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7. Abstract This document presents the Functional Design Criteria for installing Liquid Observation Wells (LOWs) into single-shell tanks containing either ferrocyanide or organic waste. The LOWs will be designed to accomodate the deployment of gamma, neutron, and electromagnetic induction probes and to interface with the existing tank structure and environment.		
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LIQUID OBSERVATION WELL (LOW) FUNCTIONAL DESIGN CRITERIA

1.0 INTRODUCTION

1.1 BACKGROUND

Installation of in-tank liquid observation wells (LOWs) was implemented in the early 1980's to provide a reliable leak detection system for the Hanford 200 East and 200 West Tank Farms. The LOWs are made from fiberglass tubes closed at one end, inserted vertically into the tank waste, and suspended from tank risers. Different surveillance probes are deployed into the LOWs to detect the liquid interface in the surrounding waste. This system has proven to be a reliable method of monitoring tank waste liquid levels.

Currently, 57 of the 149 single shell tanks have an installed functional LOW. Some tanks that do not have a LOW are suspected to contain potentially reactive wastes and have been placed on an organic or ferrocyanide watch list. Maintaining an adequate waste moisture concentration in these tanks is important to prevent exothermic chemical reactions from occurring. It has been proposed that LOWs be installed in these tanks to allow for moisture concentration monitoring. This monitoring will provide a means to determine if these wastes are stored in an intrinsically safe condition. A second generation of moisture probes is being developed to facilitate data acquisition. New materials for the LOWs have been suggested to enhance the performance of these probes (Toffer 1994). The new LOW material must be compatible with the probes while maintaining an effective barrier between the interior of the LOW and the surrounding waste.

1.2 SCOPE

This document shall provide the criteria for the design, construction and installation of LOWs for organic and ferrocyanide tanks that currently do not contain LOWs.

1.3 PROJECT INTERFACES

The project will interface with tank waste sampling efforts. Waste sampling requires a free riser to collect core samples. During conceptual design, a list of tanks with only one uncommitted riser should be produced. This will help avoid any scheduling conflicts between the LOW installation and waste sampling.

2.0 PROJECT CRITERIA

2.1 LIQUID OBSERVATION WELL (LOW) SPECIFICATIONS

2.1.1 LOW Interfaces

It is anticipated that a passive gamma probe, a thermal neutron moisture probe, an epithermal neutron moisture probe, and an electromagnetic induction probe will be used inside the LOWs. The LOWs therefore must contain low amounts of both neutron absorbers like boron and iron and moderators such as hydrogen and carbon. They should also be nonconductive (electrically) and nonmagnetic. The LOW material shall have a resistivity above 1000 Ω -cm.

The LOW will be required to fit within a 4 in. schedule 40 riser. One end of the LOW must interface with the riser flange. A plug consisting of an Ultra High Pressure Water (UHPW) borehead shall be installed at the other end of the tube to seal it. The LOW interface design must accommodate the different rates of thermal expansion of the stainless steel UHPW, the steel riser flange, and the LOW material.

Due to manufacturing methods and/or transportation considerations, the LOW may need to be manufactured from several sections to produce the required length. It is desirable that the number of joints be minimized in the LOW design.

2.1.2 LOW Dimensions

- (1) Length: should reach within 5 cm (2 in.) of the bottom. The deepest tank will require a LOW of approximately 16.8 m (55 ft) long.
- (2) Inner diameter (minimum): 7.80 cm (3.07 in.) including tube to tube joints.
- (3) Outer diameter (maximum): 9.4 cm (3.7 in.) including tube to tube joints.
- (4) Tube Straightness: the LOW shall allow passage of a cylinder with an outside diameter of 7.303 cm (2.875 in.) and length of 1.7 m (65 in.).
- (5) LOW dimension changes due to radiation exposure or chemical corrosion should not interfere with the operation of the probes or the removal of the LOWs.
- (6) The inside surface shall be relatively smooth.

2.1.3 Mechanical Properties

The LOW material including joints should be able to support three times the weight of a 16.7 m (55 ft) long LOW and the borehead plug. The material used in the LOW should be flexible enough to withstand some impact from waste movement, and yet be rigid enough to prevent large deformation caused by

buoyancy forces (approximately 300 lbs.). These properties should not vary greatly over the life expectancy of the LOW. The material shall have a minimum apparent elastic modulus of 4.8 GPa (700 kpsi) (Deichelbohrer 1982) during service conditions. A system of two materials joined end to end may be necessary to withstand the forces present in the waste tank. Extra weight shall not be added to the plug/borehead for any reason.

2.1.4 Chemical Resistance

The LOW including joints must maintain its integrity when in contact with the following solutions:

NaOH	3.0 M
NaNO ₃	5.0 M
NaNO ₂	2.0 M
Na ₂ CO ₃	0.5 M
NaAlO ₂	2.5 M
Na ₂ Cr ₂ O ₇	0.1 M

2.1.5 Radiation Resistance

Cumulative gamma radiation exposure of 1×10^6 Gy (1×10^8 rad) which simulates a worst case dosage for 20 years at approximately 5 Gy/h (500 rad/h) should not compromise the integrity of a LOW. The dimensional variation of the LOW due to radiation exposure should be minimal during its service life.

2.1.6 Pressure Requirements

The LOW including the LOW joints shall withstand an external positive hydrostatic test to 275 kPag (40 psig) for 15 minutes without any leaks.

2.1.7 Joining Methods

Methods of joining i.e. connecting the tubes end to end, the UHPW borehead, and the riser flange should not interfere with the operation of the monitoring probes or the installation of the LOWs into the tank risers. It is desirable that the joint strength be able to withstand a collision caused by a probe being lowered to an incorrect well depth and impacting the bottom. A worst case impact scenario would be equivalent to a 25 kg (55 lbs.) mass dropping from 16.7 m (55 ft) at a rate of 0.8 m/s (2.5 ft/s).

2.1.8 Absorbency/Waterproof

The LOW material shall not allow any liquid to be wicked to the inside surface. The LOW including all joints should be fabricated to be leakproof.

2.1.9 Thermal Requirements

The maximum temperature that the LOWs must withstand is 94 °C (201 °F).

2.2 TANK RISER INTERFACE

This project shall be responsible for designing a LOW interface compatible to the existing tank risers. Existing 10.2 cm (4 in.) uncommitted risers will be preferentially chosen for installation of the LOWs. This will allow larger risers to remain uncommitted and available for future applications requiring a larger riser. Location of risers should be as close as practical to the center of the tank.

2.3 DESIGN LIFE

The LOWs will be expected to have a useful life of 20 years.

3.0 PROCESS REQUIREMENTS

3.1 FREQUENCY OF USE

The schedule for use of the LOW is once a week or the current monitoring schedule.

3.2 INSTALLATION CONSIDERATIONS

During installation, water will be added to the tank by the UHPW borehead. Tank farm operating specifications shall be maintained during installation. Radiation work permits and industrial safety practices will be utilized when appropriate.

4.0 FACILITY CRITERIA

4.1 UTILITY REQUIREMENTS

None

4.2 COMMUNICATION REQUIREMENTS

None

4.3 MAINTENANCE REQUIREMENTS

Periodic inspection and repair of the risers and riser covers will be required.

5.0 GENERAL REQUIREMENTS

5.1 SAFETY

The safety analysis will be based upon the previous LOW installation project. Because similar conditions are expected to exist during this project, the required compliances and procedures will be modeled on the current LOW installation process. Additional safety requirements may be needed due to the operation of the UHWP borehead.

5.2 ENVIRONMENTAL PROTECTION AND COMPLIANCE

The applicable environmental requirements for new and modified facilities, as defined in Section 9 of WHC-CM-7-5, *Environmental Compliance Manual*, shall be identified and followed. Applicable permits will be identified and obtained before installation.

5.3 SAFEGUARDS AND SECURITY

No additional requirements are needed to those currently in place at the tank farms.

5.4 NATURAL FORCE CRITERIA

The requirements of DOE 5480.28, *Natural Phenomena Hazards Mitigation*, shall be complied with in the design whenever possible. Because the scope of this project does not include any alteration to the existing tank structure, it may not be possible to meet all of the requirements.

5.5 DESIGN FORMAT

Two-way traceability shall be provided between project drawings and the reference drawings from which they were developed. Project drawings shall identify existing drawings that will be affected by the project.

Design drawing formats shall be in accordance with:

WHC-CM-6-1, *Standard Engineering Practices*, EP-1.3, "Preparation of Engineering Drawings."

WHC-CM-6-3, *Drafting Standards Manual*

5.6 QUALITY ASSURANCE

The Quality Assurance (QA) activities for all contractors involved in the design, construction, and acceptance testing shall be executed in accordance with DOE 5700.6C, *Quality Assurance*, to provide the following assurances:

1. Design data and design decisions are documented and traceable.
2. The design and design criteria are adequately supported by the prepared plans, specifications and analyses.
3. The design meets the baseline design criteria.
4. Construction is performed in accordance with the definitive design documents.
5. Testing or modeling, as applicable, confirms the adequacy of the design, the quality of the construction and manufactured components, operability and maintainability, and reliability. The QA activities are formulated and executed through the use of the project specific quality assurance plan (QAT) in accordance with WHC-CM-4-2, Section QI 2.1, *Quality Assurance Manual*.

5.7 DECONTAMINATION AND DECOMMISSIONING

The project design shall facilitate future decontamination as prescribed in WHC-CM-7-5 Section 6.4, *Environmental Compliance*. The LOWs shall have a smooth exterior (i.e., contain no crevices that can trap waste) that will be easy to clean during removal. The project will also minimize hazardous waste generation and use of hazardous materials during construction, installation, and operation.

5.8 OPERATING PERSONNEL AND SERVICES

Additional operating personnel will be required during installation.

5.9 TESTING

Testing of the proposed LOW materials and joints will be performed to establish the durability of the material and the quality of construction in the working environment. These tests will include exposing the LOW material to expected gamma radiation while embedded in a corrosive solution and standard destructive tests to establish material properties before and after irradiation.

6.0 CODES AND STANDARDS

6.1 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

The ASTM testing standards will be used as a reference during the testing of the materials. The most current revision will be used.

6.2 U.S. DEPARTMENT OF ENERGY HEADQUARTERS

DOE 5480.28, *Natural Phenomena Hazards Mitigation*, Washington, D.C. "Interim Guidance for Preparing Safety Assessments," Revision 2, dated March 6, 1992.

DOE 5700.6C, *Quality Assurance*, Washington, D.C.

6.3 WESTINGHOUSE HANFORD COMPANY

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APPENDIX A
BIBLIOGRAPHY

THIS APPENDIX FOR ARCHITECT-ENGINEER INFORMATION ONLY

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APPENDIX B
SINGLE AND DOUBLE-SHELLED TANKS WITH LOWS

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Single and Double-Shelled Tanks with LOWs*

Tank Number	LOW Material	Date Installed	Riser Size (in)	Riser Number	Watchlist Status	LOW Status
1. A-101	FG	08/13/84	4	19	H,ORG	
2. A-103	FG	08/13/84	4	19		
3. AX-101	FG	08/15/84	6	9A	H	
4. AW-103	TZ					
5. B-104	FG	07/24/84	12	6		
6. B-105	FG	07/23/84	4	5		
7. BX-111	FG	08/09/84	4	5		
8. BY-101	FG	07/18/84	4	9A		
9. BY-102	FG	07/17/84	4	1		
10. BY-103	FG	07/16/84	4	10A	FeCN	
11. BY-104	FG	07/19/84	4	10C	FeCN	
12. BY-105	FG	07/19/84	4	10B	FeCN	
13. BY-106	FG	07/13/84	4	10B	FeCN	
14. BY-107	FG	09/13/83	12	7	FeCN	
15. BY-109	FG	07/11/84	12	12B		
16. BY-110	FG	06/25/84	4	3	FeCN	
17. BY-111	FG	06/27/84	4	1	FeCN	
18. BY-112	FG	06/28/84	6	15	FeCN	
19. S-101	FG	05/14/84	4	2		
20. S-102	FG	05/03/84	12	5	H,ORG	
21. S-103	FG	05/04/84	4	2		
22. S-105	FG	05/17/84	4	14		
23. S-106	FG	05/04/84	4	4		
24. S-108	FG	09/13/83	4	16		
25. S-109	FG	05/07/84	12	8		
26. S-110	FG	05/16/84	4	2		
27. S-111	FG	05/16/84	4	16	H,ORG	
28. S-112	FG	05/07/84	12	8	H	
29. SX-101	FG	05/22/84	4	14	H	
30. SX-102	FG	05/22/84	4	14	H,ORG	
31. SX-103	FG	05/21/84	4	14	H	
32. SX-104	TZ, FG	05/22/84	4,4	14,16	H	TZ and FG failed
33. SX-105	FG	05/25/84	4	16	H	

Tank Number	LOW Material	Date Installed	Riser Size (in)	Riser Number	Watchlist Status	LOW Status
34. SX-106	FG	05/21/84	4	14	H,ORG	
35. SY-102	TZ					
36. T-104	FG	08/23/84	4	1		
37. T-110	FG	08/23/84	4	5	H	
38. T-111	FG	06/01/84	12	7	ORG	
39. TX-102	FG	08/17/84	4	11A, 3?		r3 W. Brown says riser hit by truck
40. TX-105	FG	08/16/84		9B	ORG	
41. TX-106	FG	08/16/84	4	11A		
42. TX-108	FG	08/17/84	4	9A	ORG	
43. TX-109	FG	06/03/84	4	3		
44. TX-110	FG	06/13/84	4	13B		
45. TX-111	FG	06/15/84	4	11B		
46. TX-112	FG	07/25/84	4	12A		
47. TX-113	FG	06/11/84	4	4		
<u>48. TX-114</u>	<u>FG,FG,FG</u>	<u>06/14/84</u>	<u>12,4,4</u>	<u>7,12A,9A</u>		<u>Riser 7 Monitored</u>
49. TX-115	FG	06/14/84	4	9A		
50. TX-117	FG	07/19/84	12	7		
51. TX-118	FG	07/16/84	12	5	FeCN,ORG	
52. TY-103	FG		4	3	FeCN	Endplug failed-LOW replaced
53. U-102	FG	08/23/84	12	2		
54. U-103	FG	08/21/84	4	19	H,ORG	
55. U-105	FG	08/21/84	4	19	H,ORG	
56. U-106	FG	08/21/84	4	9	ORG	
57. U-107	FG	08/22/84	4	19	ORG	
58. U-108	FG	08/21/84	4	19	H	
59. U-109	FG	08/22/84	4	9	H	
60. U-111	FG	08/22/84	4	19	ORG	

TOTAL Number of Tanks with LOW: 60
(2 double-shell, 58 single shell)

FG=Fiberglass
TZ=Tefzel
FeCN=Ferrocyanide watchlist tank
ORG=Organic salts watchlist tank
H=Hydrogen watchlist tank

*Double-shell tanks are listed in italics.

Table adapted from an internal letter, "Riser Survey for New Liquid Observation Well (LOW) and LOW Material Considerations for Neutron Probe Applications."

APPENDIX C
RECOMMENDED FERROCYANIDE TANK RISERS FOR LOW INSTALLATION

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Recommended Ferrocyanide Tank Risers for LOW Installation*

Tank	Tank Riser #	Riser Size (in.)
BY-108	5	4
C-108	4 ¹	4
C-109	5	4
C-111	4	4
C-112	4 ²	4
T-107	8 ¹	4
TY-101	8	12
TY-104	15	4
BX-102	see note 4	
BX-106	1 ³	4

1. Move breather filter to riser 3.
2. Move breather filter to riser 6.
3. Move breather filter to riser 2 with observation port.
4. No risers currently available for LOW installation.

* Table adapted from an internal letter, "Riser Survey for New Liquid Observation Well (LOW) and LOW Material Considerations for Neutron Probe Applications."