ (296-A-42) and AZ Annulus Exhauster experienced unplanned shutdowns due to a momentary "power glitch" which occurred on the evening of 12/06/2011. According to Operations the "power glitch" was experienced across the site. The 241-AY/AZ Primary Exhauster, 702-AZ shutdown at 2045 hrs. and was restarted at 2135 hrs. However Operations personnel began to experience difficulties in keeping the exhauster operational therefore the 241-AY/AZ Primary Exhauster was secured from operation at 2256 hrs. The 241-AY/AZ Primary Exhauster was restarted at 0853 hrs on 12/07/2011. The AZ Annulus Exhauster shutdown at 2045 hrs and was restarted at 1200 hrs on 12/07/2011. No other exhausters were affected by the momentary “power glitch.”
X	12/8/2011	TOC-ENV-NOT-2011-0034	Flow Totalizer failed calibration for 296-A-42, 702AZ Primary Ventilation System. The flow totalizer for the 296-A-42 stack record sample system failed to meet calibration criteria during the performance of an annual preventive maintenance activity. The record sample and ventilation system continue to operate. Procurement of replacement components has been expedited and will be installed as soon as they are available.
X	12/29/2011	TOC-ENV-NOT-2011-0043	296-A-42, 45, 46 & P-47 At 200E Tanks Farms: AY/AZ, AN, AW & C. At 01:50 on 12-29-2011 a computer TMACS / electrical anomaly caused the 702-AZ (296-A-42) AN-VTP B-Train (296-A-45), AW A-Train (296-A-46) and Portable Exhauster POR-08 (296-P47) to shut down. Radiological sweeps of the farms have been completed and exhauster operations returned to normal.

Event

Table E-13. 2012 Environmental Notifications (3 pages)			
Notif. PDF	**Date**	**Notification Number**	**Description**
X	1/25/2012	TOC-ENV-NOT-2012-0009	296-A-42, 296-A-45, 296-A-46, 296-P-23 and 296-P-47, At 0430 on 1-25-2012 the AN-VTP B-Train (296-A-45), AW-VTP A-Train (296-A-46), the 702-AZ A-Train (296-A-42), SY B-Train (296-P-23) and Portable exhauster POR-008 (296-P-47)experienced an unplanned shutdown. The cause is thought to be related to high winds/electrical and further troubleshooting will be performed. There is no indication of a release. 702-AZ was returned to normal operation at 04:48 hrs.
X	2/21/2012	TOC-ENV-NOT-2012-0016	296-A-42, The 702-AZ Primary Exhauster had an unplanned shutdown on 02/16/2012 at 1615 hrs and was restarted at 1630 hrs. There was no apparent cause found. There was no sign of a release due to this shutdown.
X	2/22/2012	TOC-ENV-NOT-2012-0018	296-A-42, 296-A-45, 296-A-46, 296-P-23 and 296-P-47, On 02/22/2012 at 0440 hrs, several exhausters experienced an unplanned shutdown. The affected exhausters were AN-VTP B-Train (296-A-45), AW-VTP A-Train (296-A-46), 702-AZ (296-A-42), SY-VTP B-Train (296-P-23) and portable exhauster POR-008 (296-P-47). The cause is thought to be related to electrical power spikes related to the high winds. Troubleshooting is underway and ventilation will be restarted as soon as practicable. There is no indication of a release.
X	3/9/2012	TOC-ENV-NOT-2012-0022	A temporary loss of electrical distribution power, lasting ~ 8 minutes, resulted in the unplanned shutdown of the emission units listed below. After restoration of electrical power and confirmation of no release of Radioactive material, the emission units were restarted by the end of the day. AN tank farm 296-A-45 Primary ventilation, B-train AZ tank farm 296-A-42 Primary ventilation, A-train, 296-A-20 Annulus ventilation, 296-A-43 702-AZ building ventilation, B-train AY tank farm 296-A-19 AY-102 Annulus ventilation AP tank farm 296-A-40 Primary ventilation, B-train, 296-A-41 Annulus ventilation, A-train AW tank farm 296-A-46 Primary ventilation, A-train, 296-A-28 Annulus ventilation SY tank farm 296-S-25 Primary ventilation, A-train, 296-P-22 Annulus ventilation C tank farm 296-P-47 Retrieval ventilation, 296-C-107 Retrieval ventilation Retrieval activities were also shutdown, then restarted after restart of exhauster.
X	3/13/2012	TOC-ENV-NOT-2012-0023	Operational Activity Notification, 241-SY Settlement Agreement and Stipulated Order of Dismissal REVISION 1: Scheduled dates have changed as noted below. A planned maintenance outage will remove power from the 241-AY and 241-AZ DST primary level indicating ENRAF devices thereby rendering them inoperable. Following is a list of the affected tanks and planned dates: 241-AZ-101 & AZ-102 approximate start date: 3/19/2012 through finish 3/20/2012; 241-AY-101 & AY-102 have been rescheduled to start approximately 2 weeks from 3/19/2012. All annulus ENRAF leak detectors will be powered and operable for the duration of the outage. As planned, the primary tank level measurement data will be collected at least once each operating day, but the outage will exceed 24 hours. The scope of the maintenance outage includes periodic clean and inspect various electrical components such as breakers, programmable logic controllers, and lighting equipment in the AY and AZ tank farm and nearby locations. Maintenance activities are not planned on the ENRAF instruments.
X	3/14/2012	TOC-ENV-NOT-2012-0023 R1	Operational Activity Notification, this revision expanded scope description and modified the planned outage dates.

Table E-13. 2012 Environmental Notifications (3 pages)			
Notif. PDF	**Date**	**Notification Number**	**Description**
X	4/26/2012	TOC-ENV-NOT-2012-0039*	The 296-A-42 stack chiller on the AY/AZ primary exhauster was discovered not operating at 0730 on 4/23/12* and 0920hrs on 4/26/12*. The chiller was restarted on 4/23/12 and was still operating during the previous night shift rounds on 4/25/12. The chiller was successfully restarted shortly after each discovery. No specific cause of the shutdown was identified. Work planning has started an investigation of the cause of the shutdown.
X	5/3/2012	TOC-ENV-NOT-2012-0042	Operational Activity Notification, A planned maintenance outage will remove power from the 241-AY DST primary level indicating ENRAF devices thereby rendering them inoperable. The outage is expected to last from May 4, 2012, to May 5, 2012 but may be extended to May 7, 2012 pending the progress of the maintenance work. All annulus ENRAF leak detectors will be powered and operable for the duration of the outage. The scope of the maintenance outage includes periodic clean and inspect various electrical components such as breakers, programmable logic controllers, and lighting equipment in the AY tank farm and nearby locations. Maintenance activities are not planned for the ENRAF instruments.
X	5/16/2012	TOC-ENV-NOT-2012-0046	296-A-42 exhauster's stack chiller was discovered not operating at 08:05hrs on 5/16/2012. The stack chiller was successfully restarted shortly after discovery. The cause is currently unknown. There are no indications of any release to the environment.
X	6/6/2012	TOC-ENV-NOT-2012-0053	241-AY-102, The AY-102-WSTA-LDT-152 DST annulus ENRAF was identified out of service on 3/10/2012 with a required repair date of 6/8/2012. During planned repairs conducted 5/24/2012 the ENRAF displacer wire broke and the displacer and wire fell into the annular space. A video camera entered into the annulus June 4, 2012, identified the displacer in a location that would interfere with the performance of the ENRAF. The majority of fallen wire was removed but attempts to retrieve or move the displacer from the bottom of the annulus were unsuccessful. Due to the additional recovery actions needed, the ENRAF is expected to be repaired after the 90 day due date of June 8, 2012. The exact completion date is dependent upon the ability to move or retrieve the displacer. A discussion was held via phone call between the Base Operations Environmental Compliance for Team AZ and the Ecology DST permit writer late in the day on 06/05/2012 concerning the events leading up to this required notification.
X	6/7/2012	TOC-ENV-NOT-2012-0055	241-A-42, During the CY2011 annual Air Operating Permit report preparation, it was discovered the current Tank Waste Information Network System (TWINS) inventory for 241-AY&AZ tanks exceeds the air permit approval order #AIR 12-319 condition 3) Annual Possession Quantity (APQ) for 5 of 46 listed isotopes. The affected isotopes are: Actinium-227, Niobium-93(m), Plutonium-238, Thorium-229 and Uranium-233. None of the 5 isotopes were detectable in CY2011 stack samples. Actual measured emissions for 2011 were more than 4 billion times below the permitted dose limit. Compliance Plan: WRPS will review the APQ and submit a permit modification. Monitoring for actual air emissions will continue as required by permit.
X	6/18/2012	TOC-ENV-NOT-2012-0056	296-A-42, The chiller [listed abatement control technology] for the 241-AY/AZ primary tank ventilation system was found not operating during operator rounds. No specific cause was identified. The chiller was successfully restarted at 0720 hours. Primary ventilation remained in operation during the time period the chiller was not operating.

Table E-13. 2012 Environmental Notifications (3 pages)

Notif. PDF	Date	Notification Number	Description
X	7/2/2012	TOC-ENV-NOT-2012-0069	296-A-42, Electrical power will be turned off on the 702-AY/AZ primary ventilation system chiller for planned maintenance activities. The planned maintenance will consist of several short durations on July 2, 2012. The ventilation system will continue to operate and no waste disturbing activities are planned during the maintenance. This planned maintenance activity is needed to investigate recent spontaneous chiller shutdowns. Four notifications documenting five chiller shutdowns have been made since April 26, 2012. The FF-01 Radioactive Air Emissions License emission unit #93 lists the water chiller and chiller pump as abatement control technology with downtime reported by notification procedure.
X	7/11/2012	TOC-ENV-NOT-2012-0075	296-A-42, 296-P-47, POR008, and 296-P-48, POR003 experienced an unplanned shutdown due to an electrical system power fluctuation. Waste retrieval operations shut down. A-42 (AY/AZ) had been restarted and surveys completed by 1000 hours. POR003 and POR008 were restarted at approximately 0820 and 1000 respectively. There was no indication of contamination release.

Event

Appendix F

TANK AY-102 FORMAL LEAK ASSESSMENT MEETING MINUTES

TANK AY-102 FORMAL LEAK ASSESSMENT MEETING MINUTES

MEETING MINUTES

SUBJECT: Tank 241-AY-102 Leak Assessment Meeting #1 and #2				
TO: Distribution	BUILDING: 2750E/C-217			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	**AREA** 200-E	**SHIFT**	**DATE OF MEETING** 08/28/2012 08/30/2012	**NUMBER ATTENDING** 10

Distribution:

T. J. Barnes
K. D. Boomer*
J. K. Engeman+*
C. L. Girardot+*
D.G. Harlow+*
C. C. Joslyn
A. C. Prince+*
C. L. Rosenkrance*
R. P. Tucker+*
T. J. Venetz*
J. A. Voogd+*
D. J. Washenfelder+*

_____

*Attendees

Team Members+

Background:

Tank 241-AY-102 (tank AY-102)

The tank AY-102 annulus was last inspected in 2006 using multiple tank risers. The inspection showed evidence of water intrusion. The tank was included in a 2007 recovery plan intended to stop the intrusion. All actions were taken and the report was closed in 2009.

On August 1, and August 5, 2012, a video inspection of the double-shell tank 241-AY-102 annulus was completed. The inspection identified the following areas that required additional evaluation:

- An isolated build-up of brown material on the annulus floor near Riser 90 as viewed from Riser 77. This was the first time that this region of the tank had been inspected, including the last inspection in 2006.

- A small cascade of material on the insulating concrete and the annulus floor near the isolated build-up of brown material as viewed from Riser 77.
- Material on the annulus floor as viewed from Riser 87. Comparison with the 2006 inspection suggests that change has occurred, but is undetermined since new, higher resolution video equipment and an improved lighting source were used during the most recent inspection.
- An isolated patch of crystals, similar to photos of concrete leachate, but undetermined, adhered to the primary top knuckle (above the liquid level of the tank) as viewed from Riser 89. Comparison with the 2006 inspection indicates that change has occurred.

The results of the August 2012 inspection were reviewed by Base Operations and Engineering management on August 7, 2012 (see photos Attachment 2). WRPS-PER-2012-1363 was initiated August 7, 2012, and WRPS-PER-1438 on August 22, 2012, to address the tank AY-102 inspection results. It was determined that the annulus air CAM was still operating, and was not in alarm; that the annulus inspection camera recovered from the annulus inspection had no reported contamination; and that previous work evolutions in the annulus showed no signs of increased radiation levels above minimal contamination levels.

On August 8, 2012, a follow-up meeting determined near-term actions as follows:

1. Deploy camera through Riser R90 and inspect the material on the annulus floor and attempt to determine the source/location of the cascade. The brown mound was estimated to be approximately 5 ft^3.

2. Acquire contamination survey data of the annulus floor near Riser 90. A contamination smear collected from the annulus floor August 10, 2012 read 800,000 disintegrations per minute and a preliminary lab analysis of the smear indicated material consistent with tank waste.

3. Remote samplers are being developed for regions which require additional evaluation.

WRPS initiated an investigation effort lead by Operations and Engineering including an action to perform a formal tank AY-102 leak assessment. The formal leak assessment team was appointed August 20, 2012 per WRPS-1203445 and the first meeting of the team was kicked off with the presentation Attachment 1.

Team Member Actions:

Preliminary leak assessment tasks from the August 28, 2012 meeting are listed below:

The results of the tasks will be incorporated into the Leak Assessment Report.

Responsibility*	Task
	Histories
Engeman/Prince	Tank Construction History including Plate Weld Repair and Floor Buckling, Insulating Concrete Placement and Repair (Reorder boxes from Seattle Records Center)
Engeman/Prince	Construction History Annulus Ductwork Replacement and Annulus Air Supply System Reconfiguration (Talk with Harty and Tardiff)
Harlow/ Engeman	Tank diagram and description
Girardot/Harlow	• Operating (including tank C-106 sludge retrieval and Hot Commissioning Feed combination) and Thermal History (including sludge thermocouples), source early TCRs • Annulus Contamination, Annulus Intrusion, and Annulus ENRAF History • Occurrence Reports History (including any relevant AY-101 Occurrence Reports)
Rosenkrance	Chemistry History (with J Rasmussen/J Reynolds inputs)
Venetz	Leak Detection Pit History
Johnson	Review Operating History and Chemistry History
Tardiff/Prince	Dome survey and dome survey history
	Analyses
Boomer	In-Vitro Multipurpose Corrosion Probe Performance since Installation
Boomer	Wall Thinning Overlays from the Two Ultrasonic Inspections
Prince	Tank Thermal Behavior versus Annulus HVAC Status
Venetz/Prince	Leak Detection Pit Behavior versus Annulus HVAC Status (Prince/Harty may have data)
Venetz/Prince	Leak Detection Pit Sample Results (all available historical samples)
Prince/Girardot	CAM Alarm and 7-Day Decay Count CAM Sample Paper History (including Occurrence Report events)
Prince	Primary Tank Waste Level Behavior versus 7-Day Decay Count CAM Sample Paper History
Venetz/Engeman	Embedded Thermocouple Temperature History near Riser 90 since 2007 (PCSACS/SDD's
Venetz/Engeman	Insulating Concrete Properties and Waste Compatibility Behavior (with Mike E. Johnson)
Girardot	Tank History Timeline
Tucker	Diary and Results of Ongoing Evaluation Activities
Engeman	Annulus Visual Inspection Interpretations
Rosenkrance	Annulus Sample Analysis Interpretation
Voogd	Regulatory notification history

Leak Assessment Report and Status Reporting	
Harlow/Girardot	Develop Assessment Report Outline and Edit Inputs
Harlow	Prepare ESRB Leak Assessment Briefing
Harlow	Leak Causes and Locations Scenarios
Boomer/Engeman	Daily/Weekly Status Reporting and Meeting Attendance

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title
WRPS-1203445	D. J. Washenfelder, "Tank 241-AY-102 Formal Leak Assessment Appointments," WRPS, Richland, WA, August 20, 2012

Documents:

Number	Title
WRPS-PER-2012-1363	Tank AY-102 Video Inspection

Drawings:

Number	Title

Attachment:

1. "241-AY-102 Leak Assessment" Presentation from AY-102 Leak Assessment meeting #1, August 28, 2012 (6 slides).
2. Tank AY-102 Risers, Tank AY-102 Riser 77, Tank AY-102 Riser 87, Tank AY-102 Riser 89

ATTACHMENT 1

washington river protection solutions

241-AY-102 Leak Assessment

Dennis Washenfelder
Technical Integration Program
August 28, 2012

Purpose of Meeting

- Review Leak Assessment Team Makeup and Introductions
- Discuss and Tune Assignments
- Briefly Review Results from early assignments
  - Tank Inspection Status (JKE)
  - Annulus operating status vs tank waste level (ACP)
  - CAM 7-day decay sample counts since 2007 (ACP)
  - LDP level vs annulus operating status (ACP)
- Decide on future meeting durations, frequencies, locations

Page 2

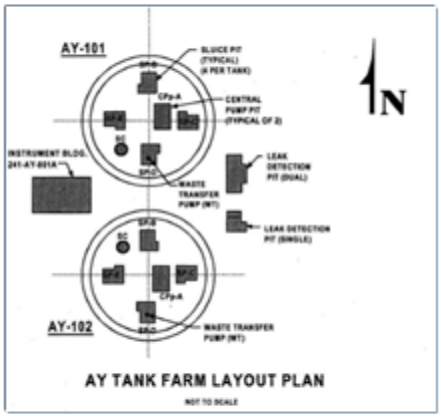
241-AY-102 Leak Assessment Team

- **Purpose:** [*Build detailed tank history*]; **Review leak evidence and determine tank leak integrity status using TFC-ENG-CHEM-D-42 "Leak Assessment Process;"** [*Determine extent of condition*]
- **Leak Assessment Team**
  - Jason Engeman
  - Crystal Girardot
  - Don Harlow
  - Andrew Prince
  - Ron Tucker
  - Jeff Voogd
  - Dennis Washenfelder
  - Team support - Ted Venetz, Kayle Boomer, Mike E. Johnson (CH2M HILL)

Page 3

Background: 241-AY Tank Farm

- 2 – 1,000,000 gal aging waste DSTs Constructed 1968-1971
- Basic tank structure
  - Primary Tank and foundation
  - Secondary tank
  - Reinforced concrete shell
- Leak detection
  - Primary tank
    - Annulus
  - Secondary tank



RPP-151236, Rev 2, System Description for AY/AZ Tank Farm Double Shell Tank Waste Storage System, Feb. 3, 2006

Page 4

Background: Tank AY-102

- February 1971 initially filled with water and maintained warm
- March 1972 received water from tank A-104
- June 1975 received cerium waste from B Plant
- November 1975 received diverter station sumps and misrouted B Plant waste (2750 gal)
- October 1976 Pumped tank AY-102 to tank A-101
- March-April 1976 received B Plant waste and BNL HLW
- August 1981 misrouting tank AY-101 to AY-102 (0.2 in)
- January 1986 supernatant to tank AW-102 and tank SY-102 to AY-102
- May 1986 supernatant to AW-102 and B Plant Waste to tank AY-102
- November 1991 misrouting 244-CR-003 to tank AY-102 (0.2 in)
- 1994-1998 multiple caustic adds
- 1998-1999 tank C-106 sluiced to AY-102 with AY 102 supernatant
- See tank AY-102 Operational Timeline for further details

Page 5

Tank AY-102 Leak Assessment Data

Schedule and Team Interactions

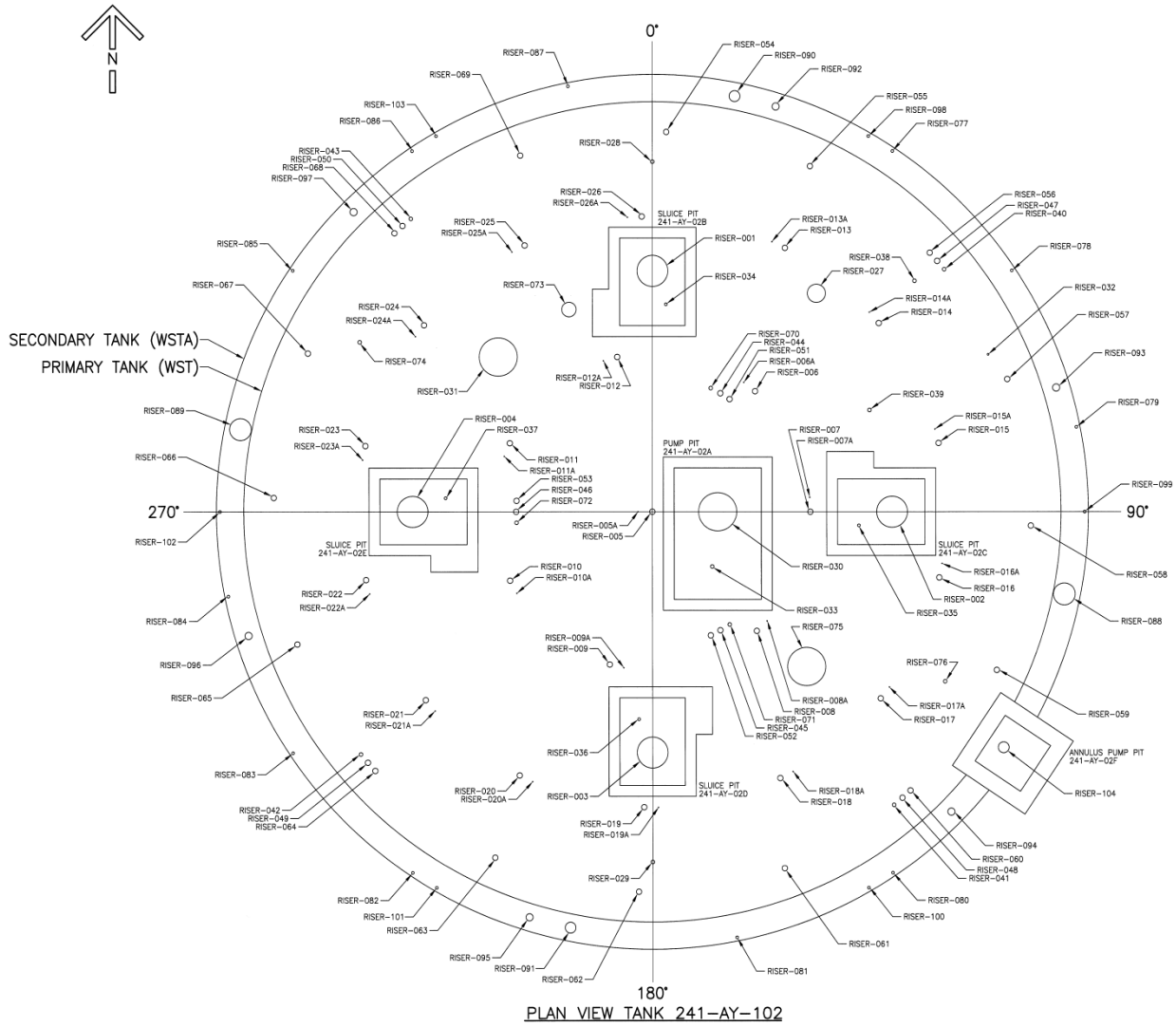
1. Assessment due one week after sample results
2. Meeting frequency dependent on information
3. All data/analysis send to Crystal Girardot
   - Completed staff work submittals have to be in final form with an explanation summary.
4. Investigators submit section write-ups to Don Harlow
5. Meeting action items will be published and distributed with brief discussion of summary documentation
6. Writing rules

Page 6

ATTACHMENT 2

Tank AY-102 Risers
Riser 77
Riser 87
Riser 89

Tank AY-102 Risers

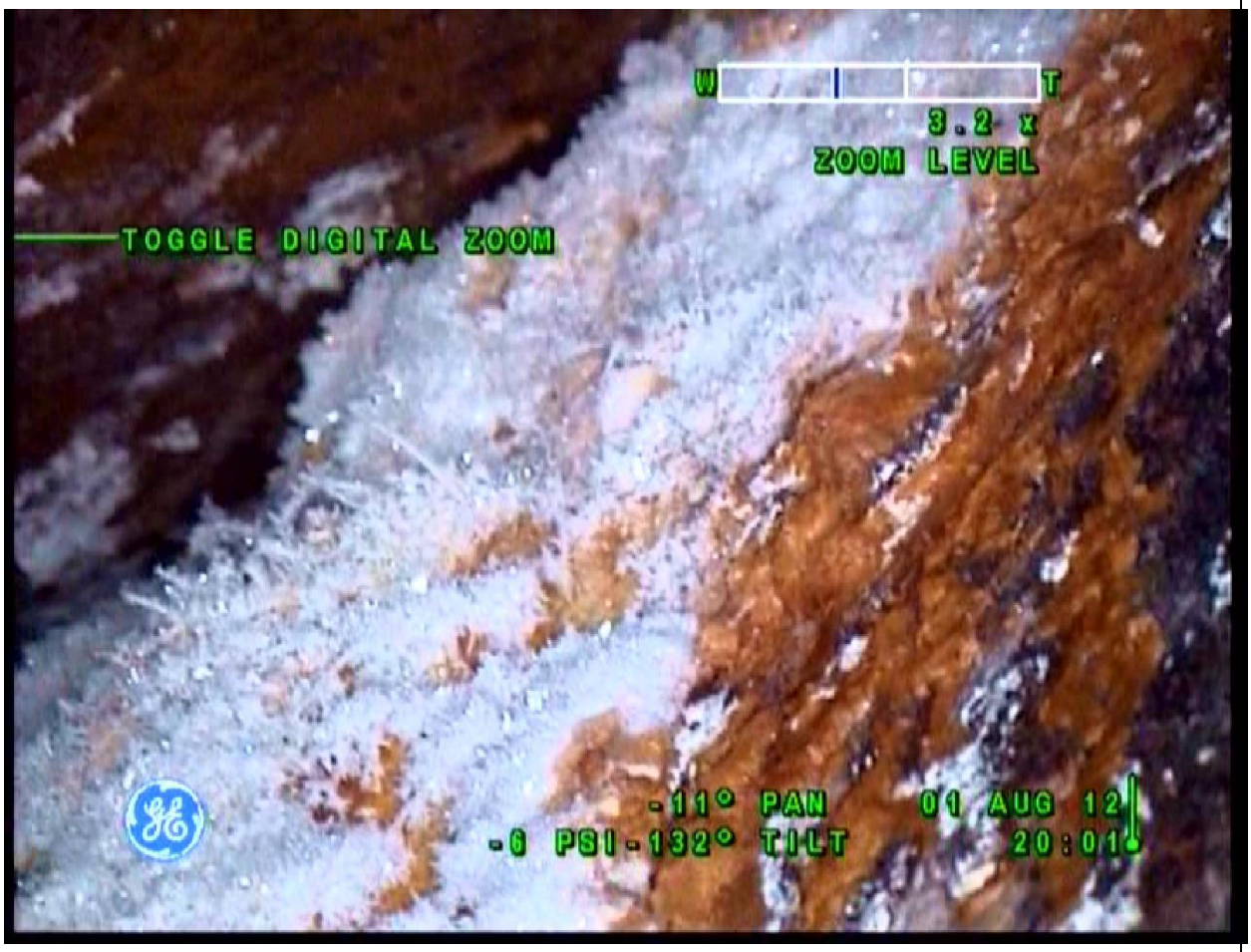


PLAN VIEW TANK 241-AY-102

Tank AY-102 Riser 77
Brown Mound

Tank AY-102 Riser 87
Annulus Floor Appearance Change

Tank AY-102 Riser 89
Crystalline Material on Exterior Primary Tank Surface above Waterline



MEETING MINUTES

	SUBJECT: Tank AY-102 Leak Assessment Meeting #3			
TO: Distribution	BUILDING: 2750E/C-217			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	**AREA** 200-E	**SHIFT**	**DATE OF MEETING** 09/04/2012	**NUMBER ATTENDING** 12

Distribution:

T. J. Barnes
K. D. Boomer*
J. K. Engeman+*
C. L. Girardot+*
D.G. Harlow+*
C. C. Joslyn*
A. C. Prince+*
C. L. Rosenkrance*
R. P. Tucker+*
T. J. Venetz*
J. A. Voogd+*
D. J. Washenfelder+*

*Attendees

Team Members+

Background:

Tank 241-AY-102

The tank AY-102 annulus was last inspected in 2006 using multiple tank risers. The inspection showed evidence of water intrusion. The tank was included in a 2007 recovery plan intended to stop the intrusion. All actions were taken and the report was closed in 2009.

On August 1, and August 5, 2012, a video inspection of the double-shell tank 241-AY-102 annulus was completed. The inspection identified the following areas that required additional evaluation:

- An isolated build-up of brown material on the annulus floor near Riser 90 as viewed from Riser 77. This was the first time that this region of the tank had been inspected, including the last inspection in 2006.
- A small cascade of material on the insulating concrete and the annulus floor near the isolated build-up of brown material as viewed from Riser 77.

- Material on the annulus floor as viewed from Riser 87. Comparison with the 2006 inspection suggests that change has occurred, but is undetermined since new, higher resolution video equipment and an improved lighting source were used during the most recent inspection.
- An isolated patch of crystals, similar to photos of concrete leachate, but undetermined, adhered to the primary top knuckle (above the liquid level of the tank) as viewed from Riser 89. Comparison with the 2006 inspection indicates that change has occurred.

The results of the August 2012 inspection were reviewed by Base Operations and Engineering management on August 7, 2012. WRPS-PER-2012-1363 was initiated August 7, 2012, and WRPS-PER-1438 on August 22, 2012, to address the tank AY-102 inspection results. It was determined that the annulus air CAM was still operating, and was not in alarm; that the annulus inspection camera recovered from the annulus inspection had no reported contamination; and that previous work evolutions in the annulus showed no signs of increased radiation levels above minimal contamination levels.

On August 8, 2012, a follow-up meeting determined near-term actions as follows:

1. Deploy camera through Riser R90 and inspect the material on the annulus floor and attempt to determine the source/location of the cascade. The brown mound was estimated to be approximately 5 ft^3. The Riser 90 inspection was completed August 10, 2012.

2. Acquire more contamination survey data of the annulus floor near Riser 90. A contamination smear collected from the annulus floor read 800,000 disintegrations per minute. Video inspections performed on August 23 and 27, 2012 indicated no change in condition from August 10, 2012

3. Remote samplers are being developed for regions which require additional evaluation.

The Tank AY-102 formal leak assessment team was appointed August 20, 2012 per WRPS-1203445.

Video through Riser 83 on August 29, 2012 indicated some green deposits. The 2006 historical benchmark of this area did not show any unknown material in this area of the annulus (see Attachment 2).

A proposed Leak Assessment Report Outline with responsibilities and estimated timing was developed from the August 28, 2012 task listings (see Attachment 1).

The basis for the leak assessment process is described in HNF-3747, *Tank Leak Assessment Process: Technical Background*. The HNF-3747 document was used to develop the leak assessment probability calculation methodology for assessing double-shell tanks (DST) (see Attachment 3).

References:

Briefings:

Date	Title
August 28, 2012	241-AY-102 Leak Assessment

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title
WRPS-1203445	D. J. Washenfelder, "Tank 241-AY-102 Formal Leak Assessment Appointments," WRPS, Richland, WA, August 20, 2012

Documents:

Number	Title
WRPS-PER-2012-1363	Tank AY-102 Video Inspection
HNF-3747	Tank Leak Assessment Process: Technical Background, December 30, 1998

Drawings:

Number	Title

Attachment:

1. "241-AY-102 Leak Assessment document Outline"
2. "Riser 83 Video Stills August 29, 2012"
3. "Tank Leak Probability Calculation Methodology w/Expert Elicitation Form

ATTACHMENT 1

241-AY-102 Leak Assessment Document Outline

Tank AY-102 Leak Assessment Outline
Responsibility and Estimated Completion
9/4/2012

a) **List References for each section/subsection**
b) **Lead Individual is responsible for integration of the indicated Section**
c) **Emphasis on 2007 to Present**
d) **Send operational recommendations/shortcomings to Harlow for compilation**

1. Introduction – Harlow
   1.1. Tank Description – Harlow and Diagram (Current) – Engeman -9/7/12
   1.2. Description of Event, Response, Results – Harlow – 9/11/12
      1.2.1. Event indicators
      1.2.2. Inspection of annulus, samples (annulus and leak detection pit)
2. Method of Analysis – Harlow – 9/7/12
3. Tank AY-102 Structural History (Time Line) – Girardot
   3.1. Construction – Engeman/Prince - Complete
   3.2. Refractory – Venetz/Engeman – 9/13/12
      3.2.1. Waste compatibility – Venetz/Engeman (w/Mike Johnson) – 9/13/12
      3.2.2. Dome Elevation Survey and History – Rast/Prince (w/Tardiff) - 9/13/12
      3.2.3. Temperature analysis – Joslyn – 9/13/12
   3.3. Upgrades – Engeman/Prince/Barnes – Prince – 9/17/12
4. Tank AY-102 Operational History (Time Line) – Girardot
   4.1. Primary Tank /Waste transfers (Applicable OSD Limits) – Girardot – 9/7/12
      4.1.1. Waste Transfers – Girardot – 9/7/12
      4.1.2. Liquid Level – Girardot- 9/13/12
         4.1.2.1. Evaporation Rates – 9/13/12
      4.1.3. Temperature – Rosenkrance – 9/13/12
      4.1.4. Samples/Chemistry – Rosenkrance – 9/13/12
      4.1.5. Ventilation – Joslyn/Rosenkrance – 9/13/12
         4.1.5.1. AY farm Record Sampler – Voogd – 9/11/12
      4.1.6. Corrosion Probe – Boomer – 9/13/12
      4.1.7. Visual inspection – Engeman – 9/13/12
      4.1.8. UT of primary tank (see 4.2.7) – Boomer – 9/11/12
      4.1.9. Occurrence Reports – Harlow – 9/7/12
   4.2. Annulus History (Applicable OSD Limits) – Girardot
      4.2.1. Annulus Description (Diagram) – Barnes/Engeman – 9/11/12
      4.2.2. Annulus History (Summary) – Girardot – 9/11/12
      4.2.3. Ventilation – Joslyn/Prince/Rosenkrance – 9/13/12
      4.2.4. ENRAF Liquid Level – Girardot/ Conner – 9/19/12
         4.2.4.1. Broken/Sticking ENRAF – 9/19/12
      4.2.5. CAM (alarms and decay count) – Prince/Girardot 9/19/12
         4.2.5.1. Stack Record Sampler – Voogd – 9/11/12
      4.2.6. Video Inspections – Engeman – 9/11-12
         4.2.6.1. 2006 versus 2012 Comparison – 9/11/12

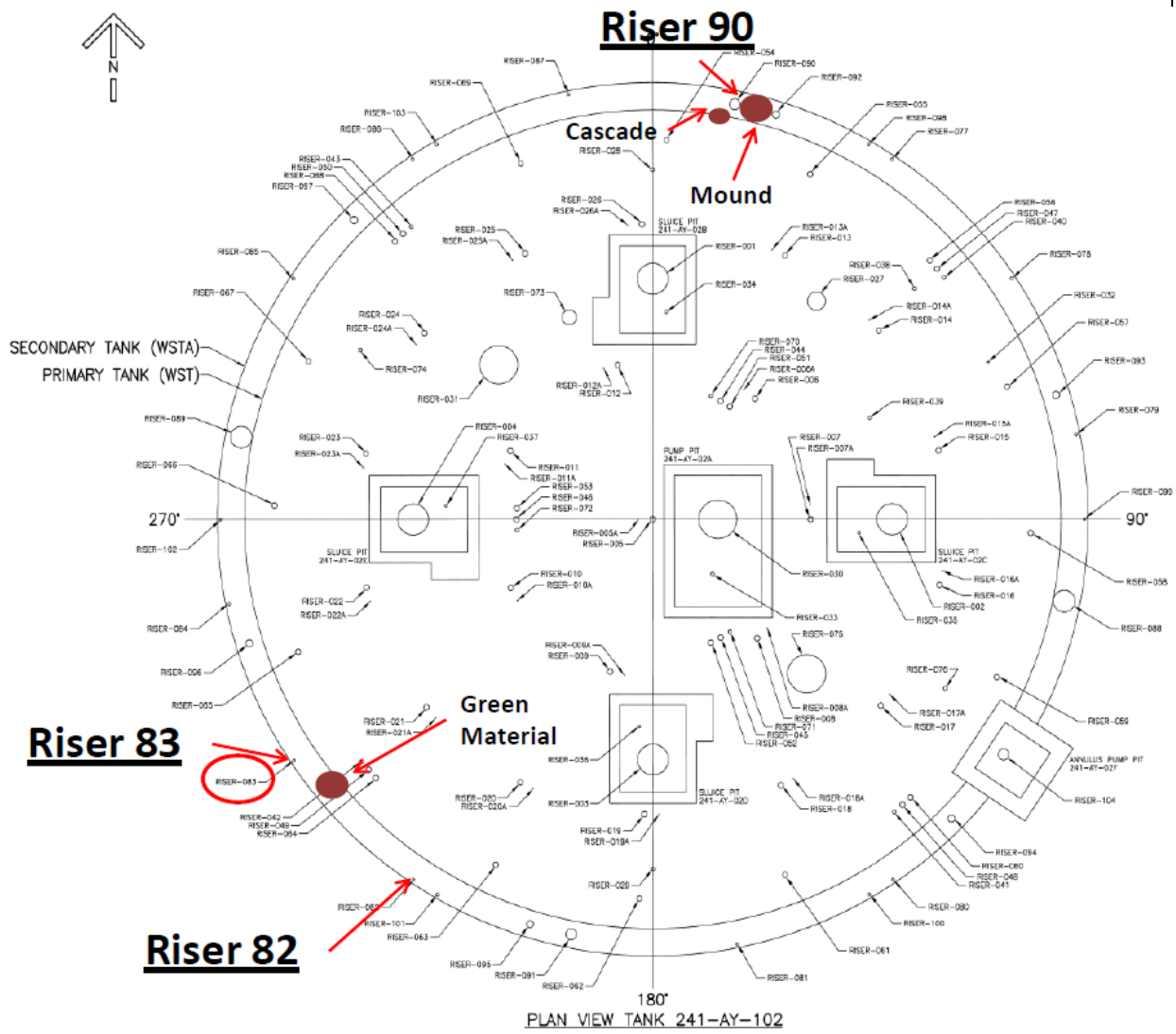
4.2.7. Concrete Shell Embedded Thermocouple Temperature History near material in annulus since 2007 – Joslyn/Venetz/Engeman – 9/13/12
4.2.8. Samples – Rosenkrance - 9/13/12
4.2.8.1. Secondary Tank Waste Containment Duration Limit – Boomer – 9/12/12
4.2.9. Occurrence Reports – Harlow – 9/7/12
4.3. Leak Detection Pit (LDP) History (Applicable OSD Limits) – Venetz – 9/12/12
4.3.1. LDP Description (Diagram) – Venetz - 9/10/12
4.3.2. LDP History (Summary) – Venetz - 9/10/12
4.3.3. Liquid Level – Venetz - 9/10/12
4.3.4. Radiation Detector – Venetz -9/10/12
4.3.5. Samples – Results - Venetz with Interpretation – Rosenkrance - 9/12/12
4.3.6. Inspection – Engeman – 9/13/12
4.3.7. Occurrence Reports – Harlow 9/7/12
4.4. Regulatory notifications – Voogd - 9/7/12
5. Leak Evaluation – Harlow/Venetz/Boomer 9/26/12
5.1. Field Evaluation Activities Summary- Tucker – weekly compilation
6. In – Tank Data and Ex – Tank Data – Girardot - 9/26/12
7. Hypotheses – Team – 9/26/12
8. Conclusions– Harlow/Venetz/Boomer
9. References – All

Appendices

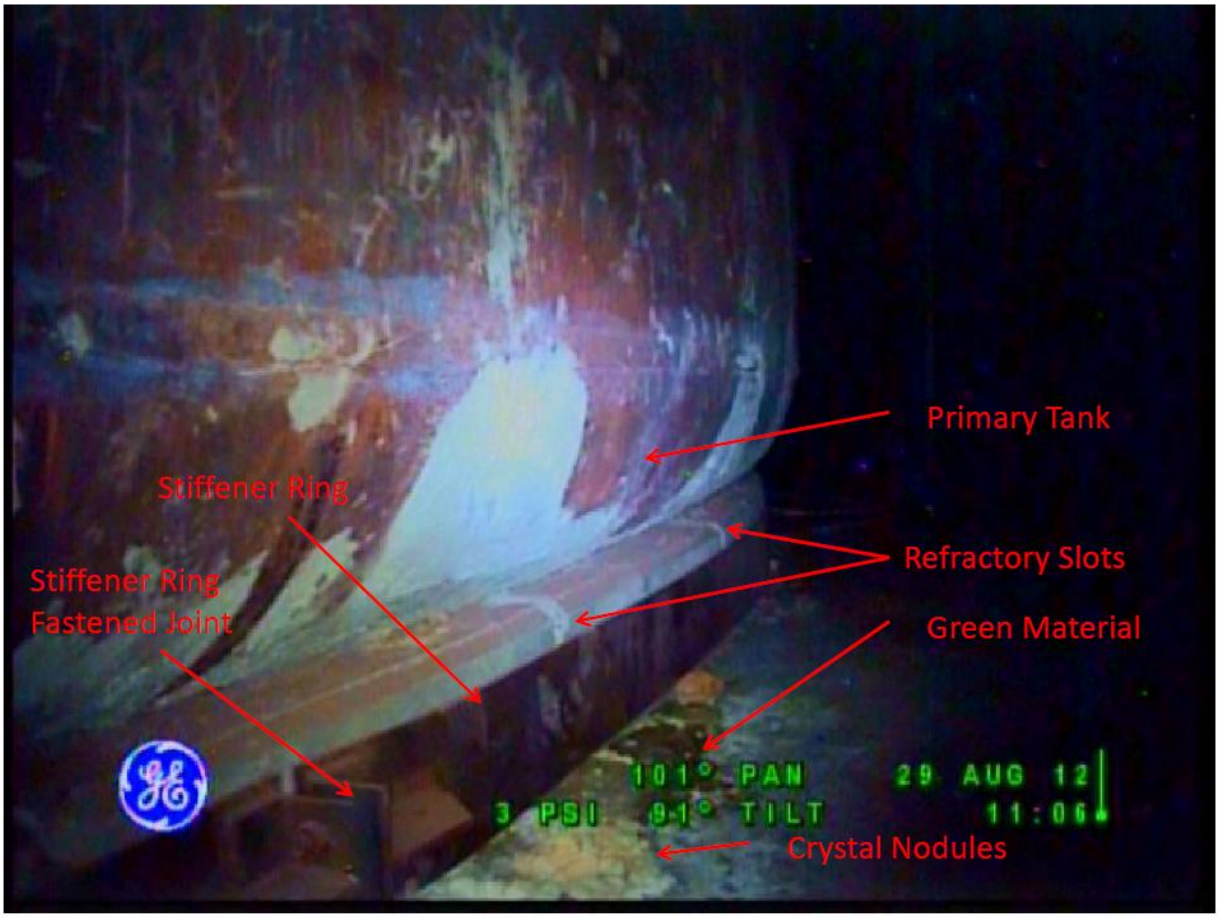
A. Tank AY-012 Timelines
B. Comparison with AY-101 data
C. Diary of Ongoing Field Evaluation Activities - Tucker
D. Meeting Minutes - Girardot
E. Tank AY-102 In-Tank and EX-Tank Data - Girardot
F. Tank AY-102 Leak Assessment Team Expert Elicitation Forms - All
G. Executive Safety Review Board Briefing – Harlow
H. Regulatory Notifications - Voogd

ATTACHMENT 2

Riser 83 Video Stills August 29, 2012


Riser 90
Cascade
Mound
Green Material
Riser 83
Riser 82
SECONDARY TANK (WSTA)
PRIMARY TANK (WST)
270°
90°
180°
N
PLAN VIEW TANK 241-AY-102

Overview of Region Viewed From Riser 83



Overview of Green Material Viewed From Riser 83

Close-Up of Green Material Viewed From Riser 83

Close-Up of Crystal Like Nodules Viewed From Riser 83

ATTACHMENT 3

Tank Leak Probability Calculation Methodology

Tank Leak Probability Calculation Methodology

The methodology used to determine the probability of a tank leak is described in HNF-3747, Rev. 0, *Tank Leak Assessment Process: Technical Background*. In order to determine the tank leak probability using data such as the ENRAF™ surface level trends, four probabilities must be known:

(1) $p(\mathrm{L})$ — The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

(2) $p(\mathrm{NL})$ — The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The $p(\mathrm{NL}) = 1 - p(\mathrm{L})$.

(3) $p(\mathrm{D}|\mathrm{L})$ — The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic tank data would be present if the tank was leaking.

(4) $p(\mathrm{D}|\mathrm{NL})$ — The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic tank data would be present if the tank was not leaking.

The probabilities (1) – (4) are combined to form likelihood ratios according to the following equations:

(5) $$\Omega_0 = \frac{p(\mathrm{L})}{p(\mathrm{NL})}$$ HNF-3747, Rev. 0, p. 15

(6) $$\Omega_1 = \frac{p(\mathrm{L}|\mathrm{D})}{p(\mathrm{NL}|\mathrm{D})} = \frac{p(\mathrm{D}|\mathrm{L})}{p(\mathrm{D}|\mathrm{NL})} \times \frac{p(\mathrm{L})}{p(\mathrm{NL})}$$ HNF-3747, Rev. 0, p. 15

(7) $$\Omega_2 = \frac{p(\mathrm{L}|\mathrm{D})}{p(\mathrm{NL}|\mathrm{D})} = \frac{p(\mathrm{D}_{\text{in-tank}}|\mathrm{L})}{p(\mathrm{D}_{\text{in-tank}}|\mathrm{NL})} \times \frac{p(\mathrm{D}_{\text{ex-tank}}|\mathrm{L})}{p(\mathrm{D}_{\text{ex-tank}}|\mathrm{NL})} \times \frac{p(\mathrm{L})}{p(\mathrm{NL})}$$ HNF-3747, Rev. 0, p. 16

(8) $$p(\mathrm{L}|\text{combined}) = \frac{\Omega_x}{1+\Omega_x}$$ HNF-3747, Rev. 0, p. 27

where:

Ω_0 — "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

Ω_1	Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic data examined during the leak assessment.
Ω_2	Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, and the event or discovery that initiated the formal leak assessment; and the diagnostic in-[primary] tank and ex-[primary] tank data examined during the leak assessment.
p(L|combined)	The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-[primary] tank and ex-[primary] tank data examined during the leak assessment.

In order to determine the probability of a tank leak, either the "prior probability" that the tank was leaking, p(L), or the prior probability that the tank was not leaking, p(NL), <u>before</u> the event or discovery that initiated the leak assessment, is determined and converted to the "prior" likelihood of a leak. "Likelihood ratios," or Ω's, in HNF-3747, and are the decimal equivalent of "odds."

After the prior likelihood ratio of a leak, Ω_0, is determined, the likelihood ratio is adjusted to take account of the event or discovery that initiated the leak assessment, and the diagnostic data examined during the leak assessment, using the "posterior probability" of the event or discovery, or the diagnostic data, has resulted from a leak, p(D|L), and the posterior probability of the event or discovery or the diagnostic data has not resulted from a leak, p(D|NL). These are converted to the "posterior" likelihood ratio that the observed event and diagnostic data resulted from a leak.

The product of the prior and the posterior likelihood ratios is the "combined likelihood ratio" that the tank leaked, based on the tank history, and the event or discovery that initiated the leak assessment, and the diagnostic data examined during the leak assessment. The combined likelihood ratio is identified in HNF-3747 as Ω_1 (Equation 6). At the end of the leak assessment the combined likelihood ratio is reconverted to the leak probability, p(L|combined).

It is important to note that the combined likelihood ratio can include the product of more than one posterior likelihood ratio if multiple events or discoveries or multiple types of diagnostic data are examined during the leak assessment. The most commonly encountered example of using the product of multiple posterior likelihood ratios to derive a combined likelihood ratio is the presence of both in-tank data and ex-tank data for single-shell tanks – for example the product of waste surface level and drywell radiation profiles posterior likelihood ratios is frequently used to determine the combined posterior likelihood ratio in single-shell tank leak assessments. Equation (7) for Ω_2 illustrates how multiple likelihood ratios from in-tank and ex-tank data are combined to determine the combined posterior likelihood ratio.

A simple example using diagnostic ENRAF™ surface level data illustrates how the Ω_1 combined posterior likelihood ratio is developed:

Combined Leak Probability, *p*(L|combined), Calculation Example:

A single-shell tank is suspected of having a small leak because of its age and operating history. The only data associated with the tank are ENRAF™ surface level data. The leak assessment panel decides that the prior probability of the tank leaking based solely on the tank's and similar tanks' age, operating histories, and leak integrity status, and not considering the event or observation that initiated the leak assessment, is $p(\mathrm{L}) = 0.40$. Therefore, the prior probability of the tank not leaking is $p(\mathrm{NL}) = 1 - p(\mathrm{L}) = 0.60$. Using equation (5), the prior likelihood ratio of the tank leaking before the event or discovery that led to the leak assessment is 0.67.

$$\Omega_0 = \frac{p(\mathrm{L})}{p(\mathrm{NL})} \qquad \text{Equation (5)}$$

$$\Omega_0 = \frac{0.40}{0.60}$$

$$\Omega_0 = 0.67$$

Next the leak assessment panel examines the ENRAF™ surface level data and decides that the data are diagnostic for a leak. If the tank were leaking, the surface level data should show a decrease. In this case, no decrease trend is apparent over the past several years. However, a small leak might not be detectable by the ENRAF™. The leak assessment panel decides that the posterior probability of a stable surface level trend from a small leak is 0.40; and that the posterior probability of a stable surface level trend from a non-leaking tank is 0.90. Therefore the posterior likelihood ratio for the surface level trend is 0.44.

$$\frac{p(\mathrm{D}|\mathrm{L})}{p(\mathrm{D}|\mathrm{NL})} = \frac{0.40}{0.90}$$

$$\frac{p(\mathrm{D}|\mathrm{L})}{p(\mathrm{D}|\mathrm{NL})} = 0.44$$

During the panel's elicitation, the combined posterior likelihood ratio that the tank leaked is determined using Equation (6). The combined posterior likelihood ratio of is the product of the surface level posterior likelihood ratio and the prior likelihood ratio:

$$\Omega_1 = \frac{p(\mathrm{L}|\mathrm{D})}{p(\mathrm{NL}|\mathrm{D})} = \frac{p(\mathrm{D}|\mathrm{L})}{p(\mathrm{D}|\mathrm{NL})} \times \frac{p(\mathrm{L})}{p(\mathrm{NL})} \qquad \text{Equation (6)}$$

$$\Omega_1 = 0.44 \times 0.67$$

$$\Omega_1 = 0.29$$

The combined likelihood ratio that the tank leaked is 0.29.

Next the panel determines the posterior probability that the tank had a small leak that was not detectable in the stable ENRAF surface level data, using Equation (8*:

$$p(\mathrm{L}|\mathrm{combined}) = \frac{\Omega_1}{1+\Omega_1} \qquad \text{Equation (8)}$$

$$p(\mathrm{L}|\mathrm{combined}) = \frac{0.29}{1+0.29}$$

$$p(\mathrm{L}|\mathrm{combined}) = 0.22$$

The panel determines that the posterior probability that the tank leaked is 0.22, or about 2 chances in 7.

MEETING MINUTES

SUBJECT: Tank AY-102 Leak Assessment Meeting #4, #5, and #6				
TO: Distribution	BUILDING: 2750E/C-217			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	**AREA** 200-E	**SHIFT**	**DATE OF MEETING** 09/07-11-13/2012	**NUMBER ATTENDING** 12

Distribution:

T. J. Barnes
K. D. Boomer*
J. K. Engeman+*
C. L. Girardot+*
D.G. Harlow+*
C. C. Joslyn*
A. C. Prince+*
C. L. Rosenkrance*
R. P. Tucker+*
T. J. Venetz*
J. A. Voogd+*
D. J. Washenfelder+*(9/7/12)

_____

*Attendees

Team Members+

Background:

Tank 241-AY-102

The Tank AY-102 annulus was last inspected in 2006 using multiple tank risers. The inspection showed evidence of water intrusion. The tank was included in a 2007 recovery plan intended to stop the intrusion. All actions were taken and the report was closed in 2009.

On August 1, and August 5, 2012, a video inspection of the double-shell tank 241-AY-102 annulus was completed. The inspection identified the following areas that required additional evaluation:

- An isolated build-up of brown material on the annulus floor near Riser 90 as viewed from Riser 77. This was the first time that this region of the tank had been inspected, including the last inspection in 2006.
- A small cascade of material on the insulating concrete and the annulus floor near the isolated build-up of brown material as viewed from Riser 77.

- Material on the annulus floor as viewed from Riser 87. Comparison with the 2006 inspection suggests that change has occurred, but is undetermined since new, higher resolution video equipment and an improved lighting source were used during the most recent inspection.
- An isolated patch of crystals, similar to photos of concrete leachate, but undetermined, adhered to the primary top knuckle (above the liquid level of the tank) as viewed from Riser 89. Comparison with the 2006 inspection indicates that change has occurred.

The results of the August 2012 inspection were reviewed by Base Operations and Engineering management on August 7, 2012. WRPS-PER-2012-1363 was initiated August 7, 2012, and WRPS-PER-1438 on August 22, 2012, to address the tank AY-102 inspection results. It was determined that the annulus air CAM was still operating, and was not in alarm; that the annulus inspection camera recovered from the annulus inspection had no reported contamination; and that previous work evolutions in the annulus showed no signs of increased radiation levels above minimal contamination levels.

On August 8, 2012, a follow-up meeting determined near-term actions as follows:

1. Deploy camera through Riser R90 and inspect the material on the annulus floor and attempt to determine the source/location of the cascade. The brown mound was estimated to be approximately 5 ft^3. The Riser 90 inspection was completed August 10, 2012.

2. Acquire more contamination survey data of the annulus floor near Riser 90. A contamination smear collected from the annulus floor read 800,000 disintegrations per minute. Video inspections performed on August 23 and 27, 2012 indicated no change in condition from August 10, 2012.

3. Remote samplers are being developed for regions which require additional evaluation.

The Tank AY-102 formal leak assessment team was appointed August 20, 2012 per WRPS-1203445.

Video through Riser 83 on August 29, 2012 indicated some green deposits. The 2006 historical benchmark of this area did not show any unknown material in this area of the annulus. See Leak Assessment Meeting Minutes #3.

A proposed Leak Assessment Report Outline with responsibilities and estimated timing was developed from the August 28, 2012 task listings (see Attachment 1).

<u>Leak Assessment Meeting #4</u>

In the Leak Assessment meeting #4, updates were given on the status of each person's section in the Leak Assessment Report Outline (see Attachment 1). The occurrence reports were discussed during the meeting and it was determined that a summary of the reports will be included in the Leak Assessment Report. The next meeting is scheduled for September 11, 2012.

<u>Leak Assessment Meeting #5 and #6</u>

Discussed status of the report outline responsibilities and provided direction for handling inputs; peer review, transfer of individual sections to ETIG, AY-102, Crystal will incorporate sections into the report. Handed out photos (Attachment 2) from the Riser 83 Inspection September 10, 2012.

References:

Briefings:

Date	Title
August 28, 2012	241-AY-102 Leak Assessment

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title
WRPS-1203445	D. J. Washenfelder, "Tank 241-AY-102 Formal Leak Assessment Appointments," WRPS, Richland, WA, August 20, 2012

Documents:

Number	Title
WRPS-PER-2012-1363	Tank AY-102 Video Inspection
HNF-3747	Tank Leak Assessment Process: Technical Background, December 30, 1998

Drawings:

Number	Title

Attachment:

4. "241-AY-102 Leak Assessment document Outline" September 4, 2012

ATTACHMENT 1

241-AY-102 Leak Assessment Document Outline

TANK AY-102 LEAK ASSESSMENT OUTLINE
RESPONSIBILITY AND ESTIMATED COMPLETION
9/4/2012 W/COMMENTS INCORPORATED

a) List References for each section/subsection
b) Lead Individual is responsible for integration of the indicated Section
c) Emphasis on 2007 to Present
d) Send operational recommendations/shortcomings to Harlow for compilation

1. Introduction – Harlow
   1.1. Tank Description – Harlow and Diagram (Current) – Engeman -9/7/12
   1.2. Description of Event, Response, Results – Harlow – 9/11/12
      1.2.1. Event indicators
      1.2.2. Inspection of annulus, samples (annulus and leak detection pit)
2. Method of Analysis – Harlow – 9/7/12
3. Tank AY-102 Structural History (Time Line) – Girardot
   3.1. Construction – Engeman/Prince - Complete
   3.2. Refractory – Venetz/Engeman – 9/13/12
      3.2.1. Waste compatibility – Venetz/Engeman (w/Mike Johnson) – 9/13/12
      3.2.2. Dome Elevation Survey and History – Rast/Prince (w/Tardiff) - 9/13/12
      3.2.3. Temperature analysis – Joslyn – 9/13/12
   3.3. Upgrades – Engeman/Prince/Barnes – Prince – 9/17/12
4. Tank AY-102 Operational History (Time Line) – Girardot
   4.1. Primary Tank /Waste transfers (Applicable OSD Limits) – Girardot – 9/7/12
      4.1.1. Waste Transfers – Girardot – 9/7/12
      4.1.2. Liquid Level – Girardot- 9/13/12
         4.1.2.1. Evaporation Rates – 9/13/12
      4.1.3. Temperature – Rosenkrance – 9/13/12
      4.1.4. Samples/Chemistry – Rosenkrance – 9/13/12
      4.1.5. Ventilation – Joslyn/Rosenkrance – 9/13/12
         4.1.5.1. AY farm Record Sampler – Voogd – 9/11/12
      4.1.6. Corrosion Probe – Boomer – 9/13/12
      4.1.7. Visual inspection – Engeman – 9/13/12
      4.1.8. UT of primary tank (see 4.2.7) – Boomer – 9/11/12
      4.1.9. Occurrence Reports – Harlow – 9/7/12
   4.2. Annulus History (Applicable OSD Limits) – Girardot
      4.2.1. Annulus Description (Diagram) – Barnes/Engeman – 9/11/12
      4.2.2. Annulus History (Summary) – Girardot – 9/11/12
      4.2.3. Ventilation – Joslyn/Prince/Rosenkrance – 9/13/12
      4.2.4. ENRAF Liquid Level – Girardot/ Conner – 9/19/12
         4.2.4.1. Broken/Sticking ENRAF – 9/19/12
      4.2.5. CAM (alarms and decay count) – Prince/Girardot 9/19/12
         4.2.5.1. Stack Record Sampler – Voogd – 9/11/12
      4.2.6. Video Inspections – Engeman – 9/11-12
         4.2.6.1. 2006 versus 2012 Comparison – 9/11/12

4.2.7. Concrete Shell Embedded Thermocouple Temperature History near material in annulus since 2007 – Joslyn/Venetz/Engeman – 9/13/12
4.2.8. Samples – Rosenkrance - 9/13/12
4.2.8.1. Secondary Tank Waste Containment Duration Limit – Boomer – 9/12/12
4.2.9. Occurrence Reports – Harlow – 9/7/12
4.3. Leak Detection Pit (LDP) History (Applicable OSD Limits) – Venetz – 9/12/12
4.3.1. LDP Description (Diagram) – Venetz - 9/10/12
4.3.2. LDP History (Summary) – Venetz - 9/10/12
4.3.3. Liquid Level – Venetz - 9/10/12
4.3.4. Radiation Detector – Venetz -9/10/12
4.3.5. Samples – Results - Venetz with Interpretation – Rosenkrance - 9/12/12
4.3.6. Inspection – Engeman – 9/13/12
4.3.7. Occurrence Reports – Harlow 9/7/12
4.4. Regulatory notifications – Voogd - 9/7/12
5. Leak Evaluation – Harlow/Venetz/Boomer 9/26/12
5.1. Field Evaluation Activities Summary- Tucker – weekly compilation
6. In – Tank Data and Ex – Tank Data – Girardot - 9/26/12
7. Hypotheses – Team – 9/26/12
8. Conclusions– Harlow/Venetz/Boomer
9. References – All

Appendices

A. Tank AY-012 Timelines
B. Comparison with AY-101 data
C. Diary of Ongoing Field Evaluation Activities - Tucker
D. Meeting Minutes - Girardot
E. Tank AY-102 In-Tank and EX-Tank Data - Girardot
F. Tank AY-102 Leak Assessment Team Expert Elicitation Forms - All
G. Executive Safety Review Board Briefing – Harlow
H. Regulatory Notifications - Voogd

ATTACHMENT 2

Riser 83 Inspection
September 10, 2012

Riser 83 Inspection 9/10/12
Refractory Slot

Riser 83 Solids Oozing from Under Refractory Band

MEETING MINUTES

SUBJECT: Tank AY-102 Leak Assessment Meeting #7 and #8				
TO: Distribution	BUILDING: 2750E/C-217			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	**AREA** 200-E	**SHIFT**	**DATE OF MEETING** 09/18/2012 09/20/2012	**NUMBER ATTENDING** 12

Distribution:

T. J. Barnes
K. D. Boomer*
J. K. Engeman+*
C. L. Girardot+*
D.G. Harlow+*
C. C. Joslyn*
K. J. Peltier*(9/18/12)
A. C. Prince+*
C. L. Rosenkrance*(9/18/12)
R. P. Tucker+*(9/18/12)
T. J. Venetz*(9/18/12)
J. A. Voogd+*(9/20/12)
D. J. Washenfelder+*

_____

*Attendees

Team Members+

Background:

Tank 241-AY-102

The tank AY-102 annulus was last inspected in 2006 using multiple tank risers. The inspection showed evidence of water intrusion. The tank was included in a 2007 recovery plan intended to stop the intrusion. All actions were taken and the report was closed in 2009.

On August 1, and August 5, 2012, a video inspection of the double-shell tank 241-AY-102 annulus was completed. The inspection identified the following areas that required additional evaluation:

- An isolated build-up of brown material on the annulus floor near Riser 90 as viewed from Riser 77. This was the first time that this region of the tank had been inspected, including the last inspection in 2006.

- A small cascade of material on the insulating concrete and the annulus floor near the isolated build-up of brown material as viewed from Riser 77.
- Material on the annulus floor as viewed from Riser 87. Comparison with the 2006 inspection suggests that change has occurred, but is undetermined since new, higher resolution video equipment and an improved lighting source were used during the most recent inspection.
- An isolated patch of crystals, similar to photos of concrete leachate, but undetermined, adhered to the primary top knuckle (above the liquid level of the tank) as viewed from Riser 89. Comparison with the 2006 inspection indicates that change has occurred.

The results of the August 2012 inspection were reviewed by Base Operations and Engineering management on August 7, 2012. WRPS-PER-2012-1363 was initiated August 7, 2012, and WRPS-PER-1438 on August 22, 2012, to address the tank AY-102 inspection results. It was determined that the annulus air CAM was still operating, and was not in alarm; that the annulus inspection camera recovered from the annulus inspection had no reported contamination; and that previous work evolutions in the annulus showed no signs of increased radiation levels above minimal contamination levels.

On August 8, 2012, a follow-up meeting determined near-term actions as follows:

1. Deploy camera through Riser R90 and inspect the material on the annulus floor and attempt to determine the source/location of the cascade. The brown mound was estimated to be approximately 5 ft^3. The Riser 90 inspection was completed August 10, 2012.

2. Acquire more contamination survey data of the annulus floor near Riser 90. A contamination smear collected from the annulus floor read 800,000 disintegrations per minute. Video inspections performed on August 23 and 27, 2012 indicated no change in condition from August 10, 2012

3. Remote samplers are being developed for regions which require additional evaluation.

The tank AY-102 formal leak assessment team was appointed August 20, 2012 per WRPS-1203445.

Video through Riser 83 on August 29, 2012 indicated some green deposits. The 2006 historical benchmark of this area did not show any unknown material in this area of the annulus. See Leak Assessment Meeting Minutes #3.

A proposed Leak Assessment Report Outline with responsibilities and estimated timing was developed from the August 28, 2012 task listings. See Attachment 1.

<u>Leak Assessment Meeting #7 and #8</u>

Discussed status of the report outline responsibilities and provided direction for handling inputs; peer review, transfer of individual sections to ETIG, AY-102, Crystal will incorporate sections into the report. Kyle Peltier provided results and interpretation of the CAM sample results. Kyle will also write up what he discussed in the meeting to be added to the leak assessment report.

References:

Briefings:

Date	Title
August 28, 2012	241-AY-102 Leak Assessment

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title
WRPS-1203445	D. J. Washenfelder, "Tank 241-AY-102 Formal Leak Assessment Appointments," WRPS, Richland, WA, August 20, 2012

Documents:

Number	Title
WRPS-PER-2012-1363	Tank AY-102 Video Inspection
HNF-3747	Tank Leak Assessment Process: Technical Background, December 30, 1998

Drawings:

Number	Title

Attachment:

1. "241-AY-102 Leak Assessment document Outline" September 4, 2012
2. Tank AY-102 Annulus Event Summary- September 20, 2012

ATTACHMENT 1

241-AY-102 Leak Assessment Document Outline

Tank AY-102 Leak Assessment Outline
Responsibility and Estimated Completion
9/4/2012 w/comments incorporated

a) List References for each section/subsection
b) Lead Individual is responsible for integration of the indicated Section
c) Emphasis on 2007 to Present
d) Send operational recommendations/shortcomings to Harlow for compilation

1. Introduction – Harlow
   1.1. Tank Description – Harlow and Diagram (Current) – Engeman -9/7/12
   1.2. Description of Event, Response, Results – Harlow – 9/11/12
      1.2.1. Event indicators
      1.2.2. Inspection of annulus, samples (annulus and leak detection pit)
2. Method of Analysis – Harlow – 9/7/12
3. Tank AY-102 Structural History (Time Line) – Girardot
   3.1. Construction – Engeman/Prince - Complete
   3.2. Refractory – Venetz/Engeman – 9/13/12
      3.2.1. Waste compatibility – Venetz/Engeman (w/Mike Johnson) – 9/13/12
      3.2.2. Dome Elevation Survey and History – Rast/Prince (w/Tardiff) - 9/13/12
      3.2.3. Temperature analysis – Joslyn – 9/13/12
   3.3. Upgrades – Engeman/Prince/Barnes – Prince – 9/17/12
4. Tank AY-102 Operational History (Time Line) – Girardot
   4.1. Primary Tank /Waste transfers (Applicable OSD Limits) – Girardot – 9/7/12
      4.1.1. Waste Transfers – Girardot – 9/7/12
      4.1.2. Liquid Level – Girardot- 9/13/12
         4.1.2.1. Evaporation Rates – 9/13/12
      4.1.3. Temperature – Rosenkrance – 9/13/12
      4.1.4. Samples/Chemistry – Rosenkrance – 9/13/12
      4.1.5. Ventilation – Joslyn/Rosenkrance – 9/13/12
         4.1.5.1. AY farm Record Sampler – Voogd – 9/11/12
      4.1.6. Corrosion Probe – Boomer – 9/13/12
      4.1.7. Visual inspection – Engeman – 9/13/12
      4.1.8. UT of primary tank (see 4.2.7) – Boomer – 9/11/12
      4.1.9. Occurrence Reports – Harlow – 9/7/12
   4.2. Annulus History (Applicable OSD Limits) – Girardot
      4.2.1. Annulus Description (Diagram) – Barnes/Engeman – 9/11/12
      4.2.2. Annulus History (Summary) – Girardot – 9/11/12
      4.2.3. Ventilation – Joslyn/Prince/Rosenkrance – 9/13/12
      4.2.4. ENRAF Liquid Level – Girardot/ Conner – 9/19/12
         4.2.4.1. Broken/Sticking ENRAF – 9/19/12
      4.2.5. CAM (alarms and decay count) – Prince/Girardot 9/19/12
         4.2.5.1. Stack Record Sampler – Voogd – 9/11/12
      4.2.6. Video Inspections – Engeman – 9/11-12
         4.2.6.1. 2006 versus 2012 Comparison – 9/11/12

4.2.7. Concrete Shell Embedded Thermocouple Temperature History near material in annulus since 2007 – Joslyn/Venetz/Engeman – 9/13/12
4.2.8. Samples – Rosenkrance - 9/13/12
4.2.8.1. Secondary Tank Waste Containment Duration Limit – Boomer – 9/12/12
4.2.9. Occurrence Reports – Harlow – 9/7/12
4.3. Leak Detection Pit (LDP) History (Applicable OSD Limits) – Venetz – 9/12/12
4.3.1. LDP Description (Diagram) – Venetz - 9/10/12
4.3.2. LDP History (Summary) – Venetz - 9/10/12
4.3.3. Liquid Level – Venetz - 9/10/12
4.3.4. Radiation Detector – Venetz -9/10/12
4.3.5. Samples – Results - Venetz with Interpretation – Rosenkrance - 9/12/12
4.3.6. Inspection – Engeman – 9/13/12
4.3.7. Occurrence Reports – Harlow 9/7/12
4.4. Regulatory notifications – Voogd - 9/7/12
5. Leak Evaluation – Harlow/Venetz/Boomer 9/26/12
5.1. Field Evaluation Activities Summary- Tucker – weekly compilation
6. In – Tank Data and Ex – Tank Data – Girardot - 9/26/12
7. Hypotheses – Team – 9/26/12
8. Conclusions– Harlow/Venetz/Boomer
9. References – All

Appendices

A. Tank AY-012 Timelines
B. Comparison with AY-101 data
C. Diary of Ongoing Field Evaluation Activities - Tucker
D. Meeting Minutes - Girardot
E. Tank AY-102 In-Tank and EX-Tank Data - Girardot
F. Tank AY-102 Leak Assessment Team Expert Elicitation Forms - All
G. Executive Safety Review Board Briefing – Harlow
H. Regulatory Notifications - Voogd

ATTACHMENT 2

AY-102 Annulus Event Summary
September 20, 2012

The AY-102 Annulus video through riser 90 has been performed a number of times using TFC-WO-12-4829. The dates are:
8-16-12 including installation of riser adapter
8-20-12
8-23-12
8-27-12
8-30-12
9-4-12
9-5-12 Engineering determined no additional videos were required at riser 90. Pulling camera and top hat at riser, installing temporary flange to support sampling material in annulus on swing shift. This completes the twice per week video at riser 90.

The AY-102 Annulus video through riser 83 has been performed a number of times using TFC-WO-12-5018. The dates are:
9-10-12
9-13-12
9-17-12

This data was gathered from daily release sheets for Team AZ.

Wednesday 9-19-12, completed pumping AY-102 Leak Det Pit to AY-101 central pump pit. Level at AY-102 LDP following pumping apx 1 inch. Camera installed to monitor drain into the AY-102 LDP.

Tuesday 9-18-12, completed preps for AY-102 Leak Det Pit pumping. Preps included video of the pit. Team AZ will pump the pit on Wednesday to AY-101.

Wednesday 9-12-12. Today was spent doing work package preparation. No field activities today.

Tuesday 9-11-12 - Strung out AY-102 Ann LDP Pump Hose to determine condition (OK) and W/D pumping route to AY-101. Also performed the assured grounding on the AY-102 Ann LDP Pump cord.

Monday 9-10 Completed the first of the twice per week riser 83 videos.

Friday 9-7-12 **UPDATE** completed the last 2 riser videos on Friday. The 100% video of the AY-102 annulus is complete. There are some disc coping to be done on Monday but the field work is done. The top hat was installed on riser 83 on swings.

Friday 9-7-12 Working a double shift on the 100% video. Completed 2 risers on day shift, will get the last 2 risers on swings. Also, will install a top hat at riser 83 to allow the twice a week video to begin on Monday. The tent frame set up outside AY farm yesterday was "skinned" today by FWS Roger Friesz, NCOs Loren Kelly and Charley Kearney.

Thursday 9-6-12 Riser 91 video completed, ENRAF LDT-153 reinstalled and terminated. Completed calibration of ENRAF LDT-153. **UPDATE** Shipped the AY-102 Leak Detection Pit sample to 222S.

UPDATE On Swing shift Wednesday 9-5-12 completed the video at riser 89 and returned ENRAF LDT-152 to service. After completing the video on riser 89, determed ENRAF LDT-153 on riser 91 to support video on days Thursday.

Wednesday 9-5-12 day shift, took video at 24 inch riser 88. Continued set up for AY-102 LD Pit Grab sample. Crane crew worked outside the farm assembling a tent frame to support AY-102 Annulus sampling.

Tuesday 9-4-12 began setup for AY-102 leak detection pit grab sample.

Tuesday 9-4-12, continued the 100% video package in the afternoon. Didn't go to the field with this package but did "grey card" test on a camera. Did do the bi-weekly video at riser 90 in the morning, date recorded above.

Didn't work over Labor Day weekend.

Thursday 8-30-12 worked the AY-102 100% video. Completed video but got a different camera stuck in riser. Will retrieve the camera when package change made to allow additional means to remove camera.

Wednesday days worked on calibration of AY102-WSTA-LDT-152 on riser 89. Calibration was completed on Thursday, 8-30-12.

The work on Tuesday swing shift (8-28-12) didn't finish. Lightning within 10 miles of the site shut work down.

Monday swing shift (8-27-12) and Tuesday (8-28-12) days and swings we worked on TFC-12-4863 Relocated AY102-WSTA-LDT-152. The work should finish on swings and

then we will calibrate AY102-WSTA-LDT-152 in its new location on riser 89 using package TFC-WO-12-4740.

Friday 8-24-12 we did the AY-AZ VTA paper changes. 702AZ VTP were not done because of resources. We also completed the ISR at AY-102 leak detection pit on Friday, 8-24-12 also.

Wednesday 8-22-12 Bench mark surveys of AY-101 and AY-102 were performed using a Level 3 work order. Data was sent directly to the engineer, Gary Tardiff.

The AY-102 Annulus CAM cal and function test was completed on 8-14-12.

On Monday, 8-13-12 we completed AY-AZ VTA and 702AZ VTP paper changes.

Friday, 8-10-12, first video of AY-102 performed using TFC-WO-12-4563. Involved crane crew to remove ENRAF -152.

Thursday, 8-2-12, Projects worked swing shift to "Perform AY-102 Annulus Video Inspection" using TFC-WO-11-5838.

MEETING MINUTES

SUBJECT: Tank AY-102 Leak Assessment Meeting #9, #10, #11, and #12				
TO: Distribution	BUILDING: 2750E/C-217			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT	**AREA**	**SHIFT**	**DATE OF MEETING**	**NUMBER ATTENDING**
Engineering - Technical Integration	200-E		09/25/2012 09/27/2012 10/02/2012 10/09/2012	11

Distribution:

K. D. Boomer*
J. K. Engeman+*
C. L. Girardot+*
D.G. Harlow+*
C. C. Joslyn*(10/2/12)
A. C. Prince+*
C. L. Rosenkrance*
R. P. Tucker+
T. J. Venetz*
J. A. Voogd+*
D. J. Washenfelder+*

_____

*Attendees

Team Members+

All team members only were present in the Leak Assessment Meeting #12 on October 9, 2012.

Background:

<u>Tank 241-AY-102</u>

The tank AY-102 annulus was last inspected in 2006 using multiple tank risers. The inspection showed evidence of water intrusion. The tank was included in a 2007 recovery plan intended to stop the intrusion. All actions were taken and the report was closed in 2009.

On August 1, and August 5, 2012, a video inspection of the double-shell tank 241-AY-102 annulus was completed. The inspection identified the following areas that required additional evaluation:

- An isolated build-up of brown material on the annulus floor near Riser 90 as viewed from Riser 77. This was the first time that this region of the tank had been inspected, including the last inspection in 2006.

- A small cascade of material on the insulating concrete and the annulus floor near the isolated build-up of brown material as viewed from Riser 77.
- Material on the annulus floor as viewed from Riser 87. Comparison with the 2006 inspection suggests that change has occurred, but is undetermined since new, higher resolution video equipment and an improved lighting source were used during the most recent inspection.
- An isolated patch of crystals, similar to photos of concrete leachate, but undetermined, adhered to the primary top knuckle (above the liquid level of the tank) as viewed from Riser 89. Comparison with the 2006 inspection indicates that change has occurred.

The results of the August 2012 inspection were reviewed by Base Operations and Engineering management on August 7, 2012. WRPS-PER-2012-1363 was initiated August 7, 2012, and WRPS-PER-1438 on August 22, 2012, to address the tank AY-102 inspection results. It was determined that the annulus air CAM was still operating, and was not in alarm; that the annulus inspection camera recovered from the annulus inspection had no reported contamination; and that previous work evolutions in the annulus showed no signs of increased radiation levels above minimal contamination levels.

On August 8, 2012, a follow-up meeting determined near-term actions as follows:

1. Deploy camera through Riser R90 and inspect the material on the annulus floor and attempt to determine the source/location of the cascade. The brown mound was estimated to be approximately 5 ft^3. The Riser 90 inspection was completed August 10, 2012.

2. Acquire more contamination survey data of the annulus floor near Riser 90. A contamination smear collected from the annulus floor read 800,000 disintegrations per minute. Video inspections performed on August 23 and 27, 2012 indicated no change in condition from August 10, 2012

3. Remote samplers are being developed for regions which require additional evaluation.

The tank AY-102 formal leak assessment team was appointed August 20, 2012 per WRPS-1203445.

Video through Riser 83 on August 29, 2012 indicated some green deposits. The 2006 historical benchmark of this area did not show any unknown material in this area of the annulus. See Leak Assessment Meeting Minutes #3.

A proposed Leak Assessment Report Outline with responsibilities and estimated timing was developed from the August 28, 2012 task listings. See Attachment 1.

<u>Leak Assessment Meeting #9 (9/25/2012)</u>

Discussed status updates on the leak assessment report.

Leak Assessment Meeting #10 (9/27/2012)

Examined the video footage of the sampling event on September 26, 2012 which was lowered into the annulus via Riser 91. The off-riser sampler was able to retrieve a sample of the material on the annulus floor located midway between Riser 82 and Riser 83, and the sample was sent to the 22-S laboratory for analysis. The "window open" reading of the sample was 45 mrem. During this sampling event, the CAM went into alarm the next morning on September 27, 2012. Principal constituents include: $NaNO_3$, Na_2CO_3, $NaNO_2$, KNO_3, ^{137}Cs (90.9 µCi/g), and ^{90}Sr (0.120 µCi/g).

Leak Assessment Meeting #11 (10/2/12)

Discussed status updates on the leak assessment report.

Leak Assessment Meeting #12 (10/10/12)

The leak and no-leak hypotheses were discussed and determined to be the following:

Leak hypothesis:

The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank.

Non-Leak hypothesis:

The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is either construction debris or dirt. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

In-tank and ex-tank data were discussed in the meeting and elicitation forms were filled out.

References:

Briefings:

Date	Title
August 28, 2012	241-AY-102 Leak Assessment

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title
WRPS-1203445	D. J. Washenfelder, "Tank 241-AY-102 Formal Leak Assessment Appo WRPS, Richland, WA, August 20, 2012

Documents:

Number	Title
WRPS-PER-2012-1363	Tank AY-102 Video Inspection
HNF-3747	Tank Leak Assessment Process: Technical Background, December 30,

Drawings:

Number	Title

Attachment:

1. Tank AY-102 Annulus Event Summary- October 10, 2012

ATTACHMENT 1

AY-102 Annulus Event Summary
October 10, 2012

The AY-102 Annulus video through riser 83 has been performed a number of times using TFC-WO-12-5018. The dates are:
9-10-12
9-13-12
9-17-12
9-24-12
9-26-12 (See comments below)
10-1-12
10-4-12
10-8-12

This data was gathered from daily release sheets for Team AZ.

Wednesday, 10-10-12. Team AZ took a video at AY-102 LDP with a "tell" hanging from the end of the camera. Results provided to engineering. Based on the results engineering has asked that we repeat the video with different condition in the annulus. We will do this on Thursday assuming the video won't interfere with Projects sampling. Projects continue to set up around AY-102 in prep for sampling at riser 90. Sampling will happen on Swing shift. Will update progress of sampling tomorrow.

Tuesday, 10-9-12. No team AZ activity at AY-102 today.

Monday, October 08, 2012 completed video at riser 83. Projects package to sample riser 90 to OEs today at 10:30. Holding pre-job at 12:30 for more set-up work. Projects working swing shift for "Prep of AY-102 Sampling Event"

Friday, 10-5-12 Team AZ took level readings at AZ LDP. This will be the last level reading taken at the AZ LDP for now while engineering determines path forward.

Thursday, 10-4-12 Team AZ took level readings at AZ LDP. Projects continues setup at Riser 90 for sampling.

Wednesday 10-3-12. Team AZ took level readings at the AZ LDP. Projects continue shop work and package prep for AY-102 Annulus sample at riser 90.

Tuesday, 10-2-12. Completed level reading at AY-102 LDP. Reading taken at various levels of vacuum in the annulus. Results sent to engineering. Sampling continues setup at AY-102 for riser 90 sampling.

Monday, 10-1-12. Completed the twice a week video at AY-102 Riser 83. Completed level reading AY-102 LDP

UPDATE Thursday 9-27-12. AY-102 Annulus Leak Detector CAM alarmed. The CAM paper was changed and the alarm cleared. Also changed the record sampler paper. No action levels detected on the record sampler paper.
Note: AY-102 Annulus Leak Detector CAM alarmed on Thursday day shift after Wednesday swing shift sampling effort described below.

Thursday, 9-27-12. The Sampling crew was scheduled to ship the sample taken from riser 91 to the Lab today. I don't have status whether that happened or not.

Druk level readings were taken at AY-102 LD Pit. Per engineering direction a level reading was taken with the riser closed. A second reading was taken with the riser open and third with the riser closed. The data below shows a change in level with the riser open or closed.
Here is a sum

		Annulus Pressure	Sump Level
Monday:			
Riser closed	0900	-12"	0.0"
Riser open	1400	-12"	+1.84"
Tuesday:			
Riser closed	1400	-12"	0.0"
Thursday:			
Riser closed	0900	-3.5"	+0.60"
Riser open	0930	-3.5"	+2.22"
Riser closed	0935	-3.5"	+0.62"

Wednesday, 9-26-12. Team AZ took daily level reading at AY-102 LD Pit. Sampling worked swing shift to sample the material at riser 91. They were able to get a sample in one location of apx. 1 tbl spoon. Dose rate readings of the sample were 40 mr/hr. The sample will be shipped to the Lab on Thursday, 9-27-12. A video under riser 83 was taken to support the sampling effort. This video, with engineering's concurrence, will be used for the twice as week video at riser 83. Thursday video has been canceled.
UPDATE – From the shift manager email status of overtime Wed 9-26-12 "AY-102 Perform Annulus Off Riser Sample, FWS Craft – Recovered a partial sample. The bucket on the sample tool broke, need to establish a path forward for repair. The small amount of sample obtained will be sent to the lab."

Tuesday, 9-25-12. Took daily level reading at the AY-102 LD Pit. Level readings are recorded in the work record of the package taking the reading and communicated daily to Jason Engeman, engineering. Projects/Sampling had a crew at AY-102 riser 91 building a platform to do sampling. Riggers went to AREVA to modify the scaffold in support of the crawler mock-up.

Monday, 9-24-12. Completed the twice a week video at AY-102 Riser 83. In addition we took an initial Druk level reading at AY-102 LDP, put a camera in the LDP and recorded for 6 hours (till disc was full) and took a final Druk reading. Water level has increased, contact Jason Engeman, engineering, for details. On swing shift projects removed the ENRAF off riser 91, AY102-WSTA-LDT-153 (Daily Report TSR/ENV OOS Equipment List) and installed a top hat. I don't have the results of the mock-up for the crawler at AREVA.

Friday, September 21, Completed paper changes AY-102 Annulus stack. Projects performed the following work for AY-102 Annulus.

- Fab top hat and build frame for AY-102 grab sample (shop work)
- Mockup at AREVA AY-102 Sample Material in Annulus (riser 90)
- EU and DL site visit walk down at AY-102 to bring crane into farm.

Wednesday 9-19-12, completed pumping AY-102 Leak Det Pit to AY-101 central pump pit. Level at AY-102 LDP following pumping apx 1 inch. Camera installed to monitor drain into the AY-102 LDP.

Tuesday 9-18-12, completed preps for AY-102 Leak Det Pit pumping. Preps included video of the pit. Team AZ will pump the pit on Wednesday to AY-101.

Wednesday 9-12-12. Today was spent doing work package preparation. No field activities today.

Tuesday 9-11-12 - Strung out AY-102 Ann LDP Pump Hose to determine condition (OK) and W/D pumping route to AY-101. Also performed the assured grounding on the AY-102 Ann LDP Pump cord.

Monday 9-10 Completed the first of the twice per week riser 83 videos.

Friday 9-7-12 **UPDATE** completed the last 2 riser videos on Friday. The 100% video of the AY-102 annulus is complete. There are some disc coping to be done on Monday but the field work is done. The top hat was installed on riser 83 on swings.

Friday 9-7-12 Working a double shift on the 100% video. Completed 2 risers on day shift, will get the last 2 risers on swings. Also, will install a top hat at riser 83 to allow the twice a week video to begin on Monday. The tent frame set up outside AY farm yesterday was "skinned" today by FWS Roger Friesz, NCOs Loren Kelly and Charley Kearney.

Thursday 9-6-12 Riser 91 video completed, ENRAF LDT-153 reinstalled and terminated. Completed calibration of ENRAF LDT-153. **UPDATE** Shipped the AY-102 Leak Detection Pit sample to 222S.

UPDATE On Swing shift Wednesday 9-5-12 completed the video at riser 89 and returned ENRAF LDT-152 to service. After completing the video on riser 89, determed ENRAF LDT-153 on riser 91 to support video on days Thursday.

9-5-12 Engineering determined no additional videos were required at riser 90. Pulling camera and top hat at riser, installing temporary flange to support sampling material in annulus on swing shift. This completes the twice per week video at riser 90.

Wednesday 9-5-12 day shift, took video at 24 inch riser 88. Continued set up for AY-102 LD Pit Grab sample. Crane crew worked outside the farm assembling a tent frame to support AY-102 Annulus sampling.

The AY-102 Annulus video through riser 90 has been performed a number of times using TFC-WO-12-4829. The dates are:
8-16-12 including installation of riser adapter
8-20-12
8-23-12
8-27-12
8-30-12
9-4-12

Tuesday 9-4-12 began setup for AY-102 leak detection pit grab sample.

Tuesday 9-4-12, continued the 100% video package in the afternoon. Didn't go to the field with this package but did "grey card" test on a camera. Did do the bi-weekly video at riser 90 in the morning, date recorded above.

Didn't work over Labor Day weekend.

Thursday 8-30-12 worked the AY-102 100% video. Completed video but got a different camera stuck in riser. Will retrieve the camera when package change made to allow additional means to remove camera.

Wednesday days worked on calibration of AY102-WSTA-LDT-152 on riser 89. Calibration was completed on Thursday, 8-30-12.

The work on Tuesday swing shift (8-28-12) didn't finish. Lightning within 10 miles of the site shut work down.

Monday swing shift (8-27-12) and Tuesday (8-28-12) days and swings we worked on TFC-12-4863 Relocated AY102-WSTA-LDT-152. The work should finish on swings and then we will calibrate AY102-WSTA-LDT-152 in its new location on riser 89 using package TFC-WO-12-4740.

Friday 8-24-12 we did the AY-AZ VTA paper changes. 702AZ VTP were not done because of resources. We also completed the ISR at AY-102 leak detection pit on Friday, 8-24-12 also.

Wednesday 8-22-12 Bench mark surveys of AY-101 and AY-102 were performed using a Level 3 work order. Data was sent directly to the engineer, Gary Tardiff.

The AY-102 Annulus CAM cal and function test was completed on 8-14-12.

On Monday, 8-13-12 we completed AY-AZ VTA and 702AZ VTP paper changes.

Friday, 8-10-12, first video of AY-102 performed using TFC-WO-12-4563. Involved crane crew to remove ENRAF -152.

Thursday, 8-2-12, Projects worked swing shift to "Perform AY-102 Annulus Video Inspection" using TFC-WO-11-5838.

Appendix G

TANK AY-102 IN-TANK AND EX-TANK DATA

TANK AY-102 IN-TANK AND EX-TANK DATA

Table G-1. Tank 241-AY-102 Leak Assessment In-Tank Data Form 2012-10-09 (9 pages)

SURFACE LEVEL MEASUREMENTS (SLM)	Observation		
ENRAF			
Unexplained, repeatable drop>tolerance	Yes	No	NA X
Significant drop (CLG)	Yes	No	NA
High-heat tank C-106 sludge retrieved into tank between November, 1998 and October, 1999. Sludge was estimated to contain 118,000 BTU (PNNL-13319). Surface level shows decrease trend since the sludge was transferred to the tank.	X		
Significant trend change (CLG)	Yes	No	NA
Year-by-year least squares fit of surface level shows decreases ranging from -0.0200 inches/day to -0.0365 inches per day for period 2007 - present. Average liquid level decrease is approximately 77 gal/day or 28,000 gal/year.	X		
FIC			
Unexplained, repeatable drop>tolerance	Yes	No	NA X
Significant drop	Yes	No	NA X
Significant trend change	Yes	No	NA X
MANUAL GAUGE			
Unexplained, repeatable drop>tolerance	Yes	No	NA X
Significant drop	Yes	No	NA X
Significant trend change	Yes	No	NA X
LIQUID OBSERVATION WELL (LOW) MEASUREMENTS	**Observation**		
Unexplained, repeatable drop>tolerance	Yes	No	NA X
Significant drop	Yes	No	NA X
Significant trend change	Yes	No	NA X
CORROBORATING EVIDENCE	**Corroborates SLM or LOW Data Given**		
Salt well screen	Leak	Alt. Hypoth.	NA X
Standard Hydrogen Monitoring System	Leak	Alt. Hypoth.	NA X

Table G-1. Tank 241-AY-102 Leak Assessment In-Tank Data Form 2012-10-09 (9 pages)

Primary Tank Visual and Ultrasonic Inspections (JKE)	Leak	Alt. Hypoth.	NA.
• Visual inspections from Riser 51 (2001 and 2012) and Riser 65 (2006) show no significant change in primary tank dome conditions above the liquid-air interface. The 2012 inspection identified a core drill string standing vertically in the waste. The ~ 125 pound 33-foot long drill string was dropped ~ 30 ft back into the waste in 2005 (PER-2005-1583).	X	X	
• Ultrasonic inspections: The reportable wall thinning identified does not exceed the acceptance criteria of 20% wall thinning. Comparison of the 1999 and 2006 first vertical scans suggest a wall loss of ~40 mils occurred in 7 years. However, the 2006 scans were completed on "cleaned" surfaces. No significant primary tank wall loss has been detected by UT. No correlation between the tank elevation and degree of pitting. The bottom of the tank cannot be UT inspected.		X	

Weather conditions	Leak	Alt. Hypoth.	NA
			X

Barometric pressure	Leak	Alt. Hypoth.	NA
			X

Precipitation	Leak	Alt. Hypoth.	NA
			X

Temperature	Leak	Alt. Hypoth.	NA
			X

Surface flooding	Leak	Alt. Hypoth.	NA
			X

Process history (CLG)	Leak	Alt. Hypoth.	NA
Initially filled with waste in February 1971 with the last transfer in January 2007. • Liquid level was pumped down below 60-in multiple times in 1976 and 1985-1986. This could have opened a pathway for contamination in the annulus pump pit due to the liquid level being low enough to provide a path from the primary tank through the annulus pump pit drain leg to the annulus.		X	
• In 1975, the transfer route from B Plant to the 200 East Area was placed into service. In 1984, Line SL-233 failed from B Plant to 244-A. In 1994, a hole was discovered in line SL-503 (connects AY-102 sluice pit 02D to central pump pit 02A). These may indicate failures due to waste chemistry.			X

Table G-1. Tank 241-AY-102 Leak Assessment In-Tank Data Form 2012-10-09 (9 pages)

Thermal history (CLR)	Leak	Alt. Hypoth.	NA
• The maximum temperature limit for AY-102 is 260°F.			X
• Temperatures 1971-1975 range 120-180°F. The tank was heated with a steam coil during the first years as preparation as the aging waste spare tank.			X
• Temperatures during 1975-1990 are unavailable but assumed to be much lower than 180°F, and more likely in the 75-100°F range.			X
• Temperature data from 1991-1994 indicated that the maximum reported tank temperature for this time period was 87°F.			X
• In 1998 after C-106 retrieval, average sludge temperatures in the center of the tank have ranged 95-140°F and sludge temperatures in the outer radius of the tank ranged 110-150°F. There have been multiple spikes over 140°F in the center region of the tank, while the outer radius sludge region shows less variability in temperatures.			X
• Nine out of the ten temperature peaks over 140°F in the center sludge region coincided with annulus ventilation outage events from 2003 to 2012.			X
• The bulk supernatant temperatures have been in the range of 90-130°F since the year 2000.			X
• The maximum temperature recorded in AY-102 was 189°F on September 24, 2002 in Riser 072, located in center-bottom (4-inches from bottom of the tank) region of the tank. Operability of the annulus ventilation system during this time is unknown. The temperature increase is consistent with temperature increases experienced during other known annulus ventilation outage events.			X
• The temperature data available indicate that the in-tank temperatures are very susceptible to annulus ventilation outage events, with the center bottom of the tank showing the highest temperature increases during these periods.			X

Waste Characteristics - Process samples (CLR)	Leak	Alt. Hypoth.	NA
• Supernatant Layer: 1971 to 1976; Water was added to the tank in February 1971 prior to the transfer of warm wastes from A farm in 1972, and a small quantity of B Plant waste in 1975. Two waste samples resulted in the pH between 10 and 11 with nitrate ion (< 0.01 M) and nitrite ion (<0.01 M). The tank was operated between 50 and 70 C. Stress Cracking Corrosion (SCC) would not be expected under these conditions. However, these dilute uninhibited solutions at the low pH 10 to 11 and temperatures near 70 C, might have caused pitting corrosion and corrosion at the air liquid interface during this interval.			X

Table G-1. Tank 241-AY-102 Leak Assessment In-Tank Data Form 2012-10-09 (9 pages)

Waste Characteristics - Process samples (CLR)	Leak	Alt. Hypoth.	NA
• Supernatant Layer: 1977 to 1984; Liquid 0.02 M nitrite ion and 0.30 M nitrate ion at pH 10.3 in 1978. Waste additions 1979 to 1981 increased the hydroxide and nitrite ion concentrations to about 2 M and the nitrate ion concentration to about 3 M nitrate ion. Transfers1983 and 1984 reduced these concentrations to a pH above 12.5 and 0.05 to 0.15 M nitrite ion and 0.2 to 0.7 M nitrate ion, temperature unknown. There is some evidence of multiple failures of a line that routed waste from B Plant that by implication may have introduced chemicals into tank AY-102 causing corrosion but information is sketchy. The threat of SCC is minimized by the low concentration of nitrate ion, the low concentrations of nitrite ion but the low ratios raise concerns. Pitting was a definite threat and may have occurred on the walls as low as 6 inches from the bottom of the tank at the beginning of this interval, and as low as 20 inches from the bottom of the tank at its end.		X	
• Supernatant Layer: 1985 to 1998; Many waste transfers were performed between 1985 and 1998 and not all of these solutions were analyzed. However, the wastes were relatively dilute solutions with nitrate ion concentration generally less than 0.01 M. The nitrite ion concentration was initially more than 0.1M, but its concentration later decreased to less than 0.01 M. The hydroxide ion concentration also decreased during this interval, and sodium hydroxide was added to correct the deficiency. The temperature of the supernatant layer during this interval varied from about 25 to 30 C. SCC unlikely solutions dilute, temperatures low. On balance, supernatant not ideally inhibited, but 0.02 M nitrite ion at higher pH and lower temperature implies that there was a small risk for pitting corrosion.			X

Table G-1. Tank 241-AY-102 Leak Assessment In-Tank Data Form 2012-10-09 (9 pages)

Waste Characteristics - Process samples (CLR)	Leak	Alt. Hypoth.	NA
• Supernatant Layer: 1999 to 2006; Tank C-106 waste was transferred December 1998 using supernatant layer of AY-102 as the transfer medium. Later dilute condensate was added to the tank and a new liquid layer formed on top of the supernatant layer. Supernatant temperature rose to between 35 and 50 C. The hydroxide ion initially about 0.1 M with about 0.15 M nitrite ion and a low concentration of nitrate ion. Concentrations both decreased to below chemistry corrosion limits and sodium hydroxide and sodium nitrite were added to bring the composition of the layer back into compliance. The concentrations of nitrate and chloride ion in this layer were very small during the period. Very low concentrations of nitrate ion and other aggressive ions forestalled SCC. Inasmuch as the nitrite content is greater than 0.033M, the pH is greater than 10 and the temperature is less than 40 C, there is a negligible propensity for pitting or corrosion at the liquid air interface.			X
• The Supernatant Layer Interval 5: 2007 to 2012; The supernatant layer was removed in late 2006 and replaced with a new supernatant layer from Tank 241-AP-101. The approximate concentrations are hydroxide ion (2.3 M), nitrite ion (0.90 M) and nitrate ion (1.8 M). The nitrite ion/nitrate ion concentration ratio is about 0.5 with a temperature between 35 and 50 C. Tests of simulants for the period show that neither SCC nor pitting occur at 50 and 77°C.			X
• Solid Layer: 1971-1976. There is no evidence that there was a solid layer during this interval. Solid Layer: 1977-1984; No samples but most, if not all of the layer was produced from solids that were introduced 1977-1979. Since the tank had been virtually emptied in 1976, the solids that deposited at this time were passed through nitrate ion-rich liquids and presumably acquired an interstitial liquid with the same composition as the supernatant layer. By implication, propensity for pitting and cracking corrosion by the interstitial liquids is the same as for the liquid in the supernatant layer at this time. SCC minimized and pitting a definite threat.			X

Table G-1. Tank 241-AY-102 Leak Assessment In-Tank Data Form 2012-10-09 (9 pages)

Waste Characteristics - Process samples (CLR)	Leak	Alt. Hypoth.	NA
• Solid Layer: 1985-1998: The first sample 1987, carbonate was the principal anion in the interstitial liquid at pH 12.1 which contained nitrate ion (0.03 M) and nitrite ion (0.17 M). The interstitial liquid also apparently contained chloride ion, but duplicate analyses yield diverse results (0.04 and 0.41 M). The uncertainties associated with subsequent transfers and the imprecise chloride ion analyses complicate the assessment of the propensity for corrosion. SCC improbable based on the dilute character of the interstitial solutions at the rather low tank temperatures. However, 0.04 M chloride ion may have been initiated pitting at the low concentration of nitrite ion.			X
• Solid Layer:1998 -2006: The interstitial liquid in the former solid layer may have the composition suggested by the analysis of the lower part of the lowest segment of Core 319, i.e., a liquid with more than 1 M carbonate ion with much lower concentrations of aluminate, chloride, fluoride, nitrate, nitrite, oxalate, sulfate, and phosphate ions. Corrosion tests demonstrated that simulants with this composition do not cause pitting or cracking corrosion of heat treated carbon steel at pH 10, 10.5 and 11 at either 50 or 77 C. The results of the testing program and information from the literature strongly suggest that the high concentrations of carbonate ion provide protection against pitting and cracking corrosion even in the presence of oxygen atmospheres. However, the concern remains that the cores have not sampled the waste at the bottom of the tank or detected elements of its lateral heterogeneity. Consequently, the interstitial liquid at the bottom of the tank may have retained nitrate ion that was deposited 1977-1984. The major change in temperature would have greatly enhanced the propensity for SCC and pitting by this waste.			X

Occurrence reports (DGH)	Leak	Alt. Hypoth.	NA
Occurrence reports from 1974 (when the reporting system was first implemented at Hanford site) to present do not record any events associated with a possible change in tank integrity.		X	

Table G-1. Tank 241-AY-102 Leak Assessment In-Tank Data Form 2012-10-09 (9 pages)

Construction history (JKE)	Leak	Alt. Hypoth.	NA
• First DST constructed; no experience basis with design and construction of new features such as refractory concrete or metal tank-in-tank construction techniques.	X		
• Floor plate ripples in both secondary liner and primary tank exceeded allowable limits. Ripples treated by flaming the area; later would appear in different location.	X		
• Floor plate welds were cut out and re-welded up to three times to pass inspection; reported gap widths up to 1 in. were filled with filler material during repairs.	X		
• During post-weld heat treatment, thermal expansion increased primary tank diameter ~ 7 in. Expansion thought to contribute to refractory cracking.	X		
• Secondary liner used as refractory concrete form – later hydrostatic loading as primary tank filled could have flattened ripples, fracturing refractory, or increasing floor plate stresses.	X		
• Refractory concrete was rainwater-soaked prior to post-weld heat treating primary tank; 21-in. wide band on outside perimeter replaced with structural concrete due to significant post-weld heat treat cracking; structural concrete repair did not fill all voids left from refractory removal.	X		
•Voids discovered between top surface of refractory concrete and primary tank convex ripples filled with styrofoam. Styrofoam blowing agents included chlorinated fluorocarbons, corrosive to carbon steel.	X		
• Inspection logs indicate significant improvement in tank AY-101 construction technique, and reduced rework. AY-102 Weld rejection was > 35% vs. AY-101 weld rejection 10% on primary tank bottom.	X		

Gas Release Events	Leak	Alt. Hypoth.	NA
			X

Equipment maintenance calibration	Leak	Alt. Hypoth.	NA
			X

In-tank operations	Leak	Alt. Hypoth.	NA
			X

Table G-1. Tank 241-AY-102 Leak Assessment In-Tank Data Form 2012-10-09 (9 pages)

Temperature Analysis - Foundation Concrete and Refractory Concrete (CCJ)	Leak	Alt. Hypoth.	NA
• Refractory and foundation slab thermocouples have a failure history that is not region-specific.			X
• Thermocouples in the AY-101 refractory concrete have survived better than those in AY-102. One-half of the AY-102 concrete foundation thermocouples have survived while all of the AY-101 thermocouples have failed.			X
• Temperature histories show changes are principally dependent on status of annulus ventilation.			X
• Comparison of thermocouple failures in the refractory concrete pads and concrete foundation for tanks AY-101 and AY-102 do not identify any meaningful differences that can be attributable to a change in the leak integrity of tank AY-102.			X

Fill Cycle Fatigue (DJW)	Leak	Alt. Hypoth.	NA
A 1968 Pittsburgh-Des Moines Steel Co. analysis determined that the number of safe fill-empty stress cycles was between 17,600 and 63,000 using ASME code references. For partial fill-empty cycles, the number increased to 76,000. Tank AY-102 has only experienced three large fill and empty cycles since 1990, a period of twenty-two years.			X

In-Tank Corrosion Probe Operating History (KDB)	Leak	Alt. Hypoth.	NA
Corrosion probe installed in tank AY-102 on March 26, 2009.			
• Evidence indicates that the corrosion probe came in contact with the bottom of the tank several times as the probe was being installed. The Riser and bottom of the tank elevations were incorrect resulting in ~8 in. discrepancy. Limited potential for damage due to controlled installation speed.	X		
• Data collected to date indicate that the tank and properly functioning tank material electrodes are not at corrosion potentials shown to cause SCC by the referenced EPOC laboratory test program results.			X
• During the current reporting period, the operational tank AY-102 MPCMS ER sensors have indicated corrosion rates near 0 mpy. Data from the immersed ER sensor are consistent with what would be expected for carbon steel in a passive, high-pH environment. Similarly, data from the ER sensor located in the VS are consistent with what would be expected for carbon steel in relatively dry air.			X

Source: HNF-3747, 1998, *Tank Leak Assessment Process: Technical Background*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

Table G-2. Tank 241-AY-102 Leak Assessment Ex-Tank Data Form 2012-10-11 (8 pages)

SPECTRAL GAMMA LOGS (SGL)	Observation		
Radionuclides			
Man-made?	Yes	No	NA X
Multiple?	Yes	No	NA X
Distribution			
Peak at bottom of tank?	actual data		No or NA NA
Peak near surface?	actual data		No or NA NA
Increased activity in between?	actual data		No or NA NA
Increased activity below tank?	actual data		No or NA NA
Activity across boreholes			
Multiple boreholes?	Yes	No	NA X
Activity over time			
Increased activity?	Yes	No	NA X

HISTORICAL GROSS GAMMA LOGS (GGL)	Observations		
Distribution			
Sign. peak at bottom of tank?	actual data		No or NA NA
Sign. peak near surface?	actual data		No or NA NA
Sign. increased activity in between?	actual data		No or NA NA
Sign. increased activity below tank?	actual data		No or NA NA
Activity across boreholes			
Multiple boreholes?	Yes	No	NA X
Consistent across boreholes?	Yes	No	NA X
Activity over time			
Abrupt increase (bottom)?	Yes	No	NA X
Abrupt increase (elsewhere)?	Yes	No	NA

Table G-2. Tank 241-AY-102 Leak Assessment Ex-Tank Data Form 2012-10-11 (8 pages)

Gradual increase (bottom)?	Yes	No	NA X
Gradual increase (elsewhere)?	Yes	No	NA X
CORROBORATING EVIDENCE	**Corroborates SGL or GGL Data Given**		
Moisture Probe	Leak	Alt. Hypoth.	NA X
Psychrometrics Psychrometric data for tank AY-101 annulus humidity for the period between April 2005 and December 2006 indicated data has not demonstrated the possibility of a net water accumulation cycle can be determined.	Leak	Alt. Hypoth. X	NA
Bore hole core sample	Leak	Alt. Hypoth.	NA X
Laterals	Leak	Alt. Hypoth.	NA X
Weather conditions			
Barometric pressure	Leak	Alt. Hypoth.	NA
Precipitation The indication of moisture in the annulus in October 2011 was thought to have been water intrusion possible caused by 0.46-in of rain in the 6 days preceding the ENRAF alarm on October 9, 2011 and 0.11-in the day after. The negative pressure on the annulus ventilation system had the potential to draw rainwater through compromised riser gaskets or other sealing points. There were a number of potential penetrations reported to have been sealed on October 13, 2011.	Leak	Alt. Hypoth. X	NA
Temperature	Leak	Alt. Hypoth.	NA
Surface flooding	Leak	Alt. Hypoth.	NA
Process history	Leak	Alt. Hypoth.	NA
Drywell drilling logs	Leak	Alt. Hypoth.	NA
Occurrence reports	Leak	Alt. Hypoth.	NA
Surface spills	Leak	Alt. Hypoth.	NA

Table G-2. Tank 241-AY-102 Leak Assessment Ex-Tank Data Form 2012-10-11 (8 pages)

Transfer line leaks	Leak	Alt. Hypoth.	NA

Construction history Described in In-Tank Data Section	Leak	Alt. Hypoth.	NA X

Equipment maintenance calibration	Leak	Alt. Hypoth.	NA X

Waste characteristics	Leak	Alt. Hypoth.	NA X

In-tank operations Described in In-Tank Data Section	Leak	Alt. Hypoth.	NA X
Refractory Concrete (TJV)	Leak	Alt. Hypoth.	NA
• Water Absorption- 80% by weight			X
• Construction history & post-construction inspection located in In-Tank Construction History			X
• Rainwater was absorbed in refractory before start of post-weld heat treatment. After post-weld heat treatment started, water boiling from the refractory prevented tank bottom temperature from rising above 210°F for two days. Earlier recommendation to hold concrete at 150°F for two weeks before firing.	X		
• The primary tank may be partially contacting one or more of the four air supply pipes if the Kaolite refractory layer lost enough compressive strength. This could have resulted in crevice corrosion to occur between the primary tank and the air supply pipes.	X		
• It was concluded, that based on the assumptions of uniform settlement and the PNNL analysis, that no design and operating limits needed to be changed as a result of the analysis of degradation of the refractory concrete. The analysis did not take into account the 21-in structural concrete repair to the refractory			X
• Waste compatibility studies suggest that given enough time, it is likely that the caustic in the tank waste would dissolve at least the silicon and aluminum components of the refractory. The extent that this would need to occur to cause damage to the tank is not certain.	X		

Dome Elevation - Dome Subsidence Survey (TJV) • All dome elevation surveys are well below the deflection criteria. Two survey points date back to 1984 the other six started in 2006. No evidence of dome deflection or tank settlement.	Leak	Alt. Hypoth.	NA X

Annulus Visual Inspections (JKE)	Leak	Alt. Hypoth.	NA
• August 1, 2012 Riser 77: Brown mound and solid white cascade seen in distance apparently originating in the refractory and flowing onto annulus floor observed near Riser 90.	X	X	
• August 1, 2012 Riser 87: White material distributed on annulus floor from source apparently near Riser 90. Flow distance determined to extend ~ 25 ft.	X	X	

Table G-2. Tank 241-AY-102 Leak Assessment Ex-Tank Data Form 2012-10-11 (8 pages)

Annulus Visual Inspections (JKE)	Leak	Alt. Hypoth.	NA
• August 1, 2012 Riser 89: White crystalline material on primary tank dome above waterline, not present when area was inspected in 2006. Different appearance from $CaCO_3$ water intrusion streaks typically observed on dome.			X
• August 10, 2012 Riser 90: Cascaded material seen from Riser 77 on August 1, flowed from the refractory slot onto the annulus floor toward Riser 87. Second refractory slot about 5 ft CCW from the first shows evidence of lesser flow.	X	X	
• August 29, 2012 Riser 83: Area adjacent to refractory concrete retainer ring shows colored nodules and green material on annulus floor, and evaporated salts along beach line of a darkened area. Subsequent inspections of area showed no apparent change.	X		
• September 27, 2012 Riser 89: Off-Riser Sampler used to collect nodule material for analysis. Nodules were brittle, and apparently hollow. Sampler movement demonstrated liquid was present underneath a salt surface in the dark area.	X		
• Visual inspection results strongly suggest the origin of the leak is from the bottom of the tank.			
• Areas inspected beneath six other annulus risers appeared normal.			X

Annulus Ventilation System Modifications (CLG)	Leak	Alt. Hypoth.	NA
• 1981: Dehumidifier was removed and inlet was modified to allow outside air as the supply air to the annulus		X	
• 1983: Annulus ventilation system modified to eliminate the supply fans and operate the annulus under more negative pressure than the primary tank which changed the minimum liquid level specification to 60-in.		X	
• 1989: Original annulus ventilation system was replaced (Project B-673) which included new cathodically protected piping tied into the original ductwork and old ducts were cut and sealed with plugs.		X	
• 1998: Project W-320 modified the annulus ventilation system to allow 100% of the flow through the air slots under the primary tank to allow the high heat material in tank C-106 to be added to AY-102. The annulus vacuum was increased to 15-in wg during this time.		X	

Annulus Ventilation System Operating History (CLG)	Leak	Alt. Hypoth.	NA
• June 1991 to March 1997, the annulus ventilation system was out of service during ventilation upgrades.	X		
• Since 2003, there were 23 instances where the annulus ventilation system was out of service with the longest outage of 129 days from Oct. 2010 to Feb. 2011.	X		
• The temperature data available indicate that the in-tank temperatures are very susceptible to annulus ventilation outage events, with the center bottom of the tank showing the highest temperature increases during these periods.			X

Table G-2. Tank 241-AY-102 Leak Assessment Ex-Tank Data Form 2012-10-11 (8 pages)

Annulus CAM Alarm History (CCJ)	Leak	Alt. Hypoth.	NA
• In late 1986 and early 1987, the annulus leak detection CAM count rate showed fourteen peaks between 5,000 cpm and 20,000 cpm; these peaks correspond to periods when the tank waste level uncovered the drain legs.		X	
• The tank AY-102 annulus has been subjected to numerous potential cross-contamination events over the years.		X	
• In mid 1998, the annulus exhauster was started and CAM count rates increased upon startup with the count rate being a nominal 1,500 cpm with many peaks between 1,800 cpm and 2,800 cpm; four peaks were recorded at 3,000 cpm or higher.	X	X	X
• The air sample taken from October 21, 2011 to October 26, 2011 had significantly more radioactivity than any other sample previously taken. Since this event, radioactivity appears to be significantly higher in the 2011-2012 period compared to previous years.	X	X	

Annulus ENRAF Alarm History (CLG)	Leak	Alt. Hypoth.	NA
• Riser 90 annulus ENRAF 152 alarmed October 2011 as liquid levels gradually increased to a maximum level of 0.51-in and then slowly declined to less than 0.25-in by November 2011. Water intrusion from rainfall was assumed to be the cause of this event; however, it remains uncertain due to recent events. The other two annulus ENRAFs did not indicate an increase.	X	X	
• On March 10, 2012, the Riser 90 ENRAF 152 was declared out of service. During planned repairs on May 24, 2012, the ENRAF displacer wire broke and fell into the annulus of tank AY-102. A bullet camera was deployed into the annulus on June 4, 2012 which identified that the displacer was in a location that would interfere with the performance of the ENRAF. During this time, it was reported the drum and reel contamination readings were 20,000 dpm/100 cm^2. On June 5, 2012 attempts to retrieve the ENRAF displacer were unsuccessful; thus, the broken displacer remains in the annulus apparently lodged in the material on the floor of the annulus.	X		

Annulus Samples	Leak	Alt. Hypoth.	NA
• Contamination swab from annulus floor beneath Riser 90 read ~ 800K dpm at distance.	X		
• Sample collected from material near Riser 83 on September 27, 2012 was wet, with 45 mrem β+ γ and 10 mrem γ readings.	X		
• 1999- all annulus risers were swabbed. No smearable contamination was found	X		

Table G-2. Tank 241-AY-102 Leak Assessment Ex-Tank Data Form 2012-10-11 (8 pages)

Annulus Water Intrusions	Leak	Alt. Hypoth.	NA
• An annulus exhaust ventilation pipe for tank AY-102 was punctured while performing air lift circulator upgrades March 31, 1986 and the pipe was severely corroded. An investigation indicated both tanks AY-101 and AY-102 annulus ventilation systems were severely corroded while the primary was not. It was determined that the annulus ductwork was corroded only where it directly contacted the soil.		X	
• In 2001, significant increased corrosion was identified on the primary tank of tank AY-102 during tank video inspection since the 1992. Increased corrosion was attributed to water intrusion from external sources (leakage from raw water lines located above the tank dome and natural storm run-on and run-off coupled with shutdown of the annulus ventilation system for an extended period.	X		
• Corrosion product was collected from the annulus side of the primary wall of tank AY-102 through Riser 80 in February 2003 sample found no radioactivity, analyses indicated steel was wetted with water resulting in aqueous corrosion.	X		
• During the FY2006 visual inspections of tanks AY-101 and AY-102 annuli, rust streaks and mineralization were observed on the outside surface of the primary tank walls. The size of the rust areas had increased, and was concentrated on the primary tank top knuckle region. The rust appeared most significant in areas where the primary and secondary liner walls converge. Water could have seeped under the 18 gauge metal flashing covering the gap where the primary and secondary liner walls converge or through the abandoned annulus ventilation piping. Soil channels created by the now isolated raw water supply leaks or the annulus ductwork may provide a path for rainfall and snowmelt seepage onto the concrete dome.	X	X	
• Condensation can occur when the annulus ventilation system is not operating, or whenever the dew point of the incoming air is higher than the tank wall temperature during operation. The condensate can also contribute to the rust. Tank AY-102 annulus humidity for the period between April 2005 and December 2006 indicated that more moisture was being seasonally withdrawn from the annulus than could be accounted for by natural humidity. The presence of rust streaking and mineral deposits originating high on the primary tank outer wall of both tanks AY-101 and AY-102 confirm that water ingress was very likely.		X	

Table G-2. Tank 241-AY-102 Leak Assessment Ex-Tank Data Form 2012-10-11 (8 pages)

Leak Detection Pit Operating History (TJV)	Leak	Alt. Hypoth.	NA
• Visual inspection results; ° Suspect intrusion of water into the leak detection pit stabilizing at specific levels. ° Leak detection pit levels increase at ~1.5-3 gallons per day when annulus ventilation system is active. 0 gallons per day when annulus ventilation system is secured. ° Liquid level began to increase when annulus ventilation system vacuum was increase to ~ -14 in. ° Debris in leak detection pit indicates the presence of dirt and insulating fiber packed into tank foundation center ° Drain line inspection shows evidence of potential microbial corrosion			X
• Post-pumping liquid level behavior. Water accumulation into DST LDPs is a chronic problem with the water level exceeding the OSD maximum authorized level for many years and exposed the drain piping to standing water for long periods. The LDP level does not appear to have exceeded the structural limit and exposed the base concrete and secondary liner bottom to prolonged water exposure, based on available LDP level readings. There are however, at times, problems with the accuracy of some of these readings. Water accumulation into the tank AY-102 LDP became a more chronic problem when the annulus vacuum was increased and the tank received tank 241-C-106 sludge. The LDP level would continually rise to historic level of 41-in (39-in indicated) and appear to stop. Up until 2010, when the LDP started to maintain to new steady state level of about 23-in, the increase in LDP level was well correlated to annulus ventilation system operation. Based on zip cord measurements taken during sampling, the LDP level is about 30-in and about 2-in above the top of the drain line inlet to the LDP riser.			X
• Fill level modeling versus actual measurement. Assuming a constant rate of ingress, the fill behavior the tank AY-102 LDP does not match what is predicted or match the tank 241-AZ-102 LDP once the level of the drain piping begins to fill.			X
• The LDP was sampled in 2007 and again in 2012. The following is a comparison between 2007 and 2012; the ^{137}Cs is lower by an order of magnitude, the ^{90}Sr lower by about half. The pH of the LDP liquid is reported as just below 7, which gives some cause for concern. The pH of the field blank pH was 3.8. The explanation of an unknown contaminant that is affecting (lowering) the pH of the field blank and, therefore, could be affecting (lowering) the pH of the LDP liquid samples does not seem feasible. Only trace amounts of other ions were detected in the LDP liquid samples. This includes detectable nitrate (about 2 ppm) and detectable sulfate and chloride (both less than a ppm). The low level of contamination found in the LDP liquid confirms that the source is not the tank AY-102 primary tank.			X

Source: HNF-3747, 1998, *Tank Leak Assessment Process: Technical Background*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

Appendix H

TANK AY-102 LEAK ASSESSMENT TEAM EXPERT ELICITATION FORMS

TANK AY-102 LEAK ASSESSMENT TEAM EXPERT ELICITATION FORMS

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: J. K . Engeman

Elicitation by:

Hypotheses:

Leaker: The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank

Non-Leaker: The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is either construction debris or dirt. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

Prior Probability Likelihood Ratio L_0 - Part 1

L	NL	L:NL
p(L)	p(NL)	L_0 = p(L) / p(NL)
0.03	0.97	0.03

While annulus inspections showed water intrusion, none indicated anomolies along the tank annulus floor nor indications of primary tank wall leaks.
UT data did identify pitting, however the pits identified were no greater than 1/8-inch which is 1/3 the thickness of the primary tank bottom.
In-tank corrosion probe indicates a passive environment for carbon steel
No sustained CAM alarms

p(L) = The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

p(NL) = The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The p(NL) = 1 – p(L).

L_0 = "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. $L_0 = \Omega_0 = p(L)/p(NL)$

Posterior Probability Likelihood Ratio $L_{in\text{-}tank}$ - Part 2

	L	NL	L:NL
In-Tank Data	$p(D_{in\text{-}tank}\|L)$ (If no $D_{in\text{-}tank}$, skip Part 2)	$p(D_{in\text{-}tank}\|NL)$	$L_{in\text{-}tank}$ = $p(D_{in\text{-}tank}\|L)$ / $p(D_{in\text{-}tank}\|NL)$
	0.95	0.95	1.00

The available tank data would not indicate a small tank leak due to the evaporation taking place.
The current tank chemistry appears to be favorable based on sampling and in-tank monitoring.

Considering the in-tank data reviewed for the leak assessment:

$p(D_{in\text{-}tank}|L)$ = The "posterior probability" that the in-tank observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was leaking.

$p(D_{in\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was not leaking.

$L_{in\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the in-tank event or discovery that initiated the formal leak assessment, and the other diagnostic in-tank data. If in-tank data are not available for the leak assessment, then $L_{in\text{-}tank}$ = 1

If there are several essentially redundant in-tank measurements (e.g., ENRAF, FIC, MT), then the probabilities should be assessed only for the most diagnostic and reliable one.

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: J. K . Engeman

Posterior Probability Likelihood Ratio $L_{ex\text{-}tank}$ - Part 3

	L	NL	L:NL
Ex-Tank Data	$p(D_{ex\text{-}tank}\|L)$ (If no $D_{ex\text{-}tank}$, skip Part 3)	$p(D_{ex\text{-}tank}\|NL)$	$L_{ex\text{-}tank}$ = $p(D_{ex\text{-}tank}\|L)$ / $p(D_{ex\text{-}tank}\|NL)$
	0.99	0.01	99.00

Material appears to originate from under the primary tank bottom.
No substantial contamination in the annulus prior to events.
Extremely difficult to explain the presence of green material other than tank waste.
Contamination levels and lab analysis results confirm the presence of tank waste.
Sample results and process history link unique waste constituent (Potassium).
Construction history indicates that tank bottom construction and support/foundation features contain regions which may lead to insufficiently supported primary tank bottom.
Correlation between ENRAF reading, CAM readings, and visual inspection findings.

Considering the ex-tank data reviewed for the leak assessment:

$p(D_{ex\text{-}tank}|L)$ = The "posterior probability" that the ex-tank observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was leaking.

$p(D_{ex\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was not leaking.

$L_{ex\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the ex-tank event or discovery that initiated the formal leak assessment, and the other diagnostic ex-tank data. If ex-tank data are not available for the leak assessment, then $L_{ex\text{-}tank}$ = 1

If there are several essentially redundant ex-tank measurements, then the probabilities should be assessed only for the most diagnostic and reliable one.

Combined Likelihood Ratio $L_{combined}$ - Part 4

Combined Likelihood Ratio for Leak Hypothesis	$L_{combined}$ = L_0 x $L_{in\text{-}tank}$ x $L_{ex\text{-}tank}$
	3.06

$L_{combined}$ = Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic in-tank and ex-tank data examined during the leak assessment.

If $L_{combined}$ = 1, then it is equally likely that the tank is leaking or not leaking.

Probability of Tank Leak $p(L|combined)$ - Part 5

$p(L\|combined)$ = $L_{combined}$ / $(1 + L_{combined})$
0.75

p(L|combined) = The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-tank and ex-tank data examined during the leak assessment.

If p(L|combined) = 0.50, then it is equally probably that the tank is leaking or not-leaking.

Key:
Manual entries (Elicited probabilities)
Calculated entries

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date:	10/10/2012
Elicitation from:	C. L. Girardot
Elicitation by:	
Hypotheses:	
Leaker:	The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank.
Non-Leaker:	The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is either construction debris or dirt. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

Prior Probability Likelihood Ratio L_0 - Part 1

L	NL	L:NL		
p(L)	p(NL)	L_0 = p(L) / p(NL)	No DSTs have leaked yet to date; however, 67 SSTs are assumed leakers. DSTs have surpassed their design life. There have been numerous construction issues with SSTs and since AY-102 was the first DST to be constructed I would expect some issues. There are also uncertainties in waste chemistry with the SSTs and even though they monitor the chemistry in DSTs, I would expect some uncertainties to exist.	p(L) = The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. p(NL) = The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The p(NL) = 1 – p(L). L_0 = "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. L_0 = Ω_0 = p(L)/p(NL)
0.04	0.96	0.04		

Posterior Probability Likelihood Ratio $L_{in\text{-}tank}$ - Part 2

	L	NL	L:NL		
In-Tank Data	p($D_{in\text{-}tank}$|L) (If no $D_{in\text{-}tank}$, skip Part 2)	p($D_{in\text{-}tank}$|NL)	$L_{in\text{-}tank}$ = p($D_{in\text{-}tank}$|L) / p($D_{in\text{-}tank}$|NL)	Liquid level decrease is consistently declining since 2007 at approximately 77 gal/day which could easily hide a small leak. Waste chemistry remains inconclusive. In-tank data doesn't seem to indicate or not indicate a small tank leak.	Considering the in-tank data reviewed for the leak assessment: p($D_{in\text{-}tank}$|L) = The "posterior probability" that the in-tank observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was leaking. p($D_{in\text{-}tank}$|NL) =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was not leaking. $L_{in\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the in-tank event or discovery that initiated the formal leak assessment, and the other diagnostic in-tank data. If in-tank data are not available for the leak assessment, then $L_{in\text{-}tank}$ = 1 If there are several essentially redundant in-tank measurements (e.g., ENRAF, FIC, MT), then the probabilities should be assessed only for the most diagnostic and reliable one.
	0.90	0.90	1.00		

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: C. L. Girardot

Posterior Probability Likelihood Ratio $L_{ex\text{-}tank}$ - Part 3

	L	NL	L:NL
Ex-Tank Data	p ($D_{ex\text{-}tank}$|L) (If no $D_{ex\text{-}tank}$, skip Part 3)	p ($D_{ex\text{-}tank}$|NL)	$L_{ex\text{-}tank}$ = p($D_{ex\text{-}tank}$|L) / p($D_{ex\text{-}tank}$|NL)
	0.99	0.01	99.00

Multiplie construction problems probably left this tank more vulnerable to SCC compared to other DSTs. ENRAF alarmed and gradual increase in the liquid level in Oct. 2011. CAM alarmed during the same period as the ENRAF that had significantly higher field counts compared to previous alarms. The annulus was swabbed in 1999 and no contamination was found. Waste liquid levels did not go below 60-in since the 1980s so cross-contamination seems unlikely. Visual evidence of new material in the annulus region that was not present in 2006. Samples collected from Riser 83 and the tape sample from Riser 90 indicate high Cs-137 radioactivity. The green color of the material near Riser 83 cannot be explained and liquid is present. Also, the CAM alarmed within 24 hours of sampling the material near Riser 83.

Considering the ex-tank data review ed for the leak assessment:

p($D_{ex\text{-}tank}$|L) = The "posterior probability" that the ex-tank observation that initiated the formal leak assessment and other diagnostic ex-tank data w ould be present if the tank w as leaking.

p($D_{ex\text{-}tank}$|NL) =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic ex-tank data w ould be present if the tank w as not leaking.

$L_{ex\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the ex-tank event or discovery that initiated the formal leak assessment, and the other diagnostic ex-tank data. If ex-tank data are not available for the leak assessment, then $L_{ex\text{-}tank}$ = 1

If there are several essentially redundant ex-tank measurements, then the probabilities should be assessed only for the most diagnostic and reliable one.

Combined Likelihood Ratio $L_{combined}$ - Part 4

Combined Likelihood Ratio for Leak Hypothesis	$L_{combined}$ = L_0 x $L_{in\text{-}tank}$ x $L_{ex\text{-}tank}$
	4.13

$L_{combined}$ = Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic in-tank and ex-tank data examined during the leak assessment.

If $L_{combined}$ = 1, then it is equally likely that the tank is leaking or not leaking.

Probability of Tank Leak p (L|combined) - Part 5

p (L|combined) = $L_{combined}$ / (1 + $L_{combined}$)
0.80

p(L|combined) = The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-tank and ex-tank data examined during the leak assessment.

If p(L|combined) = 0.50, then it is equally probably that the tank is leaking or not-leaking.

Key:

Manual entries (Elicited probabilities)

Calculated entries

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: D. G. Harlow

Elicitation by:

Hypotheses:

Leaker: The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank.

Non-Leaker: The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is either construction debris or dirt. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

Prior Probability Likelihood Ratio L_0 - Part 1

L	NL	L:NL
p(L)	p(NL)	L_0 = p(L) / p(NL)
0.02	0.98	0.02

There have been no indications of radioactivity in the annulus except some low level of airbourne detected on the CAM which has been attributed to vent cross linkage. Water has been found in the annuklus but was thought to have been coming from line leakage adn rainwater. DST have not been shown to have leaked to date.

p(L) = The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

p(NL) = The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The p(NL) = 1 – p(L).

L_0 = "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. $L_0 = \Omega_0 = p(L)/p(NL)$

Posterior Probability Likelihood Ratio $L_{in\text{-}tank}$ - Part 2

	L	NL	L:NL
In-Tank Data	$p(D_{in\text{-}tank}\|L)$ (If no $D_{in\text{-}tank}$, skip Part 2)	$p(D_{in\text{-}tank}\|NL)$	$L_{in\text{-}tank}$ = $p(D_{in\text{-}tank}\|L)$ / $p(D_{in\text{-}tank}\|NL)$
	0.98	0.98	1.00

Temperature of the waste has been relatively low.
UT did not indicate wall thinning.
Corrosion probe did not indicate undue corrosion.
Fill history has not stressed the tank.
Relatively uniform liquid level decrease since adding Tank C-106 waste can be explained by evaporation.

Considering the in-tank data reviewed for the leak assessment:

$p(D_{in\text{-}tank}|L)$ = The "posterior probability" that the in-tank observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was leaking.

$p(D_{in\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was not leaking.

$L_{in\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the in-tank event or discovery that initiated the formal leak assessment, and the other diagnostic in-tank data. If in-tank data are not available for the leak assessment, then $L_{in\text{-}tank}$ = 1

If there are several essentially redundant in-tank measurements (e.g., ENRAF, FIC, MT), then the probabilities should be assessed only for the most diagnostic and reliable one.

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: D. G. Harlow

Posterior Probability Likelihood Ratio $L_{ex\text{-}tank}$ - Part 3

	L	NL	L:NL
Ex-Tank Data	$p(D_{ex\text{-}tank}\|L)$ (If no $D_{ex\text{-}tank}$, skip Part 3)	$p(D_{ex\text{-}tank}\|NL)$	$L_{ex\text{-}tank}$ = $p(D_{ex\text{-}tank}\|L)$ / $p(D_{ex\text{-}tank}\|NL)$
	0.99	0.01	99.00

Preliminary indication of radioactive material found in the annulus seems to be more indicative of waste as opposed to carry over of contamination from previous ventilation sytem cross ties.
Construction problems probably induced stresses in the primary liner that became compromised with the chemistry that may have caused pitting or SCC.

Considering the ex-tank data reviewed for the leak assessment:

$p(D_{ex\text{-}tank}|L)$ = The "posterior probability" that the ex-tank observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was leaking.

$p(D_{ex\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was not leaking.

$L_{ex\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the ex-tank event or discovery that initiated the formal leak assessment, and the other diagnostic ex-tank data. If ex-tank data are not available for the leak assessment, then $L_{ex\text{-}tank}$ = 1

If there are several essentially redundant ex-tank measurements, then the probabilities should be assessed only for the most diagnostic and reliable one.

Combined Likelihood Ratio $L_{combined}$ - Part 4

Combined Likelihood Ratio for Leak Hypothesis	$L_{combined}$ = L_0 x $L_{in\text{-}tank}$ x $L_{ex\text{-}tank}$
	2.02

$L_{combined}$ = Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic in-tank and ex-tank data examined during the leak assessment.

If $L_{combined}$ = 1, then it is equally likely that the tank is leaking or not leaking.

Probability of Tank Leak p(L|combined) - Part 5

p(L|combined) = $L_{combined}$ / (1 + $L_{combined}$)
0.67

p(L|combined) = The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-tank and ex-tank data examined during the leak assessment.

If p(L|combined) = 0.50, then it is equally probably that the tank is leaking or not-leaking.

Key:
Manual entries (Elicited probabilities)
Calculated entries

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date:	10/11/2012
Elicitation from:	A. C. Prince
Elicitation by:	
Hypotheses:	
Leaker:	The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank.
Non-Leaker:	The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is either construction debris or dirt. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

Prior Probability Likelihood Ratio L_0 - Part 1

L	NL	L:NL
p (L)	p (NL)	L_0 = p (L) / p (NL)
0.01	1.00	0.01

•Decreasing liquid level of approximately, 10 in/yr, is reasonable considering the highest heat generating waste in tank farms was transferred from C-106 into AY-102. The tank was modified prior to receiving the waste in order to accept this waste. Waste level fluctuation at tank farms is common.
•The construction history of the tank reveals constructability problems occurred. While not ideal, the tank did appear to meet the design criteria, although it is likely that some of the strength margin was diminished because of these constructability issues.
•Of the operational history, chemical history, temperature history available, as well as the UT inspections and corrosion probe monitoring there is no indication of degraded structural integrity.

p(L) = The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

p(NL) = The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The p (NL) = 1 – p (L).

L_0 = "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. $L_0 = \Omega_0 = p(L)/p(NL)$

Posterior Probability Likelihood Ratio $L_{in\text{-}tank}$ - Part 2

	L	NL	L:NL
In-Tank Data	p ($D_{in\text{-}tank}$|L) (If no $D_{in\text{-}tank}$, skip Part 2)	p ($D_{in\text{-}tank}$|NL)	$L_{in\text{-}tank}$ = p ($D_{in\text{-}tank}$|L) / p ($D_{in\text{-}tank}$|NL)
	0.99	0.99	1.00

Postulating that a leak was small and located below the nuckle of the tank, it would be undistinguishable from the operational data present. Tank level decreases in the magnitude of 10 in/yr would mask a small slow leak. UT does not provide data below the primary tank. The likely hood of this type of leak vs. a non-leaking condition would be nearly identical and just as probable after examination of solely the in tank data.

Considering the in-tank data review ed for the leak assessment:

p ($D_{in\text{-}tank}$|L) = The "posterior probability" that the in-tank observation that initiated the formal leak assessment and other diagnostic in-tank data w ould be present if the tank w as leaking.

p ($D_{in\text{-}tank}$|NL) =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic in-tank data w ould be present if the tank w as not leaking.

$L_{in\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the in-tank event or discovery that initiated the formal leak assessment, and the other diagnostic in-tank data. If in-tank data are not available for the leak assessment, then $L_{in\text{-}tank}$ = 1

If there are several essentially redundant in-tank measurements (e.g., ENRAF, FIC, MT), then the probabilities should be assessed only for the most diagnostic and reliable one.

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/11/2012

Elicitation from: A. C. Prince

Posterior Probability Likelihood Ratio $L_{ex\text{-}tank}$ - Part 3

	L	NL	L:NL
Ex-Tank Data	$p(D_{ex\text{-}tank}\|L)$ (If no $D_{ex\text{-}tank}$, skip Part 3)	$p(D_{ex\text{-}tank}\|NL)$	$L_{ex\text{-}tank}$ = $p(D_{ex\text{-}tank}\|L)$ / $p(D_{ex\text{-}tank}\|NL)$
	0.98	0.00	980.00

•Construction history indicates that the bottom of the tank sustained some initial abuse, as mentioned above though not ideal the tank did appear to meet the design criteria, although it is likely that some of the strength margin was diminished because of these constructability issues.
•Any tank that was subjected to the unique waste of C-106, characterized by its high heat generation, could have a diminished lifetime capacity over a long enough period of time.
•I cannot with certainty determine what the mechanism of transport for the material found in the annulus space to appear there.
• The appearance of a solid white cascade in a flow shape coming from a castable slot with a travel path continuing across the floor, as well as visual evidence of liquid beneath the hard nodules, makes the probability of a leak a near certainty in my mind.

Considering the ex-tank data reviewed for the leak assessment:

$p(D_{ex\text{-}tank}|L)$ = The "posterior probability" that the ex-tank observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was leaking.

$p(D_{ex\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was not leaking.

$L_{ex\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the ex-tank event or discovery that initiated the formal leak assessment, and the other diagnostic ex-tank data. If ex-tank data are not available for the leak assessment, then $L_{ex\text{-}tank}$ = 1

If there are several essentially redundant ex-tank measurements, then the probabilities should be assessed only for the most diagnostic and reliable one.

Combined Likelihood Ratio $L_{combined}$ - Part 4

Combined Likelihood Ratio for Leak Hypothesis	$L_{combined}$ = L_0 x $L_{in\text{-}tank}$ x $L_{ex\text{-}tank}$
	4.92

$L_{combined}$ = Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic in-tank and ex-tank data examined during the leak assessment.

If $L_{combined}$ = 1, then it is equally likely that the tank is leaking or not leaking.

Probability of Tank Leak p(L|combined) - Part 5

$p(L\|combined)$ = $L_{combined}$ / $(1 + L_{combined})$
0.83

p(L|combined) = The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-tank and ex-tank data examined during the leak assessment.

If p(L|combined) = 0.50, then it is equally probably that the tank is leaking or not-leaking.

Key:
Manual entries (Elicited probabilities)
Calculated entries

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: R. P. Tucker

Elicitation by:

Hypotheses:

Leaker: The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank.

Non-Leaker: The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is either construction debris or dirt. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

Prior Probability Likelihood Ratio L_0 - Part 1

L	NL	L:NL
p(L)	p(NL)	L_0 = p(L) / p(NL)
0.01	0.99	0.01

In tank level measurements have not shown decreases that can not be explained by evaporation
There is an active DST integrity assesment program that has not reported any issues with tank AY-102.
Tank temperatures have been maintained within OSD/TSR requirements.
No other Hanford DST's have leaked.
There is and has been a robust tank waste compatiblity and chemistry control program in place to minimize possibility of tank damage/degradation.

p(L) = The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

p(NL) = The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The p(NL) = 1 – p(L).

L_0 = "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. $L_0 = \Omega_0 = p(L)/p(NL)$

Posterior Probability Likelihood Ratio $L_{in\text{-}tank}$ - Part 2

	L	NL	L:NL
In-Tank Data	$p(D_{in\text{-}tank}\|L)$ (If no $D_{in\text{-}tank}$, skip Part 2)	$p(D_{in\text{-}tank}\|NL)$	$L_{in\text{-}tank}$ = $p(D_{in\text{-}tank}\|L)$ / $p(D_{in\text{-}tank}\|NL)$
	0.99	0.99	1.00

Available in tank information including temperature data and level data are inconclusive regarding whether a small leak has occurred or not. Level change data can be explained by evaporation.
Corrosion probe results showed no abnormal corrosion rates or propensity for Stress Corrosion Cracking.

Considering the in-tank data reviewed for the leak assessment:

$p(D_{in\text{-}tank}|L)$ = The "posterior probability" that the in-tank observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was leaking.

$p(D_{in\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was not leaking.

$L_{in\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the in-tank event or discovery that initiated the formal leak assessment, and the other diagnostic in-tank data. If in-tank data are not available for the leak assessment, then $L_{in\text{-}tank}$ = 1

If there are several essentially redundant in-tank measurements (e.g., ENRAF, FIC, MT), then the probabilities should be assessed only for the most diagnostic and reliable one.

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: R. P. Tucker

Posterior Probability Likelihood Ratio $L_{ex\text{-}tank}$ - Part 3

	L	NL	L:NL
Ex-Tank Data	$p(D_{ex\text{-}tank}\|L)$ (If no $D_{ex\text{-}tank}$, skip Part 3)	$p(D_{ex\text{-}tank}\|NL)$	$L_{ex\text{-}tank}$ = $p(D_{ex\text{-}tank}\|L)$ / $p(D_{ex\text{-}tank}\|NL)$
	0.99	0.01	198.00

Tank construction history shows significant difficulty in constructing this tank. Questionable Modifications to specifications and design were made in order to accept the construction. This is the first DST constructed at Hanford and many lessons learned were incorporated into future tank construction.

Visual inspections of the tank annulus shows locations where material is cascading or flowing from underneath the tank into the Annulus. One of these locations includes pink, yellow and green colored material and evaporated salts along the beachline of the darkened area.

Highly contaminated samples were removed from Riser 90 (800,000 DPM) and Riser 83 (45 Mrem).

Considering the ex-tank data reviewed for the leak assessment:

$p(D_{ex\text{-}tank}|L)$ = The "posterior probability" that the ex-tank observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was leaking.

$p(D_{ex\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was not leaking.

$L_{ex\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the ex-tank event or discovery that initiated the formal leak assessment, and the other diagnostic ex-tank data. If ex-tank data are not available for the leak assessment, then $L_{ex\text{-}tank}$ = 1

If there are several essentially redundant ex-tank measurements, then the probabilities should be assessed only for the most diagnostic and reliable one.

Combined Likelihood Ratio $L_{combined}$ - Part 4

Combined Likelihood Ratio for Leak Hypothesis	$L_{combined}$ = L_0 x $L_{in\text{-}tank}$ x $L_{ex\text{-}tank}$
	2.00

$L_{combined}$ = Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic in-tank and ex-tank data examined during the leak assessment.

If $L_{combined}$ = 1, then it is equally likely that the tank is leaking or not leaking.

Probability of Tank Leak p(L|combined) - Part 5

$p(L\|combined)$ = $L_{combined}$ / $(1 + L_{combined})$
0.67

p(L|combined) = The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-tank and ex-tank data examined during the leak assessment.

If p(L|combined) = 0.50, then it is equally probably that the tank is leaking or not-leaking.

Key:
Manual entries (Elicited probabilities)
Calculated entries

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: J. A Voogd

Elicitation by:

Hypotheses:

Leaker: The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank.

Non-Leaker: The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is either construction debris or dirt. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

Prior Probability Likelihood Ratio L_0 - Part 1

L	NL	L:NL
p(L)	p(NL)	L_0 = p(L) / p(NL)
0.25	0.75	0.33

(L) Leak detectors are set for 1/4 inch of solution or material on the floor of the annulus. The 2006 visual inspection of the annulus showed no indication of leakage. Sudden change occurred in annulus conditions (ENRAF & CAM) in October 2011. (NL) No DST had leaked to date AY-102 has had no significant operational activity since receipt of C-106 waste AY-102 operating conditions (temperature, pressure, volume) appeared to be within a stable steady state condition prior to the event AY-102 annulus had not shown evidence (visual, leak detectors,) of tank liquids or solids prior to the event Integrity Assessment program (UT & corrosion probes) and tank chemistry had not previously identified areas of specific concern for AY-102

p(L) = The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment.

p(NL) = The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The p(NL) = 1 – p(L).

L_0 = "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. $L_0 = \Omega_0 = p(L)/p(NL)$

Posterior Probability Likelihood Ratio $L_{in\text{-}tank}$ - Part 2

	L	NL	L:NL
In-Tank Data	$p(D_{in\text{-}tank}\|L)$ (If no $D_{in\text{-}tank}$, skip Part 2)	$p(D_{in\text{-}tank}\|NL)$	$L_{in\text{-}tank}$ = $p(D_{in\text{-}tank}\|L)$ / $p(D_{in\text{-}tank}\|NL)$
	0.50	0.50	1.00

(L & NL) In tank data (liquid level, evaporation rate, temperature, chemistry, vacuum, corrosion probes, etc) did not provide clear discriminating information for determination of a leak. The apparent small volume of material found in the annulus may be within the measurement uncertainty of the waste volume measurement when considering evaporation and thermal expansion effects,

Considering the in-tank data reviewed for the leak assessment:

$p(D_{in\text{-}tank}|L)$ = The "posterior probability" that the in-tank observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was leaking.

$p(D_{in\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was not leaking.

$L_{in\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the in-tank event or discovery that initiated the formal leak assessment, and the other diagnostic in-tank data. If in-tank data are not available for the leak assessment, then $L_{in\text{-}tank}$ = 1

If there are several essentially redundant in-tank measurements (e.g., ENRAF, FIC, MT), then the probabilities should be assessed only for the most diagnostic and reliable one.

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: J. A Voogd

Posterior Probability Likelihood Ratio $L_{ex\text{-}tank}$ - Part 3

	L	NL	L:NL
Ex-Tank Data	$p(D_{ex\text{-}tank}\|L)$ (If no $D_{ex\text{-}tank}$, skip Part 3)	$p(D_{ex\text{-}tank}\|NL)$	$L_{ex\text{-}tank}$ = $p(D_{ex\text{-}tank}\|L)$ / $p(D_{ex\text{-}tank}\|NL)$
	0.90	0.10	9.00

(L) Evidence of waste material in the annulus from video, annulus CAM, and preliminary sample results around riser 83 are indicative of tank waste. The green hue and crystals would be indicative of tank waste high salt solutions. Construction history for the bottom of the tank provides ample possible avenues for small leak paths (NL) The material seen near riser 90 (mound and white cascade) could be evidence of degraded insulating refracotry, intrusion water and dust. Crystals seen in photos (riser 89) could be evidence of tank vapors pulled into the annulus due to higer negative pressure in the annulus. The material seen below rixer 83 does not have a strong hypothesis for a non leaking tank origin. Possible hyothetical origins for a non leaking tank source could be a foreign material introduced during maintenance activities post 2006 (decontamination solution - Simple Green) or a tank vapor reaction with material or conditions within the annulus and collecting below riser 83.

Considering the ex-tank data reviewed for the leak assessment:

$p(D_{ex\text{-}tank}|L)$ = The "posterior probability" that the ex-tank observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was leaking.

$p(D_{ex\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was not leaking.

$L_{ex\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the ex-tank event or discovery that initiated the formal leak assessment, and the other diagnostic ex-tank data. If ex-tank data are not available for the leak assessment, then $L_{ex\text{-}tank}$ = 1

If there are several essentially redundant ex-tank measurements, then the probabilities should be assessed only for the most diagnostic and reliable one.

Combined Likelihood Ratio $L_{combined}$ - Part 4

Combined Likelihood Ratio for Leak Hypothesis	$L_{combined}$ = L_0 x $L_{in\text{-}tank}$ x $L_{ex\text{-}tank}$
	3.00

$L_{combined}$ = Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic in-tank and ex-tank data examined during the leak assessment.

If $L_{combined}$ = 1, then it is equally likely that the tank is leaking or not leaking.

Probability of Tank Leak p(L|combined) - Part 5

$p(L\|combined)$ = $L_{combined}$ / $(1 + L_{combined})$
0.75

p(L|combined) = The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-tank and ex-tank data examined during the leak assessment.

If p(L|combined) = 0.50, then it is equally probably that the tank is leaking or not-leaking.

Key:
Manual entries (Elicited probabilities)
Calculated entries

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date:	10/10/2012
Elicitation from:	D. J. Washenfelder
Elicitation by:	
Hypotheses:	
Leaker:	The source of radioactive material discovered in the tank annulus near Risers 83 and 90 is a leak from the primary tank.
Non-Leaker:	The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is either construction debris or dirt. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.

Prior Probability Likelihood Ratio L_0 - Part 1

L	NL	L:NL		
p(L)	p(NL)	L_0 = p(L) / p(NL)	Ultrasonic Test inspections show no wall thinning; In-tank corrosion probe shows low corrosion potential; Active corrosion chemistry program retards corrosion; Temperatures well below maximum allowable; Legacy annulus contamination explained; Annulus visual inspections show no anomalies.	p(L) = The "prior probability" that the tank is leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. p(NL) = The "prior probability" that the tank is not leaking based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. The p(NL) = 1 – p(L). L_0 = "Prior likelihood" ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment. $L_0 = \Omega_0 = p(L)/p(NL)$
0.02	0.98	0.02		

Posterior Probability Likelihood Ratio $L_{in\text{-}tank}$ - Part 2

	L	NL	L:NL		
In-Tank Data	$p(D_{in\text{-}tank}\|L)$ (If no $D_{in\text{-}tank}$, skip Part 2)	$p(D_{in\text{-}tank}\|NL)$	$L_{in\text{-}tank}$ = $p(D_{in\text{-}tank}\|L)$ / $p(D_{in\text{-}tank}\|NL)$	(L) Small leak or episodic leak could not be distinguished from surface level evaporation of ~ 77 gal/day; (NL) Surface level decrease explained by introduction of ~ 94K BTU/hr tank C-106 sludge; In-tank data leak detection thresholds are too high to detect small leaks.	Considering the in-tank data reviewed for the leak assessment: $p(D_{in\text{-}tank}\|L)$ = The "posterior probability" that the in-tank observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was leaking. $p(D_{in\text{-}tank}\|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic in-tank data would be present if the tank was not leaking. $L_{in\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the in-tank event or discovery that initiated the formal leak assessment, and the other diagnostic in-tank data. If in-tank data are not available for the leak assessment, then $L_{in\text{-}tank}$ = 1 If there are several essentially redundant in-tank measurements (e.g., ENRAF, FIC, MT), then the probabilities should be assessed only for the most diagnostic and reliable one.
	0.90	0.90	1.00		

Tank 241-AY-102 Double-Shell Tank Leak Assessment Expert Elicitation Form 2012-10-10
(From HNF-3747, Rev. 0)

Elicitation Date: 10/10/2012

Elicitation from: D. J. Washenfelder

Posterior Probability Likelihood Ratio $L_{ex\text{-}tank}$ - Part 3

	L	NL	L:NL
Ex-Tank Data	$p(D_{ex\text{-}tank}\|L)$ (If no $D_{ex\text{-}tank}$, skip Part 3)	$p(D_{ex\text{-}tank}\|NL)$	$L_{ex\text{-}tank}$ = $p(D_{ex\text{-}tank}\|L)$ / $p(D_{ex\text{-}tank}\|NL)$
	0.99	0.01	198.00

Latent effects of construction problems (liner bulges, damaged or unsupported refractory, poor floor plate welds, etc.) probably left tank more vulnerable to SCC than other tanks in similar operating conditions;
High CAM alarms coincident with sample activities indicate significant contamination present in annulus, contrary to historical experience such as contamination-free withdrawal of inspection equipment;
High Cs-137 activity on sample from near Riser 83, and from tape sample collected near Riser 90 greatly exceed historically reported contamination levels for annulus pump pit, indicating HVAC cross-connection was not the source;
Physical appearance of material near Riser 83 and its response to off-riser sampler drive-through indicate liquid is present. Green color indicates origin is not carbon steel.

Considering the ex-tank data reviewed for the leak assessment:

$p(D_{ex\text{-}tank}|L)$ = The "posterior probability" that the ex-tank observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was leaking.

$p(D_{ex\text{-}tank}|NL)$ =The "posterior probability" that the observation that initiated the formal leak assessment and other diagnostic ex-tank data would be present if the tank was not leaking.

$L_{ex\text{-}tank}$ = "Posterior likelihood" ratio that tank is leaking, or not leaking, based on the ex-tank event or discovery that initiated the formal leak assessment, and the other diagnostic ex-tank data. If ex-tank data are not available for the leak assessment, then $L_{ex\text{-}tank} = 1$

If there are several essentially redundant ex-tank measurements, then the probabilities should be assessed only for the most diagnostic and reliable one.

Combined Likelihood Ratio $L_{combined}$ - Part 4

Combined Likelihood Ratio for Leak Hypothesis	$L_{combined}$ = $L_0 \times L_{in\text{-}tank} \times L_{ex\text{-}tank}$
	4.04

$L_{combined}$ = Posterior likelihood ratio that tank is leaking, or not leaking, based on the tank's history up to, but not including, the event or discovery that initiated the formal leak assessment; the event or discovery that initiated the formal leak assessment; and the diagnostic in-tank and ex-tank data examined during the leak assessment.

If $L_{combined} = 1$, then it is equally likely that the tank is leaking or not leaking.

Probability of Tank Leak p(L|combined) - Part 5

$p(L\|combined)$ = $L_{combined}$ / $(1 + L_{combined})$
0.80

p(L|combined) = The posterior probability of a tank leak considering the tank's history up to, but not but not including, the event or discovery that initiated the formal leak assessment, and the event or discovery that initiated the leak assessment, and diagnostic in-tank and ex-tank data examined during the leak assessment.

If p(L|combined) = 0.50, then it is equally probably that the tank is leaking or not-leaking.

Key:
Manual entries (Elicited probabilities)
Calculated entries

Appendix I

EXECUTIVE SAFETY REVIEW BOARD BRIEFING

washington river protection solutions

Tank AY-102 Leak Assessment

D. J. Washenfelder

October 19, 2012

Purpose

- Review Tank AY-102 Formal Leak Assessment Results
- Request ESRB Concurrence with Tank AY-102 Leak Assessment Finding

Page 2

Leak Assessment Conclusion

- *Leak Conclusion*

  The source of radioactive material discovered in the tank AY-102 annulus near Risers 83 and 90 is a leak from the primary tank.

- *Probable Cause*

  Possible corrosion at high waste temperatures compounded by mechanical impacts to a tank whose waste containment margins had been reduced by construction difficulties.

- *Estimated Leak Volume*

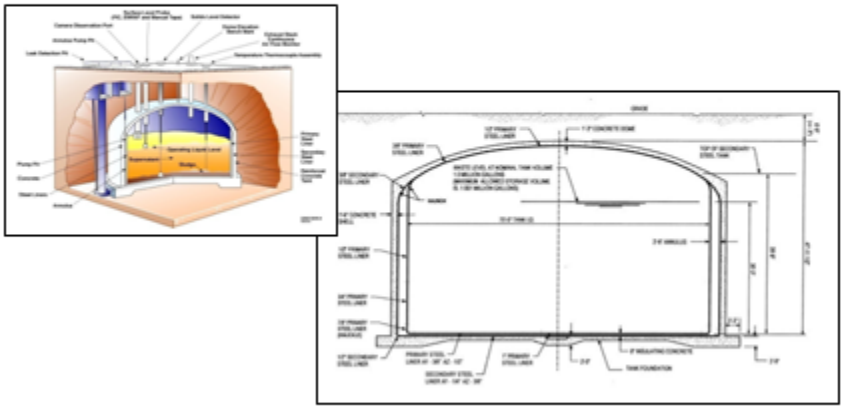
  190 – 520 gallons of waste liquid as of September 26, 2012 leaving ~ 20 – 50 gallons of dried material in the annulus.[1]

[1] Assumes 10:1 volume reduction for liquid to solid conversion for interstitial liquid in tank AY-102.

Page 3

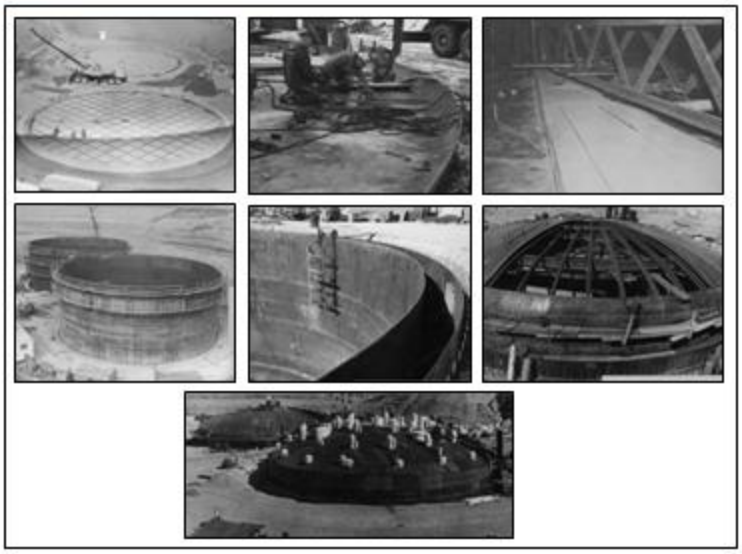
241-AY Double Shell Tank Cross-Section

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



Page 4

Construction Sequence



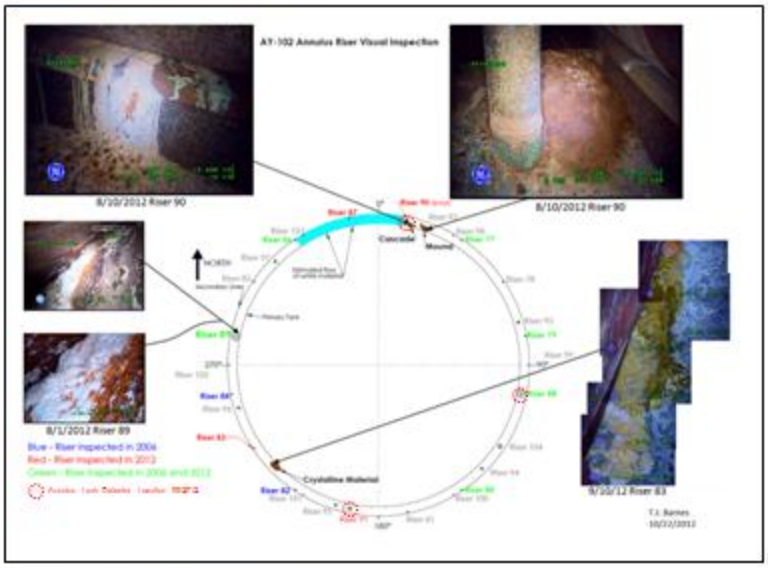
Page 5

Leak Integrity Evidence

- Annulus Inspections
- Continuous Air Monitor Alarms
- Annulus Sample Results

Page 6

Annulus Inspections: Sites with Found Material



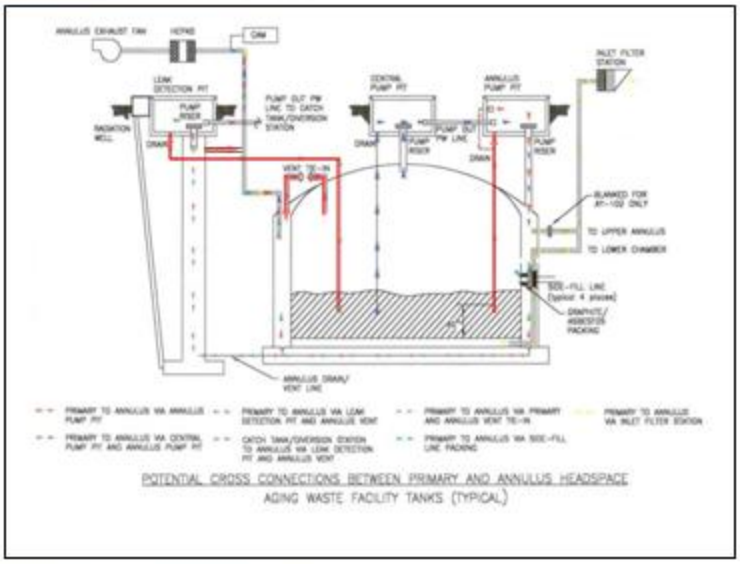
Page 7

Continuous Air Monitor Alarms

- Source of CAM alarms and high filter paper counts historically assigned to legacy contamination from open drop legs in primary tank
  - Commonly associated with significant shifts in HVAC flow or primary tank – annulus pressure shifts
  - Smearable contamination 2,000 – 3,000 dpm/100 cm^2 in annulus pump pit typical
- Recent CAM alarms no longer associated with classic causes – changes in HVAC or uncovered drop legs
  - October 26, 2011: Alarm two days after flushing Riser 90 ENRAF
  - September 27, 2012: Alarm one day after annulus floor sampling

Page 8

241-AY Double-Shell Tank Annulus and Leak Detection Pit Cross-Connections



Page 9

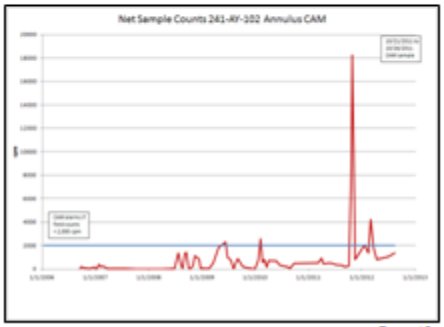
Continuous Air Monitor Alarms (cont.)

Elevated Tank AY-102 Annulus CAM Sample Results

Count Room Sample ID	Sample Number	Sample Collection Period (Date and Time)		Sample Activity (Net Counts)		Concentration	
		On	Off	α	β	α (µCi/cm³)	β (µCi/cm³)
CR11-02077	557503	10/03/11	10/21/11	3	5657	2.1E-15	5.7E-12
CR11-02070	557503	10/21/11	10/26/11	10	15270	2.1E-14	4.1E-11
CR12-00228	559930	02/15/12	02/29/12	6	4223	6.9E-15	2.6E-12
CR12-01194	590401	05/29/12	05/12/12	25	1370	1.1E-14	4.0E-12
CR12-01573	590556	09/21/12	09/27/12	12	7734	2.6E-14	1.6E-11

Tank AY-102 Annulus CAM Results (October 28, 2011)

Sample CR12-02070	αµCi/mL	βµCi/mL	β mpm
Initial	6.40E-12	4.22E-11	15,540
1 day decay	2.16E-12	4.22E-11	15,400
7 day decay	2.06E-14	4.14E-11	15,270



Page 10

Annulus Sample Results

- Annulus Floor Material near Riser 83, September 26, 2012:
  - 45 mR/hr "Window Open"
  - Principal Chemical Constituents: $NaNO_3$, Na_2CO_3, $NaNO_2$, KNO_3[1]
  - Principal Radionuclide Constituents: Sr-90, 0.120 µCi/gm; Cs-137, 90.9 µCi/gm (202 million disintegrations per minute per gram)
- Annulus Floor Material near Riser 90, August 10, 2012:
  - 800,000 dpm reading reported with detector near sample[2]

[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 contained a significant potassium inventory. Tank AY-102 has second highest potassium inventory of any Hanford waste tank.
[2] Preliminary laboratory results from material collected near Riser 90 on October 15, 2012 are consistent with the results from the Riser 83 sample.

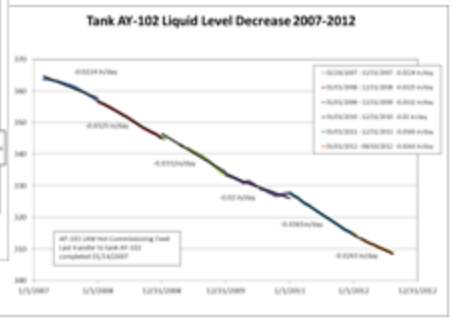
Page 11

Corroborating Evidence of Leakage

Corroborating Evidence of Leakage	Yes	No
Liquid Level Changes		X
Chemistry	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 Construction	X	

Page 12

Liquid Level Changes



- Tank C-106 sludge retrieval during 1998 – 1999 increased the tank heat load by ~ 94,000 BTU/hr
- Since AP-101 transfer in 2007, evaporation rate has averaged ~ 77 gal/day, or ~ 28,000 gal/year
- **A small, episodic leak could occur undetected inside the evaporation rate**

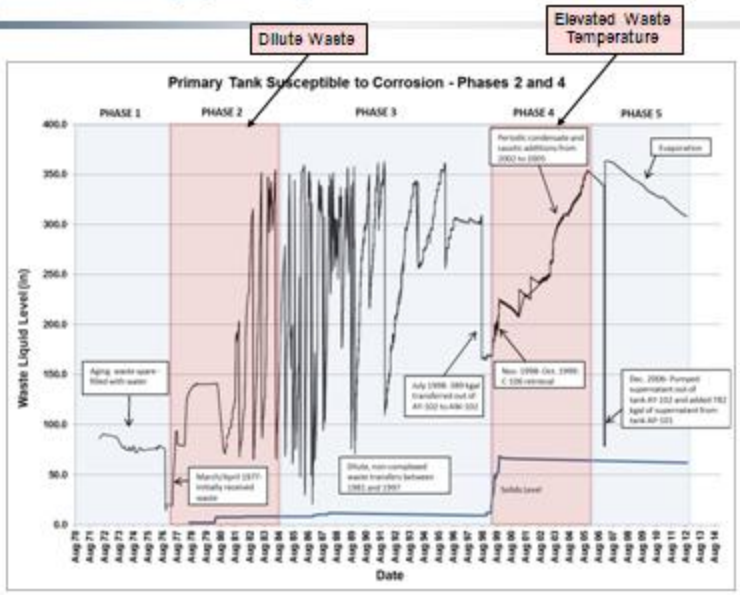
Page 13

Chemistry

- 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 types:
  - 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 based on susceptibility to corrosion
  - The first solids layer deposited in tank AY-102 in 1979 – 1984 ("Phase 2") may have the characteristics which cause corrosion when subjected to higher temperatures experienced after 1999 ("Phase 4").

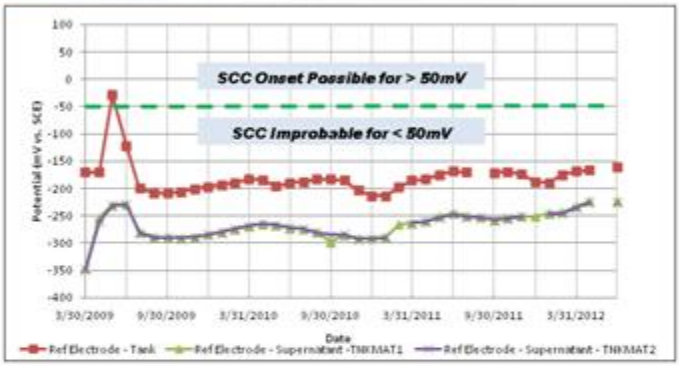
Page 14

Chemistry (cont.)



Page 15

In-Tank Corrosion Probe

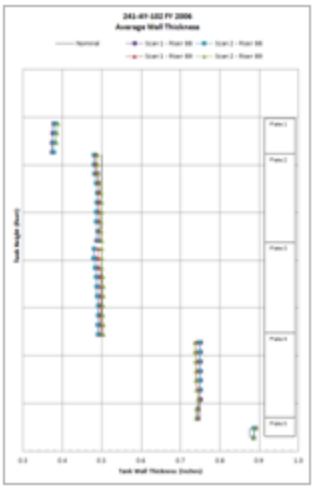


- Installed in March, 2009
- Electrodes located in supernatant and sludge layers and vapor space
- Sludge electrodes failed during corrosion probe installation. No readings are available.

Page 16

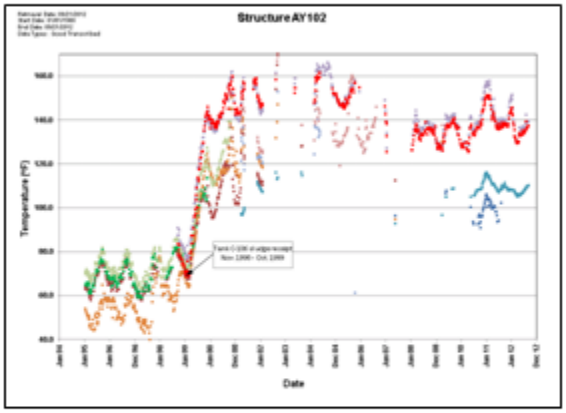
Primary Tank Ultrasonic Wall Inspections

- In 2006 vertical scan pairs were completed in Risers 88 and 89 on surfaces
- **No significant primary tank wall loss has been detected by ultrasonic wall thickness scans**



Page 17

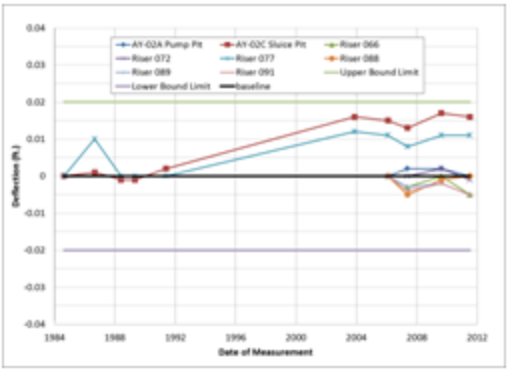
Waste Temperature



- Tank design and structural modeling temperature was 350ºF; operating limit is 260ºF
- From available records, highest waste temperature recorded is ~189ºF in the sludge
- **Waste temperatures have been well within analyzed and allowable limits.**

Page 18

Tank Dome Deflection and Tank Settlement

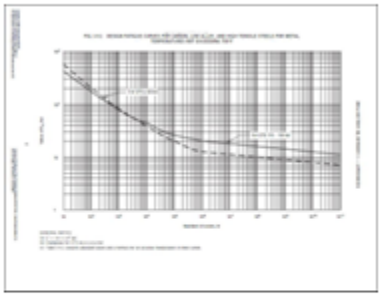


- Eight benchmarks in use – two with data since 1984 and six new benchmarks first recorded in 2006
- Dome deflections up to 0.5-inches (~ 0.04-feet) are within load limits[1]
- Survey data show a maximum dome deflection of < 0.02-feet since record keeping began
- **No evidence of dome deflection or tank settlement.**

[1] RPP-25752, DST Dome Survey Program, and RPP-RPT-25605, Hanford Double-Shell Tank Thermal and Seismic Project- Increased Concentrated Load Analysis

Page 19

Fill Cycle Fatigue



- Cycle Fatigue evaluated in 1968 after structural modeling identified a region of the primary tank dome predicted to exceed minimum tensile stress.
- **Using ASME Section III Division I cycle fatigue guidance, safe cycles estimated to be 17,600**
- Backcheck using 2008 structural model results and 2010 version of code indicates ~ 25,000 safe cycles[1]

[1] ASME Section III Division 1 Rules for Construction of Nuclear Facility Components, Appendices, Figure I-9.1 "Design Fatigue Curves for Carbon, Low Alloy, and High Tensile Steels for Metal Temperatures not Exceeding 700°F," and RPP-RPT-25605, Rev. 1, Hanford Double-shell Tank Thermal and Seismic Project – Summary of Combined Thermal and Operating Loads with Seismic Analysis

Page 20

Tank Construction (Highlights)

- Tank Construction Difficulties
  - Secondary Liner Warpage
  - Refractory Concrete Cracking
  - Primary Tank Bottom Weld Rejection
  - Primary Tank Bottom Placement Refractory Concrete Depth Implications
  - Insulating Refractory Damage during Stress Relief and Hydrostatic Test of Primary Tank
  - Gaps beneath Primary Tank and Insulating Refractory

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

Page 21

Tank Construction (cont.)

- Secondary Liner Warpage
  - Use of thin ¼-inch plates complicated by work in extreme cold (-20°F to -10°F) 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. These did not disappear as temperatures chilled.
  - 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.

Page 22

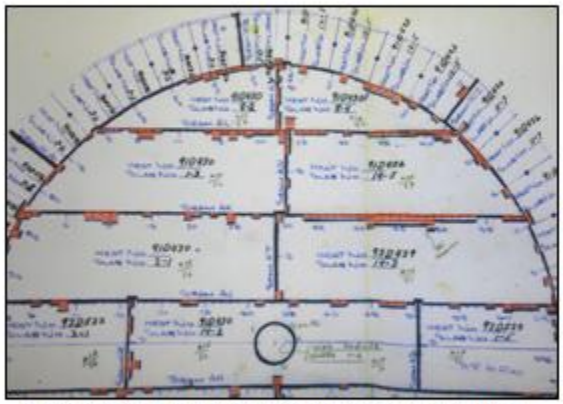
Tank Construction (cont.)

- Primary Tank Bottom Weld Rejection
  - Weld quality was a continuing concern. The floor plate weld rejection rate was ~ 36%.[1] Many welds were repaired several times before passing radiography.
  - The radiography inspector accepted welds that were later rejected by the quality inspector.[2]

[1] By comparison, the weld rejection rate for concurrent waste tank construction at the Savannah River Site was 10% - 20% (Savannah River Plate Waste Tank Discussions and ITT Stress Analysis Study, Trip Report), the weld rejection rate on AY-101 was 10%.
[2] Of 343 rejected floor plate welds, the inspector found only 294.

Page 23

Tank Construction (cont.)



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.

Page 24

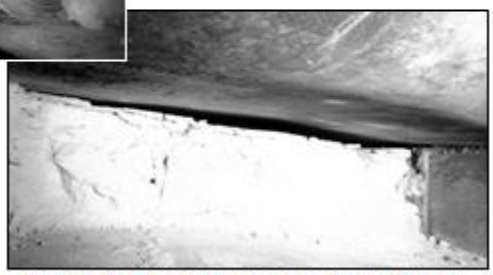
Tank Construction (cont.)

- Insulating refractory damage from stress-relief and hydrostatic test of primary tank
  - Full depth cracks ¼-inch wide extending several feet
  - Spongy top surface; affected depth increased as outer lip approached
  - Air passages blocked with spalled refractory
  - No evidence of tank settlement
  - 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

Page 25

Tank Construction (cont.)

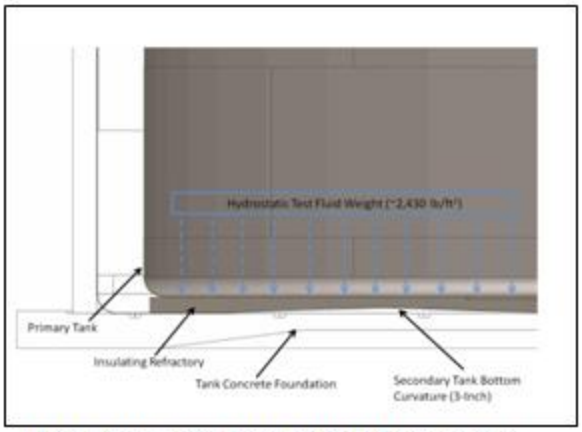
Preparing Insulating Refractory for modification with use of reinforced concrete



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

Page 26

Summary Effect of Construction Difficulties



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

Page 27

Probable Leak Cause

- *Possible corrosion at high waste temperatures compounded by mechanical impacts to a tank whose waste containment margins had been reduced by construction difficulties.*

Page 28

Probable Leak Cause (cont.)

- 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.
- In 2005, a 125 pound drill string was dropped 27-feet through the waste. Recent inspection photos show the 33-foot long drill string still held upright by 60-inches of waste.
- In 2009 the corrosion probe repeatedly contacted the tank bottom during insertion.

Page 29

Estimated Leak Volume – Liquid Basis

- Liquid Leak Volume Range:
  - Insulating refractory air channels only, and floor material near Risers 83, Riser 87 – 90 including mound = ~ 350 gallons[1]
  - Saturated Insulating Refractory 10° Wedge at Riser 90, 5° Wedge at Riser 83, and floor material near Risers 83, 87 – 90 including mound = ~ 670 gallons
- Assumptions:
  - Insulating Refractory absorbs up to 80% liquid by weight[1]
  - 10° Wedge from tank center to perimeter involved, encompassing two air slots and 80 weight% absorption[2] of 1.15 SpG waste by refractory concrete = 300 gallons
  - Floor material between Riser 90 and Riser 87, including cascade over insulating refractory retaining ring, 0.25 inches thick x 21 inches wide x 25 feet long and 10:1 liquid:solid evaporation reduction = ~ 70 gallons
  - Mound near Riser 90, 8 inches thick x 1.5 feet wide x 2 feet long and 10:1 liquid:solid evaporation volume reduction = ~ 150 gallons
  - Floor material below Riser 83, 0.5 inches thick x 6 inches wide x 22-inches long and 10:1 liquid:solid evaporation volume reduction = ~ 3 gallons

[1] Assumes waste drainage filled only the refractory air channel leading to annulus without wetting surrounding material. Volume is about 6 gallons of dried waste per channel for shortest pathway (60 gallons of liquid per channel, using 10:1 liquid:solid reduction).
[2] ARH-1833, Investigation of the 241-AY Insulating Refractory Task Force Report, page 6 (Attachment G of RPP-19297 Evaluation of Insulating Concrete in Hanford Double Shell Tanks)

Page 30

Estimated Leak Volume – Dry Basis

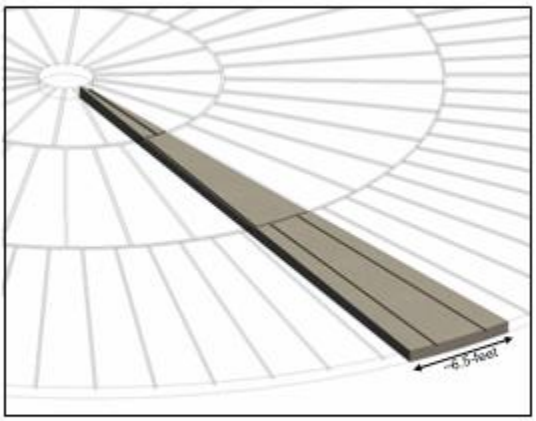
- Dry Leak Volume Range:
  - Insulating refractory air channels only, and floor material near Risers 83, Riser 87 – 90 including mound = ~ 40 gallons[1]
  - Saturated Insulating Refractory 10° Wedge at Riser 90, 5° Wedge at Riser 83, and floor material near Risers 83, 87 – 90 including mound = ~ 70 gallons
- Assumptions:
  - Insulating Refractory absorbs up to 80% liquid by weight[1]
  - 10° Wedge from tank center to perimeter involved, encompassing two air slots and 80 weight% absorption[2] of 1.15 SpG waste by refractory concrete = 30 gallons
  - Floor material between Riser 90 and Riser 87, including cascade over insulating refractory retaining ring, 0.25 inches thick x 21 inches wide x 25 feet long and 10:1 liquid:solid evaporation reduction = ~ 7 gallons
  - Mound near Riser 90, 8 inches thick x 1.5 feet wide x 2 feet long and 10:1 liquid:solid evaporation volume reduction = ~ 15 gallons
  - Floor material below Riser 83, 0.5 inches thick x 6 inches wide x 22-inches long and 10:1 liquid:solid evaporation volume reduction = ~ 0.3 gallons

[1] Assumes waste drainage filled only the refractory air channel leading to annulus without wetting surrounding materials. Volume is about 8 gallons of dried waste per channel for shortest pathway.
[2] ARH-1533, Investigation of the 241-AY Insulating Refractory Task Force Report, page 6 (Attachment G of RPP-19297 Evaluation of Insulating Concrete in Hanford Double Shell Tanks)

Page 31

Estimated Leak Volume – 10° Wedge

- Photographs below Riser 90 suggest two air distribution channels may contain material
- The occupied floor area below Riser 83 suggests a single channel could be involved



Page 32

Tank AY-102 Leak Assessment Completion Activities

ESRB Review and Concurrence with Leak Assessment Results:

Recommendation: Leak Integrity Status of Tank AY-102 be changed from "Sound" to "Assumed Leaker"

Page 33

Additional Information

Page 34

Additional Information

- Tank Construction (17 slides)
- Tank AY-102 Myths
- Formal Leak Assessment Process
- Leak Assessment Leak – No-Leak Hypotheses

Page 35

Tank Construction - I

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

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

Page 36

Tank Construction - II

- Secondary Liner Warpage
  - Use of thin ¼-inch plates complicated by work in extreme cold (-20°F to -10°F) 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. These did not disappear as temperatures chilled.
  - February, 1969 survey found 22 liner locations exceeding allowable 2-inch convexity. Root-to-crown slopes up to1-inch per foot were present, exceeding allowable 3/8-inch per foot.
  - These were eventually accepted for placement of the insulating refractory.

Page 37

Tank Construction - III

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

Page 38

Tank Construction – IV

- 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 from the tank contents.
  - The required minimum depth was 5-inches. The actual minimum depth was 7-inches.
  - 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.

Page 39

Tank Construction - V

Completion of Insulating Refractory Section Pour
(8118-Photo)

Page 40

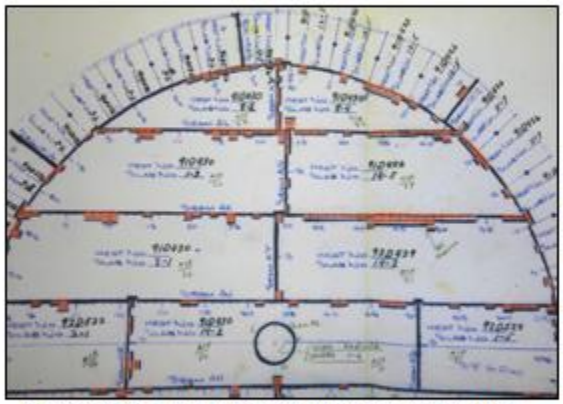
Tank Construction - VI

- Primary Tank Bottom Weld Rejection
  - Weld quality was a continuing concern. The floor plate weld rejection rate was ~ 36%.[1] Many welds were repaired several times before passing radiography.
  - The radiography inspector accepted welds that were later rejected by the quality inspector.[2]

[1] By comparison, the weld rejection rate for concurrent waste tank construction at the Savannah River Site was 10% - 20% (Savannah River Plate Waste Tank Discussions and ITT Stress Analysis Study, Trip Report), the weld rejection rate on AY-101 was 10%.
[2] Of 343 rejected floor plate welds, the inspector found only 294.

Page 41

Tank Construction - VII



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.

Page 42

Tank Construction - VIII

- Insight: Primary Tank Bottom Placement Change
  - Centering cleats were welded to the underside of the primary tank bottom and used to center the bottom on the insulating refractory pad as it was lowered into place.
  - The cleats acted as guide pins engaging the metal walls of the circular annulus air distribution chamber welded to the secondary liner at the tank center.
  - The intended engagement was 2 ¾ -inches. Allowing for nominal 8-inch insulating refractory pad, and the 7 ¾ -inch height of the distribution chamber wall, the cleats were 3-inches long.
  - A design change increased the length of the cleats to 5-inches. The increase was to ensure the intended 2-3/4-inch engagement was preserved after the insulating refractory pad was poured. This design change suggests that ***the pad at the center of the tank must have been about 10-inches thick***.
  - With a 10-inch thick pad, and the 7-inch minimum insulating refractory thickness revision, the implication is that ***secondary liner bulges up to 3-inches high were present after fabrication.***

Page 43

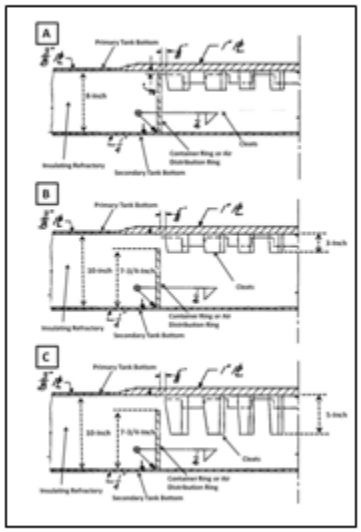
Tank Construction - IX

Primary Tank Centering Cleat Change

A The cleats' intended engagement was of the 3-inch centering cleats was 2 ¾ -inches (2 ¾-inches = 3 inches – [8-inch thick refractory pad – 7 ¾-inch high air distribution chamber]).

B The required minimum depth of the insulating pad was 5-inches. The actual minimum depth was 7-inches. The contractor had poured a 10-inch pad instead of an 8-inch pad to ensure minimum coverage of secondary liner bulges. The change reduced the cleat engagement from 2-3/4 -inches to ¾ -inch.

C The cleats' length was increased from 3-inches to 5-inches to restore the intended 2 ¾ -inch engagement.



Page 44

Tank Construction - X

- Implication of 10-Inch Thick Insulating Refractory at Center of Tank
  - Nominal thickness of refractory pad was originally specified as 8-inches, with 5-inch minimum.
  - Photographs of the 6-1/2-inch high refractory pad metal retaining ring show that the repaired portion of the pad varied between ~ 8-inches and ~ 10-inches.[1]
  - If the center of the insulating refractory pad was 10-inches thick, and the outside edge 8-inches to 10-inches thick, then it is possible that the bottom of the primary tank was "oil-canned" as it followed the contour of the pad.[2]

[1] The refractory was damaged during relief and the outside 21-inches of the pad were removed and replaced with structural concrete. It is possible that the apparent difference in pad thickness at the edge is the result of excess concrete being piled against the tank knuckle during placement, rather than actual variation in the pad's thickness.
[2] During removal of the insulating refractory, gaps between the primary tank and refractory concrete were noticed further under the tank. The gaps suggest that the primary tank was raised off the refractory concrete in some locations. The gaps were stuffed with pieces of Styrofoam when they were found.

Page 45

Tank Construction - XI

- Insulating Refractory Damage from Stress Relief and Hydrotest of Primary Tank - I
  - Prior to stress relief rain water accumulated in the annulus saturating the insulating refractory pad
  - For the first two days of attempted stress relief, tank temperature could not be raised above 210°F as steam escaped from the refractory concrete[1]
    - Recommended drying regime was 150°F for two weeks before proceeding with stress relief[2]
  - During stress relief thermal expansion increased tank diameter by ~ 7-inches[3]

[1] By contrast, tank AY-101 PWHT temperature was 500°F after 4-1/2 hours.
[2] Savannah River Plant Waste Tank Discussions and ITT Stress Analysis Study (Trip Report)
[3] Stress Relief of Primary Steel Tank – Tank 102 (Vitro – H&S Quality Assurance Report , October 2, 1969)

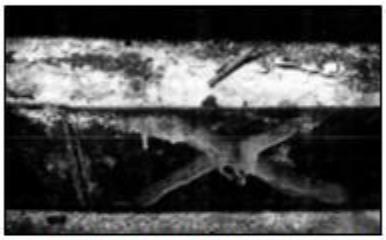
Page 46

Tank Construction - XII

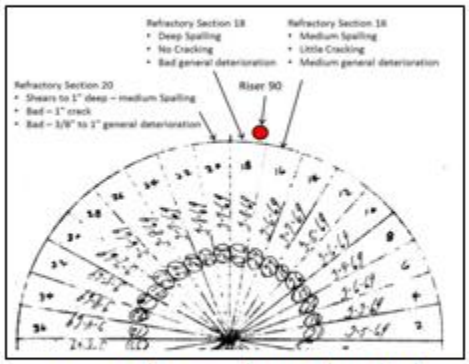
- Insulating Refractory Damage from Stress Relief and Hydrotest of Primary Tank - II
  - Full depth cracks ¼-inch wide extending several feet
  - Spongy top surface; affected depth increased as outer lip approached
  - Air passages blocked with spalled refractory
  - No evidence of tank settlement
  - Thought to result from alkali hydrolysis, skin friction as tank expanded and contracted across the surface of the insulating refractory pad, and "oil-canning" of the tank on the outside perimeter of the pad

Page 47

Tank Construction - XIII



Damaged Insulating Refractory viewed from the Annulus. Dark Band is Metal Retaining Ring



As-Found Condition of Insulating Refractory after Stress Relief and Hydrostatic Test Near Riser 90.

Page 48

Tank Construction - XIV

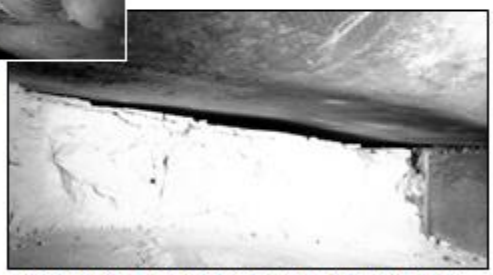
- Damaged Insulating Refractory Replacement
  - Structural analysis determined tank could tolerate 6-inches of knuckle support loss
  - Depth of friable insulating refractory surface varied from ¾-inches to 1¼ -inches and had no compressive strength.[1] At least one location was "punky" showing no measurable strength.[2]
  - Decision made to replace outer 21-inches with structural concrete
  - Inspections following insulating refractory removal found ***gaps between the refractory surface and the primary tank bottom as much as 1-1/2-inches***
    - Styrofoam was used to fill the gaps

[1] By contrast, tank AY-101 friable surface varied from ½-inch to ¾-inch thick
[2] Inspection of Kaolite in TK-101 and Discussion (Meeting Minutes, July 21, 1970)

Page 49

Tank Construction - XV

Preparing Insulating Refractory for modification with use of reinforced concrete

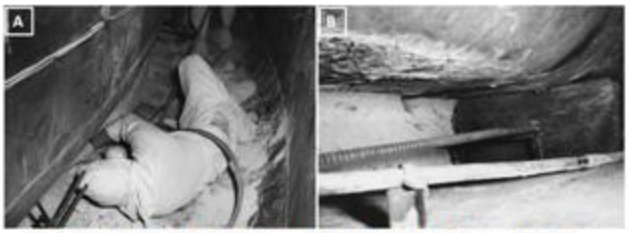


Tank AY-101 Primary Tank Gap over Insulating Refractory (52788-8-Photo). Gaps in Tank AY-102 were reported to be larger.

Page 50

Tank Construction - XVI

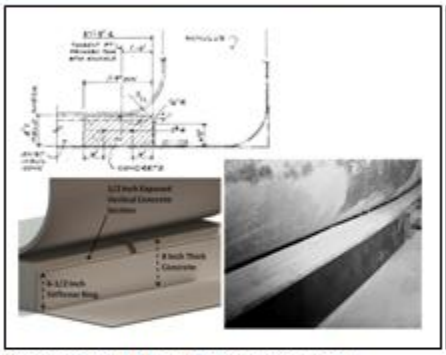
- Structural Concrete Placement
  - Initially ten skip pours were equally spaced around the tank
  - *After forms removed only the first ~ 8-inches of the 21-inches back from the knuckle had been completely filled*
  - Slump was increased, and the remaining sections completed



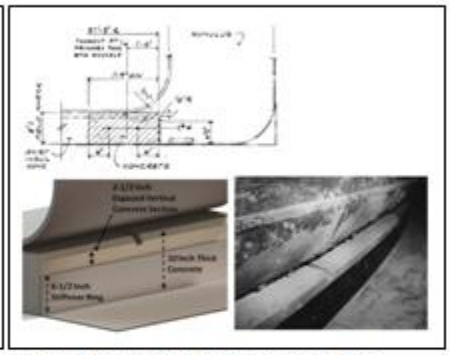
Refractory Removal and Rebar Placement for Structural Concrete Pours (A) (52735-10); Refractory Section Prepared for Structural Concrete Pour with Adjacent Section already Completed (B) (52735-1)

Page 51

Tank Construction - XVII



Comparison of 8-inch Thick Concrete Section Thickness to Photo of Southeast Section of Annulus (52720-7)



Comparison of 10-inch Thick Concrete Section Thickness to Photo of Unknown Section of Annulus (52720-6)

Page 52

Tank AY-102 Myths

Myth	Fact
Surface level decrease indicates a leak.	Stored tank C-106 sludge had a heat output of 118,000 BTU/hour in 1998. The tank AY-102 surface level has continuously decreased since the sludge waste was transferred into the tank, and is primarily evidence of evaporation. An small episodic leak would not be evident in the decrease.
Fill Cycle fatigue caused a leak.	Fill cycle fatigue was evaluated in 1968. Analysis showed 241-AY tanks could safely withstand 17,600 fill cycles, a far greater number of cycles than any double-shell tank will encounter during its service life.
Annulus floor samples aren't radioactive enough to be tank waste	Work with tank AY-102 core samples published in 2002 concluded that the tank AY-102 sludge has a great affinity for Cs-137 – 81% of the Cs-137 inventory in the tank was associated with the solids. This was thought to result from the presence of aluminosilicates in the sludge. The composition of the Kaolite 2200-LI refractory concrete under the primary tank is about 77 weight % aluminum and silicon, suggesting that Cs-137 may be preferentially adsorbed by the refractory concrete as well. Both of these would reduce the concentration of Cs-137 found in the annulus from a leak source.

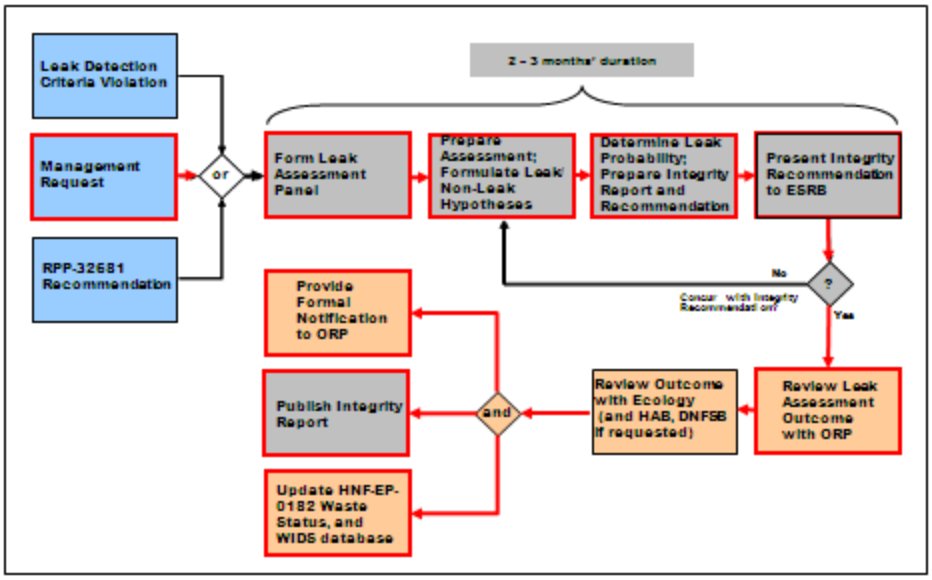
Page 53

Tank AY-102 Myths (cont.)

Myth	Fact
Raw waste was transferred into the annulus.	There is no record of such an event. In April, 1977, waste was accidentally misrouted into the tank SY-103 leak detection pit.
Acid waste was transferred into the tank.	There is no record of such an event. In October, 1972, 3,700 gallons of PUREX Acidified Sludge acid waste was accidentally transferred from the 244-AR Vault AR-001 tank into tank AY-101. The pH of the solution was 0.7 – 1.3. 150 gallons of concentrated NaOH was added to the tank to neutralize the waste.
"AY-102 was a receiver tank for B Plant processing. Once they got waste ready to go, they would add sodium hydroxide to the tank, but they were in such a hurry that they just dumped the sodium hydroxide into the process tank… "Once the waste in the tank flashed and affected the vent system. The waste was then immediately sent to 102 AY, without a chance to neutralize. He says that he observed brown fumes shooting 40 feet out of 702 A stack (which at the time was connected to AY-102). He stated that this occurred 'time and time and time again.'" Reference: Tom Carpenter Email, dated August 23, 2012	"The source of NO_x emissions, visually observed in the 241-A-702 exhaust stack (296-A-17) during September and October, is degradation of complexant waste in Tank 102-AZ. Several NO_x and NH_3 concentration measurements using Draeger tubes … support the conclusion of the reference letter that the hot liquid in 102-AZ causes NO_x emissions … the before and after measurements of NO_x concentrations in the AN Tank Farm ventilation system indicate that the 200 inches of hot AZ-102 liquid transferred into 107-AN also causes NO_x emissions from the AN Farm ventilation system…" Reference: Letter 65950-83-1696, *Source of NOx Fumes in 241-A-702 Ventilation System, Final Report*, dated December 12, 1983 located in RHO-RE-SR-83-26 Book B *Process Aids*, Volume 15, 1983. None of the tank AY-102 sample results reviewed during the leak assessment indicates the tank ever received acidic solution.

Page 54

Tank AY-102 Formal Leak Assessment Process



Leak Assessment Leak – No-Leak Hypotheses

- Leak Hypothesis:
  - *The source of radioactive material discovered in the tank AY-102 annulus near Risers 83 and 90 is a leak from the primary tank.*
- No-Leak Hypothesis:
  - *The source of the colored material near Riser 83 is radioactively contaminated material deposited by mechanisms other than a breach in primary tank containment. The mound near Riser 90 is to be sampled. The source of the dry cascades near Riser 90 is dissolved insulating refractory. The radioactive contamination in the annulus is the result of cross-connections between the primary tank and annulus ventilation system.*

Page 56

DISTRIBUTION SHEET

To	From	Page 1 of 2
Distribution	Technical Integration	Date 10/31/2012
Project Title/Work Order: RPP-ASMT-53793, Rev. 0, Tank 241-AY-102 Leak Assessment Report		EDT No. N/A
		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
T. J. Barnes	R2-53	X			
A. D. Basche	H6-02	X			
K. D. Boomer	R2-53	X			
W. C. Clark	H6-63	X			
G. A. Cooke	T6-05	X			
B. L. Duffy	R1-05	X			
D. L. Dyekman	S5-07	X			
J. K. Engeman	R3-26	X			
J. G. Field	S7-90	X			
C. L. Girardot	R2-53	X			
R. E. Gregory	S7-68	X			
D. G. Harlow	R2-53	X			
S. J. Harrington	R2-58	X			
G. J. Johnson	H6-18	X			
M. D. Johnson	H6-63	X			
C. C. Joslyn	R2-53	X			
D. B. Little	R2-58	X			
J. A. McDonald	R2-53	X			
J. E. Meacham	R2-58	X			
K. J. Peltier	S5-07	X			
A. C. Prince	S5-08	X			
R. S. Rast	R2-58	X			
C. L. Rosenkrance	R2-53	X			
T. L. Sams	R2-52	X			
R. J. Skwarek	H3-28	X			
D. K. Smith	S7-75	X			
B. R. Thomas	H6-11	X			
R. P. Tucker	S5-23	X			
T. J. Venetz	R2-53	X			
J. A. Voogd	R1-51	X			
D. J. Washenfelder	R2-53	X			
R. E. Wilkinson	S5-07	X			

DISTRIBUTION SHEET

To	From	Page 2 of 2
Distribution	Technical Integration	Date 10/31/2012
Project Title/Work Order: RPP-ASMT-53793, Rev. 0, Tank 241-AY-102 Leak Assessment Report		EDT No. N/A
		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
T. W. Fletcher	H6-60	X			
E. M. Mattlin	H6-60	X			
J. M. Johnson	H6-60	X			
P. G. Harrington	H6-60	X			
R. M. Irwin	H6-60	X			
J. H. Wicks	H6-60	X			
M. E. Johnson	A0-26	X			