ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 615004

Proj.
ECN

2. ECN Category (mark one) Supplemental ☐ Direct Revision ☒ Change ECN ☐ Temporary ☐ Standby ☐ Supersedure ☐ Cancel/Void ☐	3. Originator's Name, Organization, MSIN, and Telephone No. Michael G. Johnson, 71740, R1-80, 373-3114		3a. USQ Required? ☐ Yes ☒ No	4. Date 2/09/94
	5. Project Title/No./Work Order No. WHC-SD-WM-TI-573, Rev 1 /N1749		6. Bldg./Sys./Fac. No. NA	7. Approval Designator NA
	8. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-SD-WM-TI-573, Rev 0		9. Related ECN No(s). NA	10. Related PO No. NA
11a. Modification Work ☐ Yes (fill out Blk. 11b) ☒ No (NA Blks. 11b, 11c, 11d)		11b. Work Package No. NA	11c. Modification Work Complete NA _____ Cog. Engineer Signature & Date	11d. Restored to Original Condition (Temp. or Standby ECN only) NA _____ Cog. Engineer Signature & Date
12. Description of Change This is a new revision of WHC-SD-WM-TI-573: The primary change is the addition of the description of the intrusion detection strategy (see pages 13 and 14) that is in the process of being implemented into OSD T-151-00031. Other changes include: Incorporation of ECN 614661 (surface level criteria for sloping baselines) Update of Table 4.1-3 (Single Shell Tank Survey Equipment) to include new LOW and Enraf installations Added material from WHC-SD-WM-TI-357, Rev 1k (a listing of possible reasons for liquid level loss other than tank leakage and a Table listing LOW numbers and riser locations) Added background reading range for High Sensitivity Geiger-Muller "Green GM" probe. Changed reference for determining action criteria for Leak Detection Pits from WHC-SD-WM-TI-357 to OSD-T-151-00031 (which supersedes WHC-SD-WM-TI-357 see ECN 609249) and procedure TO-040-590. Note the actual action criteria have not changed. Various editorial changes (both grammar and clarification changes) Format changes (Different font and all Figures have been scanned and electronically incorporated into document)				
13a. Justification (mark one) Criteria Change ☒ Design Improvement ☐ Environmental ☐ Facility Deactivation ☐ As-Found ☐ Facilitate Const ☐ Const. Error/Omission ☐ Design Error/Omission ☐				
13b. Justification Details Updating WHC-SD-WM-TI-573				
14. Distribution (include name, MSIN, and no. of copies) Central Files <i>412 OSTF (2)</i> Surveillance Engineering will distribute to current holders of WHC-SD-WM-TI-573			RELEASE STAMP OFFICIAL RELEASE BY WHC DATE FEB 13 1995 <i>sto. 4</i>	

A-7900-013-2 (11/94) GEF095

A-7900-013-1 (04/94)

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ENGINEERING CHANGE NOTICE

Page 2 of 2

1. ECN (use no. from pg. 1)

615004

15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)	
	ENGINEERING			CONSTRUCTION		
	☐ Yes	Additional	☐ \$NA	Additional	☐ \$NA	Improvement
☒ No	Savings	☐ \$NA	Savings	☐ \$NA	Delay	☐ NA

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	☐	Seismic/Stress Analysis	☐	Tank Calibration Manual	☐
Functional Design Criteria	☐	Stress/Design Report	☐	Health Physics Procedure	☐
Operating Specification	☐	Interface Control Drawing	☐	Spares Multiple Unit Listing	☐
Criticality Specification	☐	Calibration Procedure	☐	Test Procedures/Specification	☐
Conceptual Design Report	☐	Installation Procedure	☐	Component Index	☐
Equipment Spec.	☐	Maintenance Procedure	☐	ASME Coded Item	☐
Const. Spec.	☐	Engineering Procedure	☐	Human Factor Consideration	☐
Procurement Spec.	☐	Operating Instruction	☐	Computer Software	☐
Vendor Information	☐	Operating Procedure	☐	Electric Circuit Schedule	☐
OM Manual	☐	Operational Safety Requirement	☐	ICRS Procedure	☐
FSAR/SAR	☐	IEFD Drawing	☐	Process Control Manual/Plan	☐
Safety Equipment List	☐	Cell Arrangement Drawing	☐	Process Flow Chart	☐
Radiation Work Permit	☐	Essential Material Specification	☐	Purchase Requisition	☐
Environmental Impact Statement	☐	Fac. Proc. Samp. Schedule	☐	Tickler File	☐
Environmental Report	☐	Inspection Plan	☐	None	☒
Environmental Permit	☐	Inventory Adjustment Request	☐		

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision

Document Number/Revision

Document Number Revision

NA

20. Approvals

[illegible]

RELEASE AUTHORIZATION

Document Number: WHC-SD-WM-TI-573, REV. 1

Document Title: Technical Bases for the Leak Detection Surveillance of Waste Storage Tanks

Release Date: 2/21/95

This document was reviewed following the procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Chris Willingham
C. Willingham

2/21/95

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. Available in paper copy and microfiche. Printed in the United States of America. Available to the U.S. Department of Energy and its contractors from:

U.S. Department of Energy
Office of Scientific and Technical Information (OSTI)
P.O. Box 62
Oak Ridge, TN 37831
Telephone: (615) 576-8401

Available to the public from:

U.S. Department of Commerce
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703) 487-4650

SUPPORTING DOCUMENT		1. Total Pages 128
2. Title Technical Bases for Leak Detection Surveillance of Waste Storage Tanks	3. Number WHC-SD-WM-TI-573	4. Rev No. 1
5. Key Words Leak detection, surveillance, intrusion, LOW, drywells, FIC, manual tape	6. Author Name: M.G. Johnson <i>Michael G. Johnson</i> Signature Organization/Charge Code 71740/N1749	
7. Abstract This document provides the technical bases for specification limits, monitoring frequencies and baselines used for leak detection and intrusion (for single shell tanks only) in all single and double shell radioactive waste storage tanks, waste transfer lines, and most catch tanks and receiver tanks in the waste tank farms and associated areas at hanford.		
8. RELEASE STAMP <div style="border: 1px solid black; padding: 5px; text-align: center;"> OFFICIAL RELEASE BY WHC DATE FEB 13 1995 <i>5</i> </div>		

TABLE OF CONTENTS

1.0 INTRODUCTION.....	5
2.0 PURPOSE.....	7
3.0 SCOPE.....	7
4.0 LEAK DETECTION METHODOLOGY.....	9
4.1 Single Shell Tanks (Leak and Intrusion Detection).....	9
4.2 Double Shell Tanks.....	22
4.3 Catch Tanks and Receiver Tanks.....	22
4.4 Transfer Lines and Encasements.....	23
5.0 FEDERAL, STATE, DOE AND WHC REGULATIONS AND REQUIREMENTS.....	25
5.1 Federal Regulations.....	25
5.2 State Regulations.....	25
5.3 DOE Orders.....	26
5.4 WHC Requirements.....	27
5.4.1 Current Operational Safety Requirements (OSR).....	27
5.4.2 Interim Operational Safety Requirements (IOSR).....	28
5.4.3 Operating Specification Documents.....	30
5.4.4 Supporting Documents.....	30
5.4.5 Investigation and Reporting Requirements.....	30
6.0 EQUIPMENT.....	31
6.1 Single Shell Tanks.....	31
6.1.1 Internal Tank Level Measurement.....	31
6.1.1.1 Manual Tape.....	31
6.1.1.2 Automatic Gauges (FIC).....	33
6.1.1.3 Automatic Gauges (ENRAF).....	35
6.1.1.4 Zip Cords.....	35
6.1.1.5 Visual Inspection.....	36
6.1.1.6 Dip Tubes.....	37
6.1.1.7 Neutron Probe.....	38
6.1.1.8 Gamma Probe.....	40
6.1.2 External Tank Leak Detection.....	41
6.1.2.1 Drywells.....	42
6.1.2.2 Leak Detection Laterals.....	44
6.1.2.3 Leak Detection Pits.....	45
6.2 Double Shell Tanks.....	58
6.2.1 Primary Tank Measurements.....	58
6.2.2 Annulus Leak Detection.....	58
6.2.2.1 Continuous Air Monitors.....	58
6.2.2.2 Fixed Conductivity Probes.....	60
6.2.2.3 Adjustable Conductivity Probes.....	61
6.2.3. External Tank Measurements.....	61
6.2.3.1 Leak Detection Pits.....	61
6.3 Catch Tanks and Receiver Tanks.....	66

6.3.1 Double Contained Receiver Tanks.....	66
6.3.2 Catch Tanks with Secondary Containment.....	67
6.3.3 Catch Tanks without Secondary Containment.....	67
6.4 Transfer Lines.....	68
7.0 MEASUREMENT FREQUENCIES.....	71
7.1 Single Shell Tanks.....	71
7.1.1 Internal Tank Level Measurement.....	71
7.1.1.1 Surface Level Measurement.....	71
7.1.1.2 Interstitial Liquid Level Measurement.....	72
7.1.1.3 In-Tank Photography.....	73
7.1.2 External Leak Detection.....	75
7.1.2.1 Drywells.....	75
7.1.2.2 Laterals.....	76
7.1.2.3 Leak Detection Pits.....	76
7.2 Double Shell Tanks.....	77
7.2.1 Annulus Monitoring.....	77
7.2.1.1 Continuous Air Monitors.....	77
7.2.1.2 Conductivity Probe Leak Detectors.....	77
7.2.2 Leak Detection Pits.....	77
7.3 Catch Tanks and Receiver Tanks.....	77
7.3.1 Double Contained Receiver Tanks.....	77
7.3.2 Catch Tanks with Secondary Containment.....	78
7.3.3 Catch Tanks without Secondary Containment.....	78
7.4 Transfer Line Leak Detection.....	78
8.0 BASELINES FOR LEAK DETECTION COMPARISON.....	79
8.1 Single Shell Tanks.....	79
8.1.1 Liquid Level Baselines.....	79
8.1.1.1 Fixed Value Baselines.....	81
8.1.1.2 Trend Baselines.....	81
8.1.1.3 Tank 241-C-106 Baseline.....	85
8.1.2 Radiation Baselines.....	92
8.2 Double Shell Tanks.....	92
8.3 Catch Tanks and Receiver Tanks.....	92
8.4 Transfer Lines.....	92
9.0 SPECIFICATION LIMITS AND GUIDELINES.....	93
9.1 Single Shell Tanks.....	93
9.1.1 Internal Tank Level Measurements.....	93
9.1.1.1 Manual Tapes.....	93
9.1.1.2 Automatic Gauges (FIC).....	94
9.1.1.3 Automatic Gauges (ENRAF).....	94
9.1.1.4 Zip Cords.....	95
9.1.1.5 In Tank Photography.....	95
9.1.1.6 Dip Tubes.....	95
9.1.1.7 Neutron Probe.....	96
9.1.1.8 Gamma Probe.....	96
9.1.1.9 Tank C-106.....	96

WEC-SD-WM-TI-573 Rev 1

9.1.2 External Tank Leak Detection.....	97
9.1.2.1 Drywells.....	97
9.1.2.2 Laterals.....	97
9.1.2.3 Leak Detection Pits.....	98
9.2 Double Shell Tanks.....	98
9.2.1 Internal Tank Measurements.....	98
9.2.2 External Tank Measurements.....	98
9.2.2.1 Annulus CAMs.....	98
9.2.2.2 Annulus Conductivity Probes.....	99
9.2.2.3 Leak Detection Pits.....	99
9.3 Catch Tanks and Receiver Tanks.....	99
9.3.1 Double Contained Receiver Tanks.....	99
9.3.2 Catch Tanks with Secondary Containment.....	100
9.3.3 Catch Tanks without Secondary Containment.....	101
9.4 Transfer Lines.....	101
10.0 Glossary of Terms.....	107
11.0 References.....	107
Appendix A.....	108

LIST OF TABLES

Table 3-1 Single Shell Tanks Subject to Leak and Intrusion Detection Criteria.....	8
Table 3-2 Double Shell Tanks Subject to Leak Detection Criteria.....	8
Table 3-3 Catch Tanks and Receiver Tanks Subject to Leak Detection Criteria.....	8
Table 4.1-1 Single Shell Tank Leak Detection Strategy.....	11
Table 4.1-2 Single Shell Tank Intrusion Detection Strategy.....	13
Table 4.1-3 Single Shell Tank Leak and Intrusion Detection or Survey Equipment and Assumed Surface Conditions.....	15
Table 4.1-4 Single Shell Tanks with Liquid Observation Wells.....	21
Table 4.3-1 Catch Tank and Receiver Tank Leak Detection Strategy.....	23
Table 4.4-1 Transfer Line Leak Detection Strategy.....	23

LIST OF FIGURES

Figure 6.1-1. Manual Flake Gauge used for In-Tank Surface Level Measurements.....	47
Figure 6.1-2. FIC Gauge Used for In-Tank Surface Level Measurements.....	48
Figure 6.1-3. ENRAF Gauge Used for In-Tank Surface Level Measurements.....	49
Figure 6.1-4. Zip Cord Used for In-Tank Surface Level Measurements.....	50
Figure 6.1-5. Typical Saltwell Dip Tube Weight Factor System.....	51
Figure 6.1-6. Schematic of LOW and Probes Used to Scan for In-Tank Interstitial Liquid Level.....	52
Figure 6.1-7. Models of Characteristic Neutron Probe Scans from LOW's.....	53
Figure 6.1-8. Models of Characteristic Gamma Probe Scans from LOW's.....	54
Figure 6.1-9. Typical Drywell and Scanning Probes.....	55
Figure 6.1-10. Typical Lateral Leak Detection and Scanning Probes.....	56
Figure 6.1-11. Typical AX Leak Detection Pit and Radiation Well.....	57
Figure 6.2-1. Typical Double Shell Tank Annulus CAM Installation.....	64
Figure 6.2-2. Typical Double Shell Tank Leak Detection Pit Arrangement....	65
Figure 7.1-1. Effect of Leak Detection Capability on Time to Spot a Leak.....	74
Figure 8.1-1. Liquid Level in a Tank with a Fixed Value Baseline.....	86
Figure 8.1-2. Trend Line for Tank Experiencing an Increasing Level Change.....	87
Figure 8.1-3. Trend Line for Tank Experiencing a Decreasing Level Change.....	88
Figure 8.1-4. Trend Line for a Tank Exhibiting Significant Seasonal Variation in Observed Level Reading.....	89
Figure 8.1-5. Comparison of Confidence Interval and Standard Deviation....	90
Figure 8.1-6. Tank 241 C-106 Level Data and Calculated Evaporation Rates.....	91

1.0 INTRODUCTION

This document describes the technical bases for leak detection surveillance requirements for the waste storage tank areas at Hanford. It is applicable to leak detection from all Single Shell Tanks, Double Shell Tanks, active catch tanks or receiver tanks, and all lines used for transfer of wastes to or from one of these tanks. Tables 3-1 to 3-3 list the applicable tanks. The requirements presented in this document will be incorporated as necessary into an Operating Specification Document (OSD) which will provide the basis for leak detection monitoring of the applicable tanks and transfer lines.

The Hanford Site produced plutonium for the nation's nuclear defense program for more than 40 years, until 1987. The chemical processing involved produced millions of gallons of radioactive chemical waste. Approximately 61 million gallons of this waste is stored at the Hanford Site in 177 large underground tanks: 36 Mgal in single-shell tanks and 25 Mgal in the newer double-shell tanks. The tanks, divided into 18 groups or "farms," are 6 to 10 ft below ground in the 200 East and 200 West areas near the center of the Site. In general, the wastes can be described as highly caustic and composed of both insoluble solids (sludge) and salts either in solution or precipitated as salt cake. In addition to the radioactive constituents, certain of the organic degradation products, metallic elements, and salt anions present are classed as hazardous wastes per Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) definitions.

In addition to the large waste-storage tanks, there are 20 smaller waste tanks, also located underground, monitored by the leak detection surveillance program. Sixteen are catch tanks that receive drainage from waste-transfer-line diversion boxes or vent system condensates, and four are receiver tanks, which temporarily store waste during the transfer of liquid waste from one storage tank to another in support of the salt-well jet-pumping program or which provide lag storage during transfers from waste generators.

A program for improving leak detection systems for the SSTs was initiated in 1993 (Godfrey 1993). This program covered changes desired to surveillance of the waste tanks to enhance leak detection capability. These changes include upgrades to the monitoring equipment, changes to monitoring priorities and frequencies, and a more systematic approach to data interpretation and reporting. Current specification limits for changes in liquid or radiation levels which set action limits for reporting and response are to be verified as acceptable, or new ones developed.

Leak detection for most tanks involves comparing periodic readings to a historical baseline. The results must be interpreted to determine whether a reading or trend is within the expected range, or if a reading is outside the range, whether it is significant. Some leak detection methods are simpler and give only a yes/no answer for the presence of leakage. The methods used for leak detection monitoring in the Hanford tank farms are discussed in this document and leak detection specification limits provided, along with a basis for the limit. These specification limits bound the permitted range of values for level readings, radiation levels or alarms used for leak detection. Readings beyond these limits or alarms will require meeting the reporting

and/or response actions specified in implementing procedures. This document also provides the basis for monitoring frequencies and baseline comparisons.

Section 4.0 describes the leak detection methodology. This section outlines the strategy behind which methods should be used as the primary and backup leak detection methods for the radioactive waste storage tanks and transfer lines in the 200 areas.

Section 5.0 summarizes documented safety, legal, contractual or internal requirements for leak detection within the waste tank areas.

Section 6.0 describes the equipment used for leak detection, the accuracy and precision of the equipment and provides a reference for specification limits or guidelines to be used for interpretation of data obtained from the equipment.

Section 7.0 discusses monitoring frequencies for each method of leak detection, and provides a basis for selected frequencies.

Section 8.0 covers how baselines are prepared and used for comparison purposes in monitoring for leak detection.

Section 9.0 lists the specification limits or guidelines which are recommended to be incorporated into the leak detection Operating Specifications Document (OSD) or plant operating procedures.

Appendix A provides tables for each leak detection surveillance method. These tables are intended to summarize the information provided in Sections 6.0-8.0.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. 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. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

2.0 PURPOSE

The purpose of this supporting document is to provide the technical bases for the leak detection surveillance of SSTs, DSTs, receiver tanks, catch tanks and transfer lines. This includes the methodology used and recommended leak detection and monitoring frequency specification limits.

This document does not provide the governing requirements or response criteria for the surveillance of these waste-storage facilities. The individual operating specification documents (OSDs), and operating procedures are the sole documented authorities for these items.

3.0 SCOPE

This document applies to leak detection for all SSTs and DSTs, the catch tanks/receiver tanks used for occasional receipt of potentially contaminated wastes, interconnecting transfer lines, and leak detection pits associated with waste storage tanks and transfer lines. Tables 3-1 to 3-3 list the tanks covered by these technical bases. Surveillance for the intrusion of liquid into a storage tank or a leak detection facility is also included within the scope of this document. The tanks, facilities and equipment discussed in this document are located both in and between the 200 East Area and the 200 West Area of the Hanford Site.

The scope of these technical bases is limited to leak detection or tank intrusion requirements. Related requirements which are in place to minimize the possibility or effect of a leak such as chemical composition controls, tank level or temperature limits, tank dome loadings and riser surveys, stabilization, and spare tankage are excluded. Requirements for monitoring of the spread of contamination from past leaks are also excluded.

This document is limited to concerns with monitoring for leaks from waste tanks or transfer lines. Excluded from this document are technical bases and limits related to tank farm waste treatment facilities (242-A, 242-T, 242-S, 204-AR, 244-AR, 244-CR, and other miscellaneous buildings), the Liquid Effluent Retention Facility (LERF), or ponds, cribs and ditches.

At the time this document was written there are approximately 50 miscellaneous inactive catch tanks which have been isolated and taken out of service, many of which have no installed monitoring capability. These tanks are not included in Table 3-3 as being subject to leak detection requirements. If some of these tanks are eventually required to have some form of leak detection, appropriate changes will be made to Table 3-3. Few changes would be expected in the conclusions or recommended limits given in section 9.3 should additions be made to Table 3-3.

Table 3-1 Single Shell Tanks Subject to Leak and Intrusion Detection Criteria (ALL)

241-A 101 to 106
 241-AX 101 to 104
 241-B 101 to 112, 201 to 204
 241-BX 101 to 112
 241-BY 101 to 112
 241-C 101 to 112, 201 to 204
 241-S 101 to 112
 241-SX 101 to 115
 241-T 101 to 112, 201 to 204
 241-TX 101 to 118
 241-TY 101 to 106
 241-U 101 to 112, 201 to 204

Table 3-2 Double Shell Tanks Subject to Leak Detection Criteria (ALL)

241-AN 101 to 107
 241-AP 101 to 108
 241-AW 101 to 106
 241-AY 101 to 102
 241-AZ 101 to 102
 241-SY 101 to 103

Table 3-3 Catch Tanks and Receiver Tanks Subject to Leak Detection Criteria

Double Contained Receiver Tanks	Catch Tanks with Secondary Containment*	Catch Tanks without Secondary Containment
244-A 244-BX 244-S 244-TX	A-350 E/W Vent Station CT 241-S-304	A-302-A A-302-B 152-AX 151-AZ 154-AZ 417-A 311-ER 240-S-302 241-S-302-A 241-TX-302-B 241-TX-302-C 241-U-301-B 241-UX-302-A

*Note: When secondary containment monitoring equipment is out of service, the tank is treated identical to a tank with no secondary containment.

4.0 LEAK DETECTION METHODOLOGY

Leak detection methodology refers to the basic philosophy as to what means are best utilized to monitor a tank or transfer line for leakage. The method used will vary depending upon tank type, contents and available monitoring equipment. This section provides the philosophies used for leak detection monitoring for each type of tank or transfer line.

4.1 Single Shell Tanks

Previous criteria for SST leak detection were set forth in WHC-SD-WM-TI-357. This document called for both internal and external tank measurements, gave the required monitoring frequencies, and permissible deviations from the measured frequencies. The strategy in this document was based upon leak detection assumptions, especially for external tank measurements, which may no longer be applicable in some cases. A revised strategy was required for SST leak detection which could be applied on a consistent basis. This revised strategy is presented in the following section of this technical bases document.

The 133 100-Series SSTs and 16 200-Series SSTs are all equipped with some form(s) of level measurement or leak monitoring device. Surface conditions in these tanks vary from liquid surface to solid surface, with all types of intermediate conditions. Table 4.1-3 lists the single shell tanks, the types of level or leak monitoring equipment currently in place (whether operable or not) for the tank at the time this document was written, and the assumed surface conditions. Assumed surface conditions for each tank are based on a subjective assessment by Engineering and Operations personnel. These assessments come from evaluating a combination of photographs and measurement data for each tank.

Past practice for SST leak detection at Hanford has been to provide both internal liquid level monitoring, which looks for an unexplainable decrease in the liquid level inside a tank, and external monitoring, which looks for the presence of radioactivity outside the tank. Internal liquid level monitoring is also used for intrusion detection.

Internal liquid level monitoring devices measure either a surface liquid level or an interstitial liquid level. Surface level measurement devices such as automatic gauges (FICs or ENRAF) or manual tapes need to measure variations in the liquid surface to be effective for leak detection. For SSTs with a largely liquid surface, measuring a change in the surface level is the most reliable leak detection method. However, as tank conditions have gradually changed from liquid surface to solid surface, many of these devices have become less effective. Variations in readings due to surface irregularities or lack of conductivity as the liquid level drops below a solid surface make surface level readings useful for leak detection only when there is a liquid surface, or a moist solid surface which is suspended in a liquid. Surface level measurement devices are installed in all of the SSTs, although several may be inoperable or temporarily removed at the time this document was written.

When the surface in a tank is solid, in-tank liquid level measurement using Liquid Observation Wells (LOWs) can be used for measuring the interstitial liquid level. These operate by inserting a neutron probe down inside the LOW and determining the interstitial liquid level (ILL) from the detector response as the probe is withdrawn. A gamma probe can also be used for ILL measurement via LOWs. Liquid Observation Wells are installed in 58 of the 149 SSTs, with 56 of them currently operable.

Radiation measurement devices such as drywells and laterals are located around the exterior of selected SSTs. They are used to detect radioactivity external to the tank in the vicinity of the drywell or lateral which may have leaked from the tank. Drywells are located around 132 of the SSTs. Only 15 of the SSTs are equipped with laterals.

Leak detection pits are located under the four SSTs in AX farm. These pits collect drainage which could accumulate in channels under the tanks.

External drywells and laterals have historically been used in combination with in-tank leak detection devices; however, the ability to detect tank leakage with external monitoring equipment is less than that afforded by in-tank measurement equipment. A drop in liquid level or a rise in external tank radiation levels are both indications that a tank may be leaking. If a surface level or interstitial liquid level measurement device that is operating properly shows a steady liquid level, it can be inferred that the tank is still sound, within the limitations of the measurement device. However, if an external radiation measurement device that is operating properly shows a steady background radiation level, it cannot be inferred that the tank is still sound based solely on this information. Thus, external radiation measurement devices such as drywells or laterals are a tool which can be used in conjunction with liquid level detection to evaluate potentially leaking tanks, but should not be relied upon by themselves for leak detection except as a temporary backup survey method when internal liquid level measurement equipment is out of service.

The preferred method of SST leak detection involves in-tank measurement of actual liquid level, regardless of tank waste conditions (whether liquid surface or interstitial liquid). External radiation measurement devices are to be used as a backup leak survey method to support in-tank leak detection systems, or when in-tank liquid level measurement is not available. Drywells may also be used for tracking contamination in the Vadose Zone, but this is not related to leak detection and is not included as part of this document.

Accuracies of measurement equipment is covered in section 6.1. The accuracy of surface level measurement devices, when used on a liquid surface is superior to LOWs. But, currently used surface level measurement equipment must be abandoned as leak detection devices when surface conditions make them ineffective. Where a surface level measurement device is employed for leak detection, photos of the waste surface are desired at some minimum frequency to ensure that the device is effectively measuring liquid level.

A strategy for SST leak detection was developed (Godfrey 1993) in mid 1993 to formalize a new philosophy for leak detection in SSTs. This strategy basically called for; 1) Surface liquid level measurement as the primary leak

detection device for tanks with a liquid surface, with backup leak detection provided by LOWs, laterals or drywells, in that order; 2) Interstitial liquid level measurement via LOWs for tanks with a solid surface, with backup leak detection provided by laterals or drywells; 3) No installation of LOWs in tanks with less than two feet of waste; and 4) Photography of tanks with surface level measurement as the primary leak detection method on a bi-annual basis.

This strategy has since been refined during evolution of the leak detection process and by discussions between WHC and DOE-RL, to the criteria listed below. This list forms the basic strategy which will be used to formally implement a revised leak detection plan for single shell tanks.

Table 4.1-1 Single Shell Tank Leak Detection Strategy

- 1) The liquid level in tanks with liquid or semi-liquid surfaces, where the surface level measurement device is touching a surface which will vary with changes in the liquid level, will be monitored with surface level measurement devices. These devices are designated the primary leak detection method for these tanks.

When the surface level measurement equipment is out of service, backup leak detection for these tanks will be provided by LOWs.

Dip tubes should be considered if LOWs do not exist. If neither LOWs nor dip tubes exist, no formal means of leak detection will be assumed to exist. Backup leak surveys for unstabilized SSTs will be provided by level readings or radiation measurements via leak detection pits, or radiation measurements from laterals or drywells, in that order, until the primary leak detection device is returned to service or an LOW is installed. Current plans call for the installation of an LOW in each dry surface tank over the next 3 years.

- 2) The liquid level in tanks with solid or semi-liquid surfaces, where the surface level measurement device is touching a surface which does not vary with the liquid level, will be monitored with LOWs. These are designated the primary leak detection device for these tanks.

If LOWs are out of service or do not exist, and the tanks are unstabilized, backup leak surveys will be provided by level readings or radiation measurements via leak detection pits, or radiation measurements from laterals or drywells in that order, until the LOW equipment is fixed or LOWs installed.

If LOWs are out of service or do not exist, and the tanks are stabilized, no formal backup leak surveys are required until the LOWs are placed in service.

- 3) LOWs will not be installed in tanks with less than 2 feet of total waste due to the inability to effectively measure an

interface within the bottom 2 feet of waste using current probes.

- 4) Tanks utilizing surface level measurement devices as the primary leak detection device should be photographed on a set frequency or when waste surface conditions are known to have changed, to verify that the surface level measurement device is effectively measuring liquid level.
- 5) For tanks which represent unique situations where the above criteria may not effectively apply (e.g. TK C-106) a leak detection method shall be put in place which will provide an equivalent degree of protection.

Data are obtained from SST leak detection or survey equipment on a periodic frequency. Monitoring frequencies are established as described in section 7.1. To monitor for leakage, successive liquid level or radiation level readings are compared to established baseline values. Preparation of these baselines is discussed further in section 8.1. Specification limits are set for the permissible deviation of readings from these baseline values, as described in section 6.1. When a verified reading is outside the established specification limit, this may indicate that a leak (or an intrusion) has occurred and an investigation is initiated to determine the cause of the out-of-specification reading.

It should be noted that there are a variety of possible causes for liquid loss other than leakage. The most significant and plausible are salt precipitation, temperature effects, evaporation (natural and forced ventilation), and losses resulting from pressure and temperature differences when venting through transfer lines, risers, and tank cascade line breather filters.

Intrusion monitoring is done using the same strategy as that of leak detection whenever possible. In the case of intrusion monitoring only internal devices can be used. The basic strategy for intrusion monitoring in single shell tanks is given below in Table 4.1-2.

Table 4.1-2 Single Shell Tank Intrusion Detection Strategy

- 1) The liquid level in tanks with liquid or semi-liquid surfaces, where the surface level measurement device is touching a surface which will vary with changes in the liquid level, will be monitored with surface level measurement devices. These devices are designated the primary intrusion detection method for these tanks.

When the surface level measurement equipment is out of service, backup intrusion detection for these tanks will be provided by LOWs. Dip tubes should be considered if LOWs do not exist. If neither LOWs nor dip tubes exist, no formal means of intrusion detection will be assumed to exist

- 2) The liquid level in tanks with solid or semi-liquid surfaces, where the surface level measurement device is touching a surface which does not vary with the liquid level, will be monitored with LOWs if an LOW is present. These are designated the primary intrusion detection device for these tanks.

IF a tank does not have an LOW then the surface level device will be the primary means of intrusion detection.

When the LOW is out of service, backup intrusion detection for these tanks will be provided for by surface level measurement devices. For tanks with non-conductive surfaces where the surface level measurement device is a FIC, the FIC will typically be set in the intrusion mode.

- 3) LOWs will not be installed in tanks with less than 2 feet of total waste due to the inability to effectively measure an interface within the bottom 2 feet of waste using current probes.
- 4) Tanks utilizing surface level measurement devices as the primary intrusion detection device should be photographed on a set frequency or when waste surface conditions are known to have changed, to verify that the surface level measurement device is effectively measuring liquid level.
- 5) For tanks which represent unique situations where the above criteria may not effectively apply an intrusion detection method shall be put in place which will provide an equivalent degree of protection.

To be conservative and to have a consistent monitoring strategy the monitoring frequencies, preparation of baselines, and specification limits for leak

detection will also be used for intrusion detection. The exception is the specification limit of FIC's set in intrusion mode. FIC Intrusion Alarms are typically set 1 to 2 inches above the waste surface, but the specification limit is whatever value the alarm is set at for that tank.

Table 4.1-3 Single Shell Tank Leak and Intrusion Detection or Survey Equipment and Assumed Surface Conditions							
TANK	FIC	MT	LOW	DRYWELLS	LATERALS	OTHER	SURFACE*
A-101		X	X	X	X		N
A-102	X			X	X		N
A-103	X		X	X	X		N
A-104		X		X	X		N
A-105		X		X	X		N
A-106	X			X	X		N
AX-101	X		X	X		LDP	N
AX-102		X		X		LDP	N
AX-103	X			X		LDP	N
AX-104		X		X		LDP	N
B-101	X			X			N
B-102	X			X			P
B-103	X			X			N
B-104		X	X	X			N
B-105		X	X	X			N
B-106	X			X		ENRAF	C
B-107		X		X			N
B-108	X			X			N
B-109		X		X			N
B-110		X	X	X			N
B-111	X		X	X			N
B-112	X			X			P
B-201		X					C
B-202		X					C
B-203		X					C
B-204		X					C

TABLE 4.1-3 Single Shell Tank Leak and Intusion Detection or Survey Equipment and Assumed Surface Conditions (Cont.)							
TANK	FIC	MT	LOW	DRYWELLS	LATERALS	OTHER	SURFACE*
BX-101		X		X			P
BX-102		X		X			N
BX-103	X			X			P
BX-104	X			X			C
BX-105	X			X			N
BX-106	X	X		X		ENRAF	P
BX-107	X			X			P
BX-108		X		X			N
BX-109	X			X			C
BX-110		X		X			C
BX-111		X	X	X			C
BX-112	X			X			C
BY-101		X	X	X			N
BY-102		X	X	X			N
BY-103		X	X	X			N
BY-104		X	X	X			N
BY-105		X	X	X			N
BY-106		X	X	X			N
BY-107		X	X	X			N
BY-108		X	X				N
BY-109	X		X	X			N
BY-110		X	X	X			N
BY-111		X	X	X			N
BY-112		X	X	X			N
C-101		X		X			N
C-102	X						N

TABLE 4.1-3 Single Shell Tank Leak and Intrusion Detection or Survey Equipment and Assumed Surface Conditions (Cont.)							
TANK	FIC	MT	LOW	DRYWELLS	LATERALS	OTHER	SURFACE*
C-103	X			X		ENRAF	L
C-104	X			X			N
C-105				X			N
C-106	X			X		ENRAF	L
C-107	X			X			C
C-108		X		X			N
C-109		X		X			N
C-110		X		X			C
C-111		X		X			N
C-112		X		X			N
C-201		X					P
C-202		X					P
C-203		X					P
C-204		X					P
S-101	X		X	X		ENRAF	N
S-102	X		X	X			N
S-103	X		X	X		ENRAF	C
S-104		X	X	X			N
S-105	X		X	X			N
S-106	X		X	X		ENRAF	P
S-107	X			X		ENRAF	P
S-108	X	X	X	X			N
S-109	X		X	X			N
S-110	X		X	X			N
S-111	X		X	X		ENRAF	L
S-112	X		X	X			N

TABLE 4.1-3 Single Shell Tank Leak and Intrusion Detection or Survey Equipment and Assumed Surface Conditions (Cont.)							
TANK	FIC	MT	LOW	DRYWELLS	LATERALS	OTHER	SURFACE*
SX-101	X		X	X			N
SX-102	X		X	X			N
SX-103	X		X	X			N
SX-104	X		X	X			N
SX-105	X		X	X	X		N
SX-106	X		X	X		ENRAF	C
SX-107		X		X	X		N
SX-108		X		X	X		N
SX-109		X		X	X		N
SX-110		X		X	X		N
SX-111		X		X	X		N
SX-112		X		X	X		N
SX-113		X		X			N
SX-114		X		X	X		N
SX-115		X		X	X		N
T-101	X			X			N
T-102	X			X		ENRAF	P
T-103	X			X			N
T-104		X	X	X			N
T-105	X			X			N
T-106	X			X			N
T-107	X			X		ENRAF	P
T-108		X		X			P
T-109	X			X		ENRAF	N
T-110	X		X	X			N
T-111	X		X	X			C

TABLE 4.1-3 Single Shell Tank Leak and Intrusion Detection or Survey Equipment and Assumed Surface Conditions (Cont.)							
TANK	FIC	MT	LOW	DRYWELLS	LATERALS	OTHER	SURFACE*
T-112	X			X			P
T-201		X					P
T-202		X					P
T-203		X					N
T-204		X					P
TX-101	X			X			P
TX-102		X	X	X			N
TX-103	X			X			N
TX-104	X			X			N
TX-105		X	X	X			N
TX-106		X	X	X			N
TX-107	X			X			N
TX-108	X		X	X			N
TX-109	X		X	X			N
TX-110		X	X	X			N
TX-111		X	X	X			N
TX-112		X	X	X			N
TX-113		X	X	X			N
TX-114		X	X	X			N
TX-115		X	X	X			N
TX-116		X		X			N
TX-117		X	X	X			N
TX-118	X		X	X			N
TY-101	X			X			P
TY-102	X			X			L

TABLE 4.1-3 Single Shell Tank Leak and Intrusion Detection or Survey Equipment and Assumed Surface Conditions (Cont.)							
TANK	FIC	MT	LOW	DRYWELLS	LATERALS	OTHER	SURFACE*
TY-103	X		X	X			N
TY-104	X			X			P
TY-105		X		X			N
TY-106		X		X			N
U-101		X		X			L
U-102	X		X	X			N
U-103	X		X	X		ENRAF	P
U-104		X		X			N
U-105	X		X	X		ENRAF	P
U-106	X		X	X		ENRAF	L
U-107	X		X	X		ENRAF	L
U-108	X		X	X			N
U-109	X		X	X		ENRAF	P
U-110	X			X			N
U-111	X		X	X			N
U-112		X		X			N
U-201		X					P
U-202		X					P
U-203		X					N
U-204		X					P

- * L - Assumed liquid surface under surface level measurement device
P - Assumed partial liquid/floating crust surface under surface level measurement device
C - Assumed conductive solid surface at least partially supported by liquid under surface level measurement device
N - Assumed non-conductive solids or solid surface independent of liquid level under surface level measurement device

TABLE 4.1-4 Single Shell Tanks Equipped with
Liquid Observation Wells.

Tank No.	Riser No.	LOW No.	Tank No.	Riser No.	LOW No.
101-A	19	10-01-69	102-SX	14	41-02-61
103-A	19	10-03-69	103-SX	14	41-03-61
101-AX	9-A	11-01-60	104-SX	14	41-04-61OutofService
104-B	6	20-04-70	104-SX	16	41-04-65OutofService
105-B	5	20-05-71	105-SX	16	41-05-65
110-B	1	20-10-64	106-SX	14	41-06-61
111-B	4	20-11-65	104-T	1	50-04-61
111-BX	5	21-11-68	110-T	5	50-10-68
101-BY	9-A	22-01-63	111-T	7	50-11-67
102-BY	1	22-02-63	102-TX	3	51-02-69
103-BY	10-A	22-03-66	105-TX	9-B	51-05-63OutofService
104-BY	10-C	22-04-66	106-TX	11-A	51-06-69
105-BY	10-B	22-05-66	108-TX	9	51-08-63
106-BY	10-B	22-06-66	109-TX	3	51-09-69
107-BY	7	22-07-69	110-TX	13	51-10-60
109-BY	12-B	22-09-60	111-TX	11-A	51-11-69
110-BY	3	22-10-69	112-TX	12	51-12-60
111-BY	1	22-11-63	113-TX	4	51-13-60
112-BY	15	22-12-65	114-TX	7	51-14-69
101-S	2	40-01-66	115-TX	9-A	51-15-63
102-S	5	40-02-63	117-TX	7	51-17-69
103-S	2	40-03-66	118-TX	5	51-18-63
104-S	2	40-04-66	103-TY	3	52-03-69
105-S	14	40-05-61	102-U	2	60-02-62
106-S	4	40-06-72	103-U	19	60-03-70
108-S	16	40-08-65	105-U	19	60-05-70
109-S	8	40-09-60	106-U	9	60-06-63
110-S	2	40-10-66	107-U	19	60-07-70
111-S	16	40-11-65	108-U	19	60-08-70
112-S	8	40-12-60	109-U	9	60-09-63
101-SX	14	41-01-61	111-U	19	60-11-70

4.2 Double Shell Tanks

Primary leak detection for DSTs is provided by Continuous Air Monitors (CAMs) sampling the air from the tank annulus. If the CAMs are unavailable, backup leak detection is provided by conductivity probes in the annulus. At least one leak detector is required to be operational by the DST Operational Safety Requirements (OSRs) per WHC-SD-WM-SAR-016. When the Interim Operational Safety Requirements (IOSRs) in WHC-SD-WM-OSR-016 are implemented, both of these methods will be required to be operational. This is covered in more detail in sections 5.4.1 and 5.4.2.

Surface level measurements are used for determining compliance with other requirements and for providing needed information about the tank, but are not used as primary or backup monitoring instruments for DST leak detection. Drops in liquid level are investigated and surface level measurements would be used to provide backup information in the event of a leak, but tank level readings are not formally required for leak detection.

Leak detection pits for DSTs are capable only of detecting leaks from the annulus. The leak detection pit level measurement and radiation level instrumentation are not used as a primary means of leak detection for DSTs. When the Interim Operational Safety Requirements (IOSRs) in WHC-SD-WM-OSR-016 are implemented, some of the equipment in the DST leak detection pits will be required to be operational to support leak detection activities. Leak detection pit liquid level measurement is currently required to be operational, to ensure compliance with maximum leak detection pit liquid levels stated in OSD-TO-151-007, which is unrelated to leak detection. At the time this document was written there has not been a leaking DST primary tank, so the effectiveness of leak detection pits in collecting leaked waste from DST secondary containment has not been demonstrated.

Readings are taken of the annulus CAM filter paper radiation levels at specified frequencies for each DST. The readings are compared to a baseline value and when the level exceeds a nominal limit or when an annulus CAM alarms, an investigation may be started. Historical data are used for comparison purposes to investigate trends in weekly readings. Conductivity probes are set at a fixed level above the secondary tank bottom. The height of variable conductivity probes off the secondary tank bottom is checked during calibrations and by procedure to ensure they can effectively monitor for primary tank leakage.

4.3 Catch Tanks and Receiver Tanks

These tanks are much smaller than other waste storage tanks. All have surface liquid level instrumentation and all are either empty or have a liquid or semi-liquid surface which can be measured by available surface level measurement equipment.

The leak detection strategy to be used for these tanks is based on current practice for hazardous wastes which uses liquid increase in secondary containment as the preferred means of leak detection. Where not

available or out of service, change in tank surface level is the means of leak detection. The following list gives the strategy used for these tanks.

Table 4.3-1 Catch Tank and Receiver Tank Leak Detection Strategy

- 1) For those tanks enclosed in a secondary containment which has installed leak detection equipment (i.e.-sump probes or sump level measurement equipment) in the secondary containment this equipment provides the primary leak detection method. When the secondary containment leak detection equipment is out of service the installed tank surface level instrumentation provides backup leak detection capability. If the tank surface level equipment is out of service, temporary level sensing equipment can be used.
- 2) For tanks without secondary containment leak detection capability, or for direct buried tanks, the tank surface level instrumentation provides the primary means of leak detection. If this is out of service, temporary level sensing equipment can be used.

4.4 Transfer Lines and Encasements

Transfer lines may be either a double enclosed pipe-in-pipe, a pipe enclosed in a concrete encasement, direct buried pipe, or a pipe jumper passing through a diversion box (or similar pit). Leak detection is only required for transfer lines during transfers.

Leak detection requirements for transfer lines are given in existing documentation (see section 5.4). The methodology is summarized below.

Table 4.4-1 Transfer Line Leak Detection Strategy

- 1) Leak detection is required for all pits which can receive leakage during a transfer. Where pit leak detectors are out of service, portable zip cords or similar monitoring equipment must be used. Catch tanks can not be used as the sole means of leak detection for transfers through a pit, although catch tank levels are still monitored during transfers as a backup.
- 2) Leak detection for pipe-in-pipe encased lines is the encasement leak detector. If this is unavailable or if the detector effectiveness is in question, the leak detector or level detection instrumentation in the pit or catch tank to which the encasement drains will provide equivalent monitoring for leakage.
- 3) Leak detection for concrete encased lines is provided by the leak detector or level detection instrumentation in the pit or catch tank to which the encasement drains. In addition, a pressure test is periodically required for the concrete encased cross site transfer line, per OSD-TO-151-00010. If the concrete encased line pressure test is beyond the time limit

required by the OSD for pressure testing, the transfer cannot be made until the line is retested.

- 4) Leak detection for direct buried lines, except those specifically exempted from pressure testing, is the pressure test required per OSD-TO-151-00010. If the direct buried line test is beyond the time limit required by the OSD for pressure testing, the transfer cannot be made until the line is retested.
- 5) Material balance calculations are also used for transfers between tanks to check for potential leaks. These calculations are required by most transfer procedures, and are especially important for direct buried lines.

5.0 FEDERAL, STATE, DOE AND WEC REGULATIONS AND REQUIREMENTS

This section identifies the leak detection monitoring and surveillance regulations and requirements applicable to Hanford waste tank systems.

5.1 Federal Regulations

The federal regulations are issued by the U.S. Environmental Protection Agency in 40 CFR 265. Subpart J of 40 CFR 265 applies to tank systems for the storage of hazardous waste.

40 CFR 265.193 Containment and Detection of Releases

40 CFR 265.193 (c) ... secondary containment systems must be; (3) Provided with a leak detection system that is designed and operated so that it will detect the failure of either the primary or the secondary containment structure or any release of hazardous waste or accumulated liquid in the secondary containment system within 24 hours, or at the earliest practicable time if the existing detection technology or site characteristics will not allow detection of a release within 24 hours.

40 CFR 265.195 Inspections

40 CFR 265.195 (a) The owner or operator must inspect, where present, at least once each operating day ... (3) Data gathered from monitoring equipment and leak detection equipment, (e.g. pressure and temperature gauges and, monitoring wells) to ensure that the tank system is being operated according to its design.

Compliance with these requirements for double shell tanks or catch/receiver tanks with secondary containment monitoring can be demonstrated. However, compliance is impractical for single shell tanks and direct buried catch tanks due to the lack of secondary containment, and the inability of monitoring many of the SST LOWs or drywells on a daily basis.

5.2 State Regulations

The state regulations are issued by the Washington State Department of Ecology in Dangerous Waste Regulations, Chapter 173-303 WAC. WAC 173-303-400 Interim status facility standards applies to the Hanford high level waste tanks. All dangerous waste treatment and storage tanks at the Hanford site are currently operating under interim status. Final status standards are given in WAC 173-303-640 Tank Systems. For information purposes, the leak detection requirement for final status tanks are identical to the leak detection requirements for interim status tanks.

WAC 173-303-400 Interim status facility standards.

WAC 173-303-400(3)(a) Interim status standards shall be standards set forth by the Environmental Protection Agency in 40 CFR 265 Subparts F through R which are included by reference into this regulation ...

As mentioned in section 5.1, compliance with these requirements is impractical for SSTs and many catch tanks. At the time this technical basis document was written, DOE-RL was working with the State to formalize a practical agreement for leak detection in these tanks. The form of this agreement is uncertain, but it may be a recognition of the Tank Farm Leak Detection Operating Specification Document (OSD-T-151-00031) that is based on this technical basis

document as the formal means of compliance. This OSD will state what form of monitoring is required for each tank, the monitoring frequencies and the permissible deviation of readings from a baseline value.

5.3 DOE Orders

DOE 5820.2A, Radioactive Waste Management

For doubly contained HLW tanks, Chapter I, Item 3(b)(3) Monitoring, Surveillance, and Leak Detection establishes the requirements below:

(3) Monitoring, Surveillance, and Leak Detection.

- (a) Monitoring and leak detection capability shall be incorporated in the engineering systems (e.g., liquid level sensing devices and alarms for high-level waste liquid systems) to provide rapid identification of failed containment, and measurement of abnormal temperatures. The following, at a minimum, shall be monitored; temperature; pressure; radioactivity in ventilation exhaust; and liquid effluent streams associated with high-level waste facilities. Where the possibility exists for the generation of flammable and explosive mixtures of gases, monitoring shall be conducted. For facilities storing liquid high-level waste, the following should also be monitored: liquid levels; sludge volume; tank chemistry; condensate and cooling water.
- (b) Leak detection systems (e.g., conductivity probes) shall be designed and operated so that they will detect the failure of the primary containment boundary, the occurrence of waste release, or accumulated liquid in the secondary containment system.
- (c) A method for periodically assessing waste storage system integrity (e.g., coupons for corrosion testing, photographic and periscopic inspections, leak detectors, liquid level devices) shall be established, documented, and reported as required in the Waste Management Plan.
- (d) Electrical monitoring and leak detection devices essential to safe operations shall be provided with backup power, as appropriate, to ensure operability under emergency conditions.

- (e) Surface water systems associated with the high-level waste storage area shall be monitored according to applicable National Pollution Discharge Elimination System permits and EM Order requirements.
- (f) A system of ground water or vadose zone monitoring wells meeting the Resource Conservation and Recovery Act requirements per 40 CFR 264 shall be installed, as a minimum, around clusters of liquid waste storage tanks.

In addition, the release detection requirements for singly contained HLW tank systems are specified in Chapter I, Item 3(c)(3), "Monitoring, Surveillance and Leak Detection as follows:

(3) Monitoring, Surveillance, and Leak Detection.

- (a) Monitoring and surveillance capability shall exist to provide liquid volume, waste inventory data, and identification of failed containment.
- (b) A method for periodically assessing waste storage tank integrity (e.g., coupons, photographic inspections, leak detectors, liquid level devices) shall be established and documented.
- (c) Emergency power (see paragraph 3b(3)(d)).
- (d) Monitoring wells (see paragraph 3b(3)(f)).

5.4 WHC Requirements

The following subsections list the applicable WHC documents which have been prepared to implement the foregoing federal and state regulations and requirements.

5.4.1 Current Operational Safety Requirements (OSR)

The currently implemented Operational Safety Requirements (OSR) for tank farms are found in the applicable Safety Analysis Reports. These documents include:

- WHC-SD-WM-SAR-006, Single Shell Tank Isolation Safety Analysis Report
- WHC-SD-WM-SAR-016, Double Shell Tank Farm Facility Safety Analysis Report
- WHC-SD-WM-SAR-032, Safety Analysis Report for Saltwell Waste Receiver Facilities
- WHC-SD-WM-SAR-033, Safety Analysis Report for 241-A-350 Catch Tank
- WHC-SD-WM-SAR-034, Stabilization of Single Shell Tanks by Saltwell Jet Pumping
- WHC-SD-HS-SAR-010, Aging Waste Facility Safety Analysis Report

These documents identify the hazards and possible accidents associated with the transfer and storage of high level waste. The OSRs contain safety limits

for measurable variables or administrative controls outside of which serious consequences can occur, including variables related to leak detection. The OSRs from these documents directly related to leak detection are listed below.

- 1) Drywell monitoring is required per RHO-CD-213 until SSTs are stabilized. - (WHC-SD-SAR-034).
- 2) DSTs require minimum one annulus leak detection device, either annulus CAM or leak detector. - (SD-WM-SAR-016)
- 3) Transfer system leak detectors are required to be operational during transfers. (same as above)

Document RHO-CD-213 has been superseded by WHC-SD-WM-TI-357. Document WHC-SD-WM-TI-357 has been superseded by OSD-T-151-00031.

5.4.2 Interim Operational Safety Requirements (IOSR)

The Interim Operational Safety Requirements (IOSR) for tank farms are found in the applicable Interim Safety Analysis Reports. These documents are intended to replace the current SARs until new SARs are written. These documents include:

- o WHC-SD-WM-OSR-005, Single Shell Tank Interim Safety Analysis Report
- o WHC-SD-WM-OSR-004, Aging Waste Facility Interim Safety Analysis Report
- o WHC-SD-WM-OSR-016, Double Shell Tank Interim Safety Analysis Report

The IOSRs are being systematically implemented per a compliance plan. At the time this technical basis document was written, no IOSRs for leak detection have been formally implemented. When implemented, these IOSRs will have to be complied with. The IOSRs from these documents directly related to leak detection are listed below.

- 1) For SSTs, WHC-SD-WM-OSR-005 Rev 0 gives leak detection requirements in Administrative Control 5.23.2. This states that there shall be a program to detect leaks promptly, and that the program shall include:
 - a. Periodic surveillances on specified frequencies
 - b. Functional testing of leak detection systems
 - c. Procedures for responding to leaks and corrective actions to take if leak detection system is inoperable
 - d. Procedures for maintaining levels below assumed leak locations

In addition, section B 5.23 of WHC-SD-WM-OSR-005 Rev 0 states:

"The preferred method of monitoring tanks with a liquid surface is a direct contact method. For tanks without a liquid surface, the preferred method of monitoring is the Liquid Observation Well. External radiation measurement devices are used as backup to in-tank leak detection systems or when in-tank systems are not available. The Frequency of monitoring shall be specified. Data obtained from monitoring SST leak detection equipment will be compared to established

WHC-SD-WM-TI-573 Rev 1

baseline values. Deviations from the established baseline shall be promptly evaluated and appropriate actions taken."

2) For DSTs and Aging Waste Tanks, WHC-SD-WM-OSR-004 and WHC-SD-WM-OSR-016, state in requirement 3.5.1 that both annulus CAM and annulus conductivity probe systems must be operable, but one is permitted to be out of service for 10 days. If repair isn't completed within 10 days the Action Statement is entered, which requires repair within an additional 82 days.

3) For DSTs and Aging Waste Tanks, requirement 3.5.2 specifies one or two of the leak detection pit devices (liquid level and radiation monitor) must be operable, depending upon whether waste has leaked into an annulus or not.

4) WHC-SD-WM-OSR-005 Rev 0, requirement 3.5.2 states that one DCRT annulus leak detection system shall be operable while retaining waste in the DCRT.

5) Similar transfer line leak detection requirements are given in each of the IOSR documents. These require a leak detection system to be operable during transfers. Transfer line leak detection systems may be inoperable in support of planned work activities: 1) when surveillance is provided once per hour at the locations where leak detection systems are inoperable, or; 2) for process pipeline encasements that drain to pits where leak detection systems are operable. In addition, WHC-SD-WM-OSR-004 also requires the encasement leak detector systems for the AY-101-B and the AZ-101/102 transfer line encasement leak detection pits be operable during applicable transfers, or surveillance be provided at the pits when the leak detector systems are inoperable.

6) Monitoring of SSTs for intrusions is required by LCO 3.1.1 of WHC-SD-WM-OSR-005, Rev 0. This requires a primary waste level monitoring system to be operable on SSTs and that increases in the waste level be monitored.

Some of the IOSR requirements are slightly different than those in the current OSRs. The primary differences are the requirements for; 1) both DST annulus leak detection systems to be operable; 2) at least one of the DST leak detection pit devices to be operable; 3) a DCRT annulus leak detection system to be operable when waste is in the tank; and 4) monitoring SSTs for intrusions.

While these requirements are usually met at the present time, compliance is not met consistently, and prior to implementation of the IOSRs maintenance priorities will have to be improved to the point where inoperable leak detection equipment can be repaired on a priority basis.

There are no OSR or IOSR requirements for leak detection from catch tanks. Catch tanks are classified as auxiliary or low hazard facilities per WHC-SD-WM-ISB-001 Rev-0A. There are no OSR level requirements for leak detection from these tanks.

5.4.3 Operating Specification Documents

The OSDs are a lower tier document than the OSRs/IOSRs and contain limits and controls imposed upon a process or operation which, if violated, could jeopardize the safety of personnel; could damage equipment, facilities, or the environment; or adversely affect product quality. The current OSD leak detection requirements, excluding those which are a restating of OSR leak detection requirements are:

- 1) Pressure testing is required for direct buried and cross site transfer lines. - (OSD-T-151-00010) ..
- 2) Drywells for SSTs shall be monitored on a periodic basis set by WHC-SD-WM-TI-357. - (OSD-T-151-00013). Drywell frequencies set in document WHC-SD-WM-TI-357 will be superseded by frequencies set in procedure TO-040-331 Revision E-1, Perform Dry Well Surveillance/Operate Acoustic Van, when the latter is issued.

5.4.4 Supporting Documents

WHC-SD-WM-TI-357, Tank Farm Leak Detection Criteria, contains specific leak detection surveillance requirements for waste tank facilities. Document WHC-SD-WM-TI-357 has been superseded by OSD-T-151-00031.

WHC-CM-7-5, Environmental Compliance, establishes the general environmental compliance requirements and guidelines for WHC in conjunction with applicable U.S. DOE Orders and federal, state, and local laws and regulations. Requirements applicable to waste storage tanks and transfer lines are located throughout this document, but the primary ones applicable to tank farms are provided in sections 3.9, 7.10 and 7.12.

5.4.5 Investigation and Reporting Requirements

Leak detection involves setting specification limits for various level reading variations, monitoring frequencies or specific response actions; obtaining data or taking required actions to ensure operation is maintained within the specification limits; and identifying and responding to deviations from these limits accordingly. Section 5.6.1 of WHC-IP-0842 lists the actions to take for occurrence reporting when specification limits are exceeded. Normally, exceeding an OSD specification limit requires an Off Normal occurrence report.

Alert limits are internal limits set by Surveillance Engineering personnel which can serve as a flag to instigate an investigation before a specification limit is reached. When an alert limit is reached, or when a significant trend in data is noticed that doesn't exceed a specification limit, the tank is placed on the monthly Alert List and a Discrepancy Report is normally issued.

Section 7.14 of WHC-IP-0842 provides the guidelines for waste tank anomaly analysis and reporting. If a Discrepancy Report is required, one is prepared and issued per section 12.1 of WHC-IP-0842. See section 9.0 of this technical bases document on the implementation of leak detection specification limits by OSD.

6.0 EQUIPMENT

This section provides a description of the types of equipment used for leak detection monitoring within tank farms and the basis for specification limits associated with the equipment.

6.1 Single Shell Tanks

6.1.1 Internal Tank Level Measurement

Internal tank level measurements refer to leak detection monitoring methods which are based on sensing a change in a tank's liquid level. These methods include both direct measurement of the surface, and indirect sensing of the level from inside a sealed Liquid Observation Well (LOW) which has been inserted below the waste surface.

Surface level measurements in SSTs are normally taken with a manual tape gauge, an automatic gauge (FIC or ENRAF) or with a portable "zip cord". The FIC gauges are named after the original manufacturer, Food Instrument Corporation. Manual tapes and zip cords are sized for a particular tank, while all FIC and ENRAF gauges have the reference height for that tank set electronically after installation. About half the tanks have manual tapes and half have FICs (see Table 4.1-1). At the time this document was written, Waste Tank Operations is in the process of changing from the FIC gauge to the newer ENRAF model. As of the end of September, 1994, 17 of these gauges have been installed. The zip cord is a portable gauge which may be installed through any opening in the tank to provide a temporary reading when other level measurement equipment is out of service or an alternate measurement is desired.

Liquid Observation Wells (LOWs) are in-tank drywells into which a neutron or gamma probe is lowered to detect the liquid level. These are closed-bottom steel, fiberglass or TEFZEL¹ (fiberglass-reinforced plastic) tubes, 3.0 inches ID, which are inserted through a riser down to near the tank bottom and left there to form permanent dry observation wells in the waste. Either surface or interstitial liquid level (ILL) may be measured from within an LOW. The liquid level is measured from inside the LOW either with a neutron source and detector or a gamma probe.

6.1.1.1 Manual Tape

Description The manual tape consists of a reel-mounted calibrated steel tape to which a 2-7/8 in. diameter ring (doughnut) or 3/8 in. diameter rod (pencil) is attached. These plummets are electrically conductive. The steel tape is cut to a specific length for each tank and mounted so that a "zero" reading normally represents an empty tank. Setting this tape length takes considerable care as it entails consideration of the bottom of the tank and the riser elevations as

1

* TEFZEL is a trademark of du Pont de Nemours.

determined from drawings or elevation surveys, the thickness of any gaskets or spool pieces, and an internal dimension length for the tape housing.

The tape, plummet, waste, tank wall and a portable conductivity meter make a simple resistance circuit. Contact with a liquid or moist surface as the plummet is lowered completes the circuit, which is indicated by a full scale needle deflection on the meter. The tape then reads directly the depth of the waste in the tank, i.e., surface level. The tape reading is manually recorded on a data sheet.

For tanks with a non conductive solid surface, a "slack tape" measurement can be taken. This is done by lowering the plummet until the operator sees the tape is just going slack. The plummet is then raised until the tape appears to just go taut. This may be repeated several times.

The most widely used manual tape gauge is the Flake gauge shown schematically in Figure 6.1-1. This "Flake" style reel housing represents about a third generation Hanford design, and is the most common type of manual tape. A reading is obtained by sighting through a scribed Plexiglas window at the tape reel housing. An earlier and now seldom used gauge utilized a sighting crossbar for the tape readings. The Flake gauge is mechanically and electrically stable for extended periods. The pencil type plummets are used predominantly for measuring liquid surfaces. The doughnut plummet is frequently used for measuring sludge or moist salt cake surfaces.

The plummets are occasionally prone to salt buildup which can make the level in a tank appear higher than actual. Salt buildup is noted by observing the data trend, or by in-tank photography. The salt is removed by flushing with water or other chemicals.

Accuracy/Precision The Manual Tapes have markings down to 1/16th of an inch, but realistically are capable of length measurements readings only to the nearest 1/4 in. ($\pm 1/8$ in.) because of parallax errors when taking readings. A value of $\pm 1/4$ in. for manual tape readings was initially used years ago as an action limit for investigation of possible leakage, but the range of readings obtained was greater than this and a number of inaccurate or "false alarm" readings occurred. After reviewing the spread in the measurement data representing all individuals, tanks, and conditions and considering the effects of known variables on the gauge readings, a measurement precision of $\pm 1/2$ in. was empirically established for the manual tape when used on a liquid surface. The specification limit for a manual tape reading from a tank with a liquid surface was then set by consensus at twice the precision or ± 1.0 in. Thus, the $\pm 1/2$ in. value was used as an internal action limit point at which people were alerted to a potential problem, and ± 1.0 in. became the limit at which a formal response or investigation was required.

For SSTs with floating solids, the variation in manual tape readings increased significantly over tanks with liquid surface. Using in-tank photography in conjunction with liquid level data showed a measurement spread of ± 1 in. for the manual tape. This became the established precision for manual tape readings from tanks with floating solids, and the specification limit was set at twice this value, or ± 2.0 in.

Manual tape readings from SSTs with a solid conductive (moist) surface suspended in the liquid, or which varied with liquid level, showed a greater data scatter than from SSTs with floating solids. The precision was empirically determined to be about 50% less for manual tape measurements from these surfaces, so the specification limit for manual tape readings from SSTs with a solid, conductive surface was set at ± 3.0 in.

If the solid surface doesn't float with liquid level, surface level measurements are ineffective for leak detection even if the surface is wet from capillary action from the liquid below and gives a level indication from the manual tape. When this point is reached, surface readings are suitable largely for intrusion detection. When a surface dries out it becomes non-conductive, and only "slack tape" readings can be obtained. The variation in "slack tape" measurements on a non-conductive surface will be greater than for conductivity readings from a moist surface due to the more subjective nature of the reading. These readings are for information only, and not used for leak detection.

A manual tape will have a small variance in length with temperature. A 30 ft length of tape will expand about 1/32 in. for every 10°F rise. A 40°F yearly variation in the vapor space temperature in a ventilated tank could thus cause the apparent surface level to cycle about 1/8 in. The actual level change in a tank due to seasonal temperature variations will be negligible as the liquid temperature will normally change little during the year. Tanks with moderate to high heat loads which are under active ventilation could show a temperature change, and thus a small liquid level change, if the exhauster was shut down for a long period of time. It would take a 40°F rise in liquid temperature to cause about a 1% change in the volume of liquid in the tank, excluding other changes which could also occur such as redissolution of salt cake with the temperature rise.

6.1.1.2 Automatic Gauges (FIC)

Description The FIC type automatic gauge also uses an electrically conductive plummet suspended on a calibrated steel tape. A control system automatically adjusts the plummet position to make contact at the air/waste interface every 60-90 seconds. A baseline calibration setpoint is set for the unit after installation. The tape does not have to be cut to a special length for the FIC gauge as it does for a manual tape. Readings are automatically sent to the Computer Automated Surveillance System (CASS), or they can be obtained manually in the field. Instead of directly reading a tape length, the tape passes over a wheel which is attached to a counter which displays "inches above the tank instrument bottom". The automatic gauge is shown schematically in Figure 6.1-2.

The gauge was manufactured and sold by Food Instrument Corporation when the first gauges were purchased in 1971-72. (These gauges are no longer in production, but the Robertshaw Co. bought the rights to the gauge and currently manufactures and markets a different version of it. As of the time this document was written, all the automatic gauges in service on SSTs are the FIC model. There are no plans to install Robertshaw type gauges on SSTs.) As modified by Westinghouse Hanford Company, the FIC gauge can obtain precise liquid level measurements at preset intervals while unattended and can be operated in a manual reading mode without loss in precision. The modified FIC

gauge is mechanically and electrically stable for extended periods but, like the manual tape, is occasionally prone to salt buildup on the plummet.

The Robertshaw Model 175 (currently used only on the S-304 catch tank) will make a "conductive" measurement at 300 ohms, or less, while the FIC gauge requires 200 ohms, or less, resistance to make a reading (Peters 1993).

Surface measurements from FICs in tanks with a non-conductive surface provide little useful leak detection information, but the instruments are still valuable in detecting intrusions. Under these conditions, the plummet is usually set in the intrusion mode as close to the surface of the waste as practical. A nominal value of 1 inch above the waste surface has been empirically established for setting FICs in the intrusion mode. When in the intrusion mode, the instrument will input a constant value to the CASS system equal to the level the plummet is set at. An alarm is generated when liquid rises and makes contact with the plummet.

Accuracy/Precision The counter reads to the nearest 0.05 in. in the field, while the CASS reading lists the surface level to the nearest 0.10 in. Vendor information shows that under "normal conditions" this gauge is capable of measuring distances to 100 feet with a total unit accuracy of ± 0.03 in. and a repeatability of 0.01 in..

This value of ± 0.03 in. was initially used years ago as an action limit for investigation of possible leakage, but the number of readings outside the expected range was so large that it became obvious that the permitted range would have to be increased. After reviewing the spread in the measurement data representing all individuals, tanks, and conditions and considering the effects of known variables on the gauge readings, a measurement precision of $\pm 1/4$ in. was empirically established for the FIC when used on a liquid surface. The specification limit for FIC readings from tanks with a liquid surface was then set at twice this value, or ± 0.5 in.

For SSTs with floating solids, the variation in FIC readings from a tank increased when compared to readings from a tank with an entirely liquid surface. Using in-tank photography along with liquid level data showed a measurement spread of about $\pm 1/2$ in. This became the established precision for an FIC when used on a tank with floating solids. The specification limit for FIC readings from tanks with floating solids was then set at twice this value, or ± 1.0 in.

FIC readings from tanks with a solid conductive surface which varied with liquid level showed a greater data scatter than from tanks with floating solids. The precision appeared to be about the same as for manual tape readings from similar tanks, so the specification limit for FIC readings from tanks with a solid, conductive surface was set at ± 3.0 in., the same as for manual tapes.

Like for manual tapes, the variation in "slack tape" measurements from an FIC on a non-conductive surface will be greater than conductive readings from a moist surface due to the more subjective nature of the reading. These readings are for information only, and not used for leak detection.

Temperature effects on FIC gauges will be similar to those for manual tapes.

6.1.1.3 Automatic Gauges (ENRAF)

Description By June 1994, displacer (weighted wire) gauges (an Enraf-Nonius 854 Advanced Technology Gauge (ATG)) were installed in two SSTs (TK 241-S-103 and S-107) as part of a planned upgrade project for the level detection equipment in tank farms.

The ATG displacer gauge uses a weight (displacer) suspended on a 0.007 in. diameter stainless steel wire. The device detects the change in the apparent weight of the displacer by buoyancy or by contact with a solid. A stepper motor that pays out the wire provides the depth measurement. Normally, the displacer stays partly submerged or in contact with the surface and apparently can compensate for crystal growth on the weight. The buoyancy of the float used is slightly dependent upon the density of the waste and will sink a fraction of an inch deeper into water than it will into a waste with a SpG of 1.4. This can be compensated for in the electronics for the gauge. Pacific Northwest Laboratory recently conducted studies which compared this and other devices to those currently in use at Hanford (Peters 1993). Figure 6.1-3 shows an ENRAF gauge and displacer float.

Accuracy/Precision The accuracy of the ATG is reported as ± 0.01 in. and the precision as ± 0.01 in. Any specification limits applicable to this gauge will be developed after a suitable testing period. Until limits are developed, the specification limits for FIC gauges will be used for the ENRAF gauge, as the latter appear to be at least as accurate as the former.

6.1.1.4 Zip Cords

Description Zip cords are normally used for taking temporary level readings.

This is normally required when other level measurement equipment is out of service, or there is a question concerning the normal reading. Usually the zip cord will be installed in a different opening than the existing level measurement equipment. A zip cord consists of a length of insulated wire with an electrically conductive probe on the end. The cord is prepared by measuring it against a tape measure and putting marks or small strips of tape around the cord at incremental distances along its length. Because of this, the readings may not be as exact as those from manual tapes or FICs where a calibrated tape is in place. A photograph of a typical zip cord is shown in Figure 6.1-4.

The zip cord is taken to the tank to be measured and lowered through an opening into the tank. The open lead from the probe wire is connected to a DC meter and the other lead from the meter is connected to a conductive part of the tank. The principle is the same as used for a manual tape. The wire, probe, conductive waste, tank wall and meter complete a circuit when the probe contacts the waste. The point on the cord corresponding to a selected tank reference elevation (normally the edge of the riser flange or drain hole used for the zip cord) when the meter needle deflects "full scale" is noted. The length from this point on the cord to the nearest incremental distance mark is measured to obtain the depth to the waste at that location. The difference between the selected tank reference elevation used for the zip cord and the reference elevation used for the installed tank level measurement equipment is added or subtracted to the zip cord reading as applicable to obtain a waste level reading for comparison with routine readings.

Accuracy/Precision Zip cords are normally used for temporary measurements. The accuracy is expected to be less than for a manual tape due to the potential for the cord used to stretch when lowered into a tank, errors with marking distances on the zip cords, the more subjective means of measuring an exact location on the cord against a reference elevation on the tank, and the need to add or subtract the difference in height between the zip cord reference and the manual tape or FIC reference elevation.

Due to the possible errors caused by these variables, no systematic accuracy or precision will be stated in this document for zip cord readings. Ignoring all the potential errors caused by these limitations, a zip cord would be expected to have accuracy comparable to a manual tape. The specification limits for zip cord readings will therefore conservatively be kept the same as for manual tape readings.

6.1.1.5 Visual Inspection

Description Visual inspection refers to in-tank photography and video inspection. In-tank photography has been used for many years for inspection of the waste tanks, but only recently has video inspection been used to any extent. The greater clarity, permanence, flexibility of use, and greater ability to scale distances from reference points makes photography a preferred method for most tank inspections. Video imaging is usually faster, provides the ability to observe the tank contents during inspection and focus in immediately on items of interest, and is used for some general inspections.

In-tank photos of waste tanks are taken by lowering a camera and flash unit down a riser and taking repetitive photos. The camera angle is adjusted between shots so 360° of the tank surface and vertical walls (or as much as practical or desired) is covered. The individual pictures are cut out and arranged with distinctive features in each photo lined up next to each other to give a composite picture with minimum distortion errors. This is necessary since the different viewing angle and the depth of the field in each picture causes parrallax differences between pictures.

Photos are used largely to determine general surface conditions in a tank, to help troubleshoot problems with erratic level readings, to spot intrusions, or to provide backup information when investigating possible tank leaks.

Video imaging is done by inserting a small camera unit, complete with lighting and rotational capability down an open riser. The video image is displayed on a local screen, and can also be recorded on tape for subsequent viewing.

Accuracy/Precision There is no formal accuracy applied to photos or video images for detecting surface level changes. The ability to determine a surface level change from a photo or video image is based on the judgement of the viewer and the presence of reference points in the picture. Reference points may be an item of equipment with known dimensions (such as a pump or tape plummet) extending down from a riser or a mark on the tank wall where the liquid level was at for an extended period of time. Thus, the ability to accurately determine liquid level changes from photos or video images could range from less than an inch to six inches or more.

In-tank photos and television scanning are used for information only. There are no precision-based specification limits for their use at this time.

6.1.1.6 Dip Tubes

Description Dip tube weight factor/SpG measurement systems have been used at Hanford since the 1940's. They are reliable and accurate under normal conditions, but are not used as routine measurement systems in tank farms because the high SpG's in most of the waste tanks would result in frequent pluggage of the sensing tubes. Dip tubes measurement systems are included in this section only because they are used in limited cases (such as for C-102) where surface level measurement can't be used, LOWs aren't available, and dip tube systems have been installed for saltwell jet pumping. Dip tubes are used as part of a control loop for tanks being saltwell jet pumped, and when in place and working they can provide liquid level measurement for the tank. Most of the dip tube systems used for saltwell pumping have slowly flowing water drips added to the dip tubes to reduce the possibility of pluggage.

Figure 6.1-5 shows a typical dip tube arrangement. Three dip tubes extend into the tank. One goes almost to the bottom of the tank, one is located a set distance above it (normally 10 inches) and the third is at the top of the vapor space. Instrument air, at a very low flow rate, is fed into the three dip tubes. The differential pressure is sensed between the bottom and the top tube to give a weight factor indication for the tank. The transmitter is normally calibrated to sense the input DP in inches of water. The DP across the lower two tubes is used to sense the SpG of the solution. The weight factor can be divided by the SpG to give the correct liquid level in the tank.

Accuracy/Precision The normal means of determining accuracy for a system such as shown in Figure 6.1-5 is to calculate a sum-of-the-squares for the errors in the equipment. These errors include the input and output errors for the transmitters and recorders, plus other system errors such as variations in the instrument air pressures, temperature effects, or reading errors. Errors can also result from leaks or plugs in the dip tubes. Conservatively ignoring all effects except the output errors for the transmitters and recorders the weight factor loop error calculates to be:

$$\text{weight factor loop error} = +_{-} \sqrt{Te^2 + Re^2}$$

6-1

where: Te = transmitter error
Re = recorder/indicator error

A similar calculation can be done for the SpG loop. For the weight factor transmitter and recorder for C-102, the vendor information gives $\pm 0.2\%$ of the span for the transmitter output accuracy, and $\pm 0.5\%$ of the span for the recorder output accuracy. The transmitter range is 0-500 inches H₂O. This calculates to a weight factor loop error of $\pm 0.54\%$, or ± 2.7 inches. In a similar fashion the SpG loop error could also be calculated. However, it is recommended that SpG loop error not be included in this instance, since the object of interest for leak detection is not the absolute value of the liquid level in the tank, but changes in that value. Including errors for the SpG will increase the overall liquid level error associated with dip tube measurements substantially, and could thereby make the calculated specification limit excessively large.

To be more precise, the accuracy associated with the calibration test equipment could be included in calculating a loop accuracy. Including these values ($\pm 0.05\%$ of scale for the transmitter test equipment and $\pm 0.02\%$ of scale for the recorder test equipment) results in only a 1% difference in the calculated loop error, and so can be ignored for the purposes of leak detection.

Individual weight factor error specification limits could be calculated for each set of dip tube systems used for saltwell level detection. This is not necessary for the purpose of determining specification limits to use when using the dip tube readings for leak detection. The equipment is similar between saltwell systems, transmitter ranges should be similar, and the use of dip tubes for leak detection on SSTs is expected to be seldom enough that listing separate specification limits for each dip tube system would be both confusing and provide no additional benefit. The ± 2.7 in. error calculated for C-102 can be applied to all saltwell dip tube systems used for for leak detection.

6.1.1.7 Neutron Probe

Description Neutron probes are used for sensing a tank liquid level through the wall of an LOW. The basic components of this assembly are a fast neutron source and a slow (or, thermal) neutron detector. The source/detector (neutron probe) is attached to a cable and wired into electronics located in a portable van. A schematic of this probe is included in Figure 6.1-6.

When the fast neutron source is lowered into the well, hydrogen in the water molecules around the well will predictably produce a slow neutron flux density when activated. Some of these slow neutrons are picked up by the neutron detector. Since water is much more prevalent in the liquid phase than the solids, the measured neutron flux will indicate the relative moisture content of the waste surrounding the well. Thus, the neutron count rate is used to estimate the distribution of liquid within the tank. The count rate is a relative value only, and is not used to measure an actual liquid concentration.

Prior to taking a scan, the neutron probe is lowered down a 100 foot deep reference hole to set a depth calibration for the equipment. This calibration is used to eliminate positional measurement errors by ensuring data are taken at the position indicated. When ready to take a reading, the probe is lowered to the bottom of the LOW and withdrawn at a controlled rate to obtain a thermal neutron scan from the bottom to the top of the tank. The data are summed over each 0.1 ft interval and the subsequent count value is given as the count value for the midpoint of that interval. A timer times the interval traverse to 0.01 seconds and the counts are normalized to a counts/sec/interval. The vertical distance into the well is read from a shaft encoder on the cable reel which has a maximum resolution of 0.6 in. The sampling interval is 0.1 ft and the scan speed is 0.1 ft/sec. The result is a plot of count rate vs. distance from the tank bottom. This profile is then converted to liquid level indication.

The actual liquid level in a tank is calculated from each neutron scan. Until the fall of 1993, levels were calculated manually from plots such as those in Figure 6.1-7. The schematics in Figure 6.1-7 are representative of the neutron probe traces obtained from tanks a) with no pumping, b) with some jet pumping, and c) completely jet pumped (Stong 1986). Starting and ending points were selected corresponding to when the neutron flux began to increase and when it began to level off. A straight line was drawn between the two points, and the point where this straight line crossed the neutron scan line was selected as the ILL. This process required a fair amount of manual interpretation, and combined with repeatability errors inherent with some of the equipment and data interpretation, there was in a larger than desired scatter in the measured ILL, and a subsequent difficulty in judging whether some tanks were leaking or not.

A reassessment was done of the method of interpreting LOW scans in mid 1993. These scans are now normally read by computer, and the ILL determined by mathematically calculating the inflection point for the flux curve. One of three computer methods (derivative, count rate, or sigmoid) is selected to calculate the ILL for each tank from which LOW data are obtained. All the available LOW neutron probe data since 1986 was evaluated for each tank and the ILL calculated by all three methods. The results were plotted for each tank and the method which resulted in the lowest standard deviation in calculated ILLs was selected for evaluation of future LOW data from that tank. The computer program also reduces a potential source of previous error by comparing the calculated position of the tank top from the LOW scan to a reference value for that tank and applies the difference as a depth correction to the calculated ILL value. A probe offset

correction factor which relates the position of the neutron probe to the position of the neutron detector is also applied to all calculated ILL values.

A more detailed description of the various methods of calculating ILLs from LOW data, and the error corrections involved is given elsewhere (Johnson, 1994).

Accuracy/Precision A neutron probe system precision of ± 2.4 in. around an established baseline was arrived at under the previous means of calculating ILLs by adding system errors (± 1.2 in.) and interpretation errors (± 1.2 in.).

The system error was estimated from inherent errors with the mechanical and electronic equipment, with the limiting factor being the ± 0.6 in. resolution of the shaft encoder which estimates the distance travelled by the probe cable. The interpretation error was approximated from five individuals interpreting the same 14-scan sets of randomly selected scans (Walker 1982). The specification limit was empirically set at 1.5 times the obtainable precision, or ± 3.6 inches.

No accuracy has been set for the new method of calculating ILLs. The more consistent means of analyzing data, applying correction factors, and calculating the ILL should give more accurate results, and especially more consistent results with less deviation between readings. The primary interest for leak detection is consistency and less deviation between readings. This gives a smaller standard deviation and thus permits a smaller specification limit, which can mean earlier spotting of tank leaks. Unofficial estimates are that the revised means of ILL calculation may be consistent to within ± 1.0 in., but this hasn't been formally demonstrated yet. Almost all LOW data is evaluated on a statistical basis now, and thus specification limits for ILLs are based upon calculated standard deviations for each specific tank as described in section 8.1.1, rather than a fixed value for all ILLs as before.

6.1.1.8 Gamma Probe

Description This probe is a lead shielded, highly collimated Geiger-Muller (GM) detector. A schematic of this probe is also shown in Figure 6.1-6. The probe is operated similar to the neutron probe. The GM tube is lowered to the bottom of the LOW and a gross gamma count rate vs. depth obtained as the probe is withdrawn.

The major gamma emitting radionuclide in the single shell tank liquid phase is Cs^{137} . Cesium is very soluble in the aqueous phase, so a plot of gamma count rate vs. depth can indicate the distribution of liquid in a tank similar to a neutron probe. However, because of the greater penetration of gamma rays when compared to slow neutrons, their presence throughout the waste instead of being induced like the slow neutrons, and the somewhat less exact nature of the gross gamma method, the ILL usually appears less exact on gamma scans from LOWs than neutron probe scans. This normally makes gamma scans from LOWs less accurate than neutron probes in determining an ILL. Gamma scans are thus normally used for information purposes only or to help backup LOW neutron readings. Typical gamma probe scans are shown in Figure 6.1-8. The schematics in Figure 6.1-8 are representative of the gamma probe traces obtained from tanks a) with no pumping, b) with some jet pumping, and c) completely jet pumped (Stong 1986).

In a very few instances, a gamma scan will give a sharper percentage count rate change, or a better defined count rate change than a neutron scan from an LOW. The exact reason for this is unknown, but various theories have been postulated. When gamma scans appear to provide a better defined interface, gamma scans may be used instead of neutron scans for ILL determination. At the time this document was written, ILLs are calculated from neutron probe data for all 56 operable LOWs. However, there are about 4-5 tanks where the gamma scans may eventually be used.

Accuracy/Precision . The gamma probe is normally used to provide supporting information for the routine neutron probe scans. The count rate is used to estimate soluble radionuclide (and thus liquid) distribution within the tank. The equipment accuracy is not a primary concern for this purpose. The count rate is not used to estimate actual radionuclide or liquid concentrations. Any specification limits for ILLs calculated from gamma scan data will be based upon calculated standard deviations for each specific tank as described in section 8.1.1.2, rather than a fixed value.

6.1.2 External Tank Leak Detection

When in-tank measurement leak detection methods can not be used, it is possible, within the limitations discussed in section 4.1, to provide some degree of leak survey capability by using sensors to look for an increased presence of radionuclides or moisture in the soil around a tank. These sensors are deployed from vertical shafts (drywells) arranged around the tank circumference or horizontal shafts (laterals) located under some tanks. Leak detection pits are also present for the four SSTs in AX farm.

The drywells and laterals are used to observe changes (with time) in the radiation level and the moisture content of the soil around the tanks, which can aid in detecting leakage. Their effectiveness depends (among other things) on the proximity of the drywell to the leak, the proximity of other leaking tanks to the drywell, the liquid migration behavior in the soil, radionuclide absorption in the soil, the magnitude of the measured characteristic (i.e.-the concentration of the radionuclide in the leaked waste solution and the energy level of it's gamma emission), the sensitivity of the sensing device, the total measurement precision, and the monitoring frequency.

Because of these limitations, drywells and laterals will not be used as primary means of leak detection monitoring for a tank. Data from them will be used to provide information during tank investigations, and they can be used to provide backup leak survey data when the primary leak detection equipment on a tank is inoperable or not yet installed.

Drywells are also used for monitoring the migration of radionuclides which have entered the vadose zone from a waste tank, crib, or other facility. The requirements for vadose zone monitoring are considerably different than for providing backup leak surveys or investigating potential tank leakage. The discussion in this document is limited to monitoring of drywells for leak surveys or leak investigation support only.

6.1.2.1 Drywells

Drywells are vertical boreholes with 6 or 8-inch diameter carbon steel casings and are positioned radially around SSTs. A small number are located at more remote peripheral locations. They are called drywells because they do not

penetrate to the water table. A typical drywell installation is shown in Figure 6.1-9. These wells range between 50 and 250 feet deep, and are monitored between 50 and 150 feet.

Periodic monitoring is done with gamma or neutron probes to obtain scan profiles of radiation or moisture in the soil. These are compared to past scans to reveal any new presence of tank leakage. Probes are lowered to the bottom of the drywell and withdrawn at a constant rate while the probe sends a signal to a portable van containing the electronics and cable retrieval system. The van-mounted equipment integrates the sensor response for each reference interval (about 12 inches) to form a series of data points which is then automatically plotted to form the profile scan.

The ability of a drywell to spot leaks from SSTs is dependent upon a wide variety of variables. These include the distance of the drywell from the leak, the level of radioactivity in the solution, the size of the leak, soil characteristics, the monitoring frequency for the drywell, the radioactivity background (or moisture level) around the drywell, and the sensitivity of the detector for the radionuclide(s) (or moisture changes) being measured. Since most of these factors affect the selected monitoring frequency, their impact is discussed in section 7.1. The discussion below is limited to a physical description of the monitoring equipment and its accuracy.

Four sensor types are used; three to monitor gamma radiation and one to monitor soil moisture. The choice of gamma probe to use depends upon the radiation levels encountered. A natural background radiation level of about 7 $\mu\text{R/h}$ exists in the drywells.

6.1.2.1.1 Gross Count Scintillation "#4 or S Probe"

Description This gamma detector is the primary probe used in drywells. Because of its sensitivity, this probe is normally used only in drywells which have previously not shown the elevated radiation levels which would be evident from a nearby tank leak. A schematic of this probe is shown in Figure 6.1-9.

This probe will detect about 5 $\mu\text{R/h}$ above background for a single observation (data point). The electronics are designed to give a count response independent of the gamma energy encountered by the sensor, thus improving the signal to background ratio in the lower energy spectrum. The gamma scan data is sent to a computer where the total counts in each reference interval is calculated.

The range of this detector is approximately four decades (5 $\mu\text{R/h}$ to 100 mR/hr) above background.

Accuracy/Precision The background reading is about 33 c/s with this probe and the detection limit used is 20 c/s above background. The measurement precision is ± 10 c/s. These values are all empirical. This detector is employed for detecting radiation levels for subsequent comparison to past scans. There is no intent to measure actual soil radionuclide concentrations.

The specification limit which was developed in the past when drywell scans were used as a primary means of leak detection is that the radiation level must double and exceed 200 c/s. The basis for the specification limit being

above the detection capability was to allow time for a preliminary investigation at the lower levels of activity. In the case of a doubling of level without reaching 200 c/s, then all pertinent surveillance information was reviewed to determine the need for an increased monitoring frequency. The 200 c/s value was based on the assumption that Ru^{106} would be the active radionuclide in a leak plume front (Isaacson and Gasper 1981). Negligible Ru^{106} is present in SST waste now. The major radionuclide from a soil leak survey standpoint is Cs^{137} . This is based upon its high concentration in the waste tanks in comparison to most other radionuclides, its greater solubility in tank waste and the relatively high energy level of the gamma emission from its daughter, $\text{Ba}^{137\text{m}}$. Unlike Ru^{106} , Cs^{137} is adsorbed fairly well by Hanford soils, so the concentration in the leading plume of waste leaking from a tank will likely reduce with distance from the tank.

The 200 c/s value could be reevaluated and a lower number arrived at based on Cs^{137} instead of Ru^{106} , but this is unwarranted, and could lead to a false sense of security for a presumed accuracy level for the drywell scans. Drywell scans with this probe, when used for leak survey support will be performed for information purposes, to look for trends or gross changes. New specific alert or action limits are not required, as a decision on tank integrity will likely not be made based solely on drywell scan data, unless the count rates are far above the specification limit, which has shown to be the case with most past tank leaks which have been detected by drywell scans. Whether the specification limit is set at 200 c/s, or lower, will not make a major difference with the role drywells will be playing for leak detection in the future.

6.1.2.1.2 Probe Type 1: High Sensitivity Geiger-Muller-"Green GM"

Description This probe is used primarily for monitoring for activity change in drywells when the background gamma activity exceeds the normal operating range of the "S" Probe. A schematic of this probe is included in Figure 6.1-9. This probe's sensor utilizes three large GM detectors operating in parallel and it has a functional range of about 5 decades ($\sim 40 \mu\text{R/h}$ to 1 R/h) above background.

Accuracy/Precision The background reading is about 20 to 40 c/s with this probe and the detection limit for this probe is 10 c/s above background. The measurement precision is ± 5 c/s. These values are empirical. As for the "S" probe, this detector is employed for detecting radiation levels for subsequent comparison to past scans. There is no intent to measure actual soil radionuclide concentrations.

The specification limit developed in the past for this probe was that the radiation level must triple for normal background and must double for backgrounds greater than 1,000 c/s. The bases for this limit were similar to those stated above for the "S" Probe. Drywell scans with this probe, when used for leak survey support will be performed for information purposes, to look for trends or gross changes. Revised specification limits are not warranted, for the same reasons stated above for the S Probe.

6.1.2.1.3 Probe Type 2: High Level Geiger-Muller-"Red GM"

Description This probe assembly is not used for leak detection, but rather for leak plume monitoring. A schematic of this probe is included in Figure 6.1-9.

The sensor is a small highly shielded GM detector with a response level tailored to high radiation levels. It provides a response of approximately 7 c/s at 10 mR/hr and has a functional range from ~15 mR/h to 300 R/hr.

Accuracy/Precision This gamma probe is used to provide plume monitoring for past SST leaks. It's accuracy and precision is not a subject for this document.

6.1.2.1.4 Probe Type 3: Soil Moisture Monitor - Neutron

Description This detector is designed to measure the moisture content of the soil surrounding the Drywell. It is similar in operation to the neutron probe used for LOW monitoring. It utilizes a fast neutron source and counts the lower energy thermal neutrons generated by the presence of hydrogen from the moisture in the soil.

The probe's sensor is a Boron-Triflouride (BF_3) tube with an active length of 8.1 in. that can be used with or without a lead shield. This detector can operate in any gamma field encountered in drywells.

Accuracy/Precision Calibration of the detector is only approximate due to limitations with the present facilities, but the performance is more than adequate for the application. The major requirement is to detect changes in the soil moisture content which may be caused by leakage from a tank. The absolute value of the water concentration is not measured. The application is suitable in any soils with above a few percent moisture. The calibration curve for the probe is non-linear and is most accurate in the range of 0 to 45% moisture by volume.

6.1.2.2 Leak Detection Laterals

The laterals are 4-in diameter steel pipes located horizontally 8 to 10 ft below a tank's concrete base and into which 3-in. diameter tubing is inserted. The tubes rise to instrument enclosures through vertical caissons adjacent to the tank. The first tank equipped with laterals, SX-113, has five 6-in diameter pipes. These have all been capped off, the 3 in tubes removed and the tank no longer monitored by the horizontal laterals system. All other tanks with laterals (all 6 tanks in 241-A farm, SX-105, SX-107 to SX-112, SX-114 and SX-115) have three 4-in pipes per tank. The horizontal portions extend in a fan-like manner beneath the tank (from the same caisson) and reach beyond the far side perimeter. A typical tank lateral system is shown in Figure 6.1-10.

A Geiger-Muller radiation detector is forced pneumatically from the caisson to the end of the tube, and then retracted by a cable drive mechanism. A radiation profile scan is obtained during the withdrawal. The instrument readout system records total gamma response for each 1.05 ft of travel. Data are presented in the form of an x-y chart profile and/or are stored electronically.

The natural background level in the laterals is about 7 uR/h. Two types of GM probes are used.

6.1.2.2.1 Geiger-Muller Green Probe - Type 1.

Description This is a standard GM detector similar to the "Green GM" used for drywell monitoring, with a functional range of $\sim 40\mu\text{R/h}$ to 1 R/h . Leather ring flaps are attached to the outside of the tube to provide a seal for when the tube is pneumatically blown to the end of the lateral tube. A schematic of this probe is shown in Figure 6.1-10.

Accuracy/Precision At background, the detection limit is 10 c/s and the measurement precision is $\pm 5\text{ c/s}$. These values are empirical. As for the drywell probes, this detector is employed for detecting radiation levels for subsequent comparison to past scans. There is no intent to measure actual soil radionuclide concentrations.

The specification limit developed for this probe in the past was that at normal backgrounds of less than 12 c/s, the radiation must increase by 10 c/s and exceed 12 c/s. For a higher background, the limit was a 50% increase in radiation count rate. These limits were empirically derived to provide a workable limit that could detect when a significant change had occurred and yet still provide time for an early leak investigation. Lateral scans with this probe, when used for leak detection support will be performed for information purposes, to look for trends or gross changes. New specific alert or action limits are not required, as a decision on tank integrity will likely not be made based solely on lateral scan data. The existing limits will still be used as guidelines for interpretation purposes only.

6.1.2.2.2 Geiger-Muller Green Probe - Type 2

Description This is a less sensitive GM probe originally used for caissons 2 & 4 in SX farm. It will no longer be used.

6.1.2.2.3 Geiger-Muller Red Probe

Description This is a less sensitive probe that is not used for leak surveys, but to monitor migration of existing contamination. This probe comes in two configurations and is roughly equivalent to the GM #2 Drywell probe. A schematic of this probe is included in Figure 6.1-10.

Accuracy/Precision This probe was used for tracking migration only. Accuracy and precision are not a subject for this document.

6.1.2.3 Leak Detection Pits

Leak detection pits collect any liquid which might accumulate beneath a tank bottom. The only SSTs with leak detection pits are those in AX farm. Liquid is collected from channels under the tank and drained to a collection pit for each tank. These tanks are monitored for weight factor, specific gravity and gamma activity. Either a level rise, a SpG above 1.0 or an increase in gamma levels could indicate a possible tank leak.

Description The pit consists of a tall pipe section that extends from grade level to a point adjacent to and below the tank concrete foundation. At the bottom is an expanded section for liquid collection. The concrete tank foundation has an interconnected grid of channels to collect any leakage which would then drain to the pit through horizontal drain pipes. Additionally, a vertical "radiation dry well" extends from grade level and terminates adjacent

to the bottom of the leak detection pit. Each leak detection pit drains a single tank foundation.

The two modes of leak detection are: 1) weight factor/specific gravity instrumentation located in the large vertical pipe and 2) a GM sensor in the 6-in. radiation dry well. One of the pits (for Tank 241 AX-102) has plugged dip tubes, so the level is checked with a zip cord. The liquid level is usually maintained above a minimum in each leak detection pit with periodic water additions so that small changes in the weight factor reading can be spotted.

Accuracy/Precision The weight factor in the AX leak detection pits is indicated by a 0-30" H₂O dial gauge. Manufacturer's data state the gauges are accurate to 2% of full scale. This would give an accuracy of ± 0.6 in. A weight factor rise of 8.0 in. was set as an action criteria limit in WHC-SD-WM-TI-357. WHC-SD-WM-TI-357 has been superseded by OSD-T-151-00031 and procedure TO-040-590, Leak Detection Wells and Annulus Leak Detection Systems, which also use a weight factor is of 8.0 in. as the action criteria. This value is unrelated to instrument accuracy. It is empirically based on past experience with water intrusions into the pits, to minimize false alarms. To allow for water intrusions in the future, the specification limit should be kept at +8 inches. An 8 in. rise in an AX leak detection pit represents a 12 gal increase.

The sensor at the bottom of the radiation well consists of two GM detectors with a functional range of about 10 μ R/h to 300 R/h. The detection limit is 0.5 c/s and the measurement precision is ± 1.7 c/s. These are empirical values. A schematic of this probe is included in Figure 6.1-11. These detectors do not form a linear response system. Small increases in radiation will activate the more sensitive GM. When radiation levels increase, the small detector can become swamped and the output die off. As this happens the higher level detector is activated and the alarm stays on. The detectors sense radiation levels which are recorded and compared to a baseline. There is no intent to compare a radiation level with a radionuclide concentration or leak volume.

The action criteria for the radiation detectors was set in WHC-SD-WM-TI-357 at a rise of three times the background count rate for that pit. WHC-SD-WM-TI-357 has been superseded by OSD-T-151-00031 and procedure TO-040-590, Leak Detection Wells and Annulus Leak Detection Systems, which also use a rise of three times the background count rate for a pit as the action criteria. This is empirically based on past experience to minimize false alarms, as the recorded background count rate readings was found to vary by a factor of about ± 1.5 times the baseline during a normal year.

Figure 6.1-1. Manual Flake Gauge used for In-Tank Surface Level Measurements.

59308014.3

Figure 6.1-2. FIC Gauge Used for In-Tank Surface Level Measurements.

Figure 6.1-3. ENRAF Gauge Used for In-Tank Surface Level Measurements

Figure 6.1-4. Zip Cord Used for In-Tank Surface Level Measurements

WMC-SD-WM-TI-573 Rev 1

Figure 6.1-5. Typical Saltwell Dip Tube Weight Factor System

Figure 6.1-6. Schematic of LOW and Probes Used to Scan for In-Tank Interstitial Liquid Level.

S8309023.2

Figure 6.1-7. Models of Characteristic Neutron Probe Scans from LOW's (Stong, 1986), see text for description.

S9309023.1

Figure 6.1-8. Models of Characteristic Gamma Probe Scans from LOW's (Stong, 1986), see text for description.

Figure 6.1-9. Typical Drywell and Scanning Probes

GM Green Probe

GM Red Probe

39308014.2

Figure 6.1-10. Typical Lateral Leak Detection and Scanning Probes.

Figure 6.1-11. Typical AX Leak Detection Pit and Radiation Well.

6.2 Double Shell Tanks

Leak detection for double shell tanks relies upon continuous air monitors (CAMs) on the annulus exhaust air as the primary means of leak detection and electronic leak detectors in the annulus as an alternate.

6.2.1 Primary Tank Measurements

Surface level measurement or other means of internal tank level sensing are not used as primary means of leak detection in DSTs. These would be used to provide backup information in the event of a suspected tank leak, and level drops are investigated when noted, but primary tank liquid level measurement in DSTs is not relied upon as a primary or backup means of leak detection.

6.2.2 Annulus Leak Detection

The annulus enclosures of the double shell tanks are equipped with leak detection devices to detect a leak from the primary tank. In the event of a primary liner failure, drain channels in the insulating concrete pad between the primary and secondary liners are designed to carry leakage to the surrounding annulus section where the leak detection facilities are situated.

Leak detection includes CAMs on the annulus exhaust air, fixed position leak detection conductivity probes, and adjustable Flake type conductivity probes (shown in Figure 6.1-1).

6.2.2.1 Continuous Air Monitors

Description The annulus ventilation system in each DST draws air through the annulus and exhausts it through HEPA filters and a stack. Air is drawn into the annulus via up to eight locations. The annulus air flow is a nominal 200 cfm/annulus for SY tanks, about 800 cfm/annulus for AW and AN tanks, a little over 1000 cfm/annulus for AP tanks, and can be up to 3500 cfm/annulus for AY and AZ tanks. A nominal 1000 cfm through an annulus represents about three annulus air changes per hour. The CAM for each annulus draws an air sample from the the outlet stream at about two cfm and monitors it for radioisotopes indicative of tank leakage. A typical CAM installation is shown in Figure 6.2-1.

Accuracy/Precision Air passing through the annulus should entrain long lived particulates from any radioactive waste in the annulus as the air passes over the waste. The air should also pick up gaseous daughter products released from any actinides present in waste which has leaked into the annulus. These will decay to particulate matter which is caught on the filter paper in the CAM. The presence of any long lived radionuclides or short lived daughter products not indicative of natural uranium decay indicates a possible leak into a DST annulus and must be investigated. The presence of a markedly increased rate of activity buildup on the CAM filter paper is also a subjective indication of a leak.

Continuous air monitor radiation levels are read on a routine basis and recorded on data sheets. Procedures (TO-040-590) call for notification of shift management whenever an annulus CAM filter paper radiation level increases to a level three times the normal background baseline for that CAM.

The basis for using three times background is that normal fluctuations from sound tanks have historically fluctuated by a factor of two times the baseline, so setting a procedural warning at 3X background should provide an early warning that there may be a problem while reducing the number of false

alarms. The baseline count rate for most annulus CAM filter papers is between 200-400 cpm, resulting in shift management being notified whenever an annulus CAM reads 600-1200 cpm or greater.

Annulus CAMs also have high radiation alarm setpoints. The CAM filter papers are changed on a weekly basis. Alarm set points for the CAMs are determined by HPT personnel. Most of the annulus CAM alarms are set at a nominal 2000 cpm based upon past practice. A previous Health Physics procedure (WHC-CM-4-13, Section 7.3.2.1, Rev 1) called for the alarm set point for annulus CAMs to be set at 2000-4000 cpm above background. This procedure has since been discontinued and has not been replaced. Health physics procedure 4.2 Rev 0 of WHC-IP-0718 provides the basis for setting personnel protection CAM alarm set points based upon CAM air flow and detector efficiency, the Derived Air Concentration (DAC) for the radioisotopes of concern, and a DAC-hrs constant. The latter is dependent upon whether the work is for 40 hours/wk normal work without a mask, work using a Personnel Air Purifying Respirator (PAPR), work using fresh air without egress equipment, or with Self Contained Breathing Apparatus (SCBA.) This procedure is not applicable to annulus CAM setpoints. Since annulus CAMs are a process instrument used for detecting annulus leaks, not protecting personnel, there is no basis for which radioisotope or any DAC-hrs value to use.

A CAM alarm set point for leak detection cannot be readily calculated because there is no quantitative basis for what level of radionuclides needs to be present in the annulus air to detect a leak. Annulus CAMs are useful for qualitative indication of a leak only. The minimum size leak which could be detected by an annulus CAM is impractical to assess since the radiation level will depend upon the location of the leak in the tank, the size and nature of the leak, the concentration of radionuclides in the tank waste, and radionuclide entrainment into the annulus air. The CAM alarm set point needs to be set as low as practical without resulting in frequent false alarms. Over the years, 2000 cpm has been shown to be a reasonable number, with only 2-3 tanks (AN-107 and sometimes AZ-101 or 102) showing frequent alarms at this level. To date, all these CAM alarms have been shown to be due to radon from naturally occurring uranium or thorium.

While there is little basis for an annulus CAM alarm set point that can be directly tied to a quantitative specification limit for leak detection, several examples can indicate what a 2000 cpm alarm could theoretically relate to.

- 1) Based upon a 2 cfm CAM air flow and a filter paper which has a constant (not increasing) reading of 2000 cpm, and assuming this count rate was all due to radon daughter products, the radon daughter products exiting the annulus (at a 1,000 cfm annulus exhaust rate) would be roughly equivalent to the amount of radon daughter products estimated to be emitted from 0.01-1.0 g of natural uranium. [The waste in DSTs contains uranium which has gone through several processing steps which result in the ratio of daughter products to uranium being different than is present in natural, unprocessed material. Other actinides and their daughters are present which can further alter these ratios.]

2) If an annulus contained 10 gallons of waste with a Cs^{137} concentration of 0.1 ci/gal, and the annulus exhaust air entrained material at a rate of one-millionth (10^{-6}) of this solution a day (equivalent to about 0.04 ml containing 11 nanograms of Cs^{137}), the annulus CAM filter paper should alarm after about 12-24 hours.

These are only theoretical examples, and not assumed conditions used to arrive at a calculated 2000 cpm CAM alarm setpoint.

When an annulus CAM alarms the filter paper is removed and checked to determine the type of radioactivity. This is necessary to determine if the primary tank is leaking or if there is a false alarm. If the radiation levels on the filter paper decay by at least half in about 50 minutes, it is assumed the radiation is due to radon (Rn^{219} or Rn^{222} , mostly the latter) daughter products associated with the natural uranium decay chain. If it takes a day to decay by half, it is assumed the radiation is due to radon (Rn^{220} or "thoron") daughter products associated with the natural thorium chain. See USD-HEW 1970 (or similar reference documentation) for a more complete picture of the actinide decay chains and the principal radioisotopes involved.

If the radiation does not decay in the relatively short period of time indicative of particulate matter from gaseous daughter products from natural uranium or thorium, the possibility exists that the tank could be leaking because of the presence of long lived fission products.

Because of the uncertainties involved, annulus CAM readings above the 3X background limit should be investigated by operations as deemed necessary. All CAM alarms must be investigated. As a minimum, this means counting the paper to determine whether the material is radon or not. If the filter paper doesn't decay off at expected levels for natural uranium or thorium daughter products, the sample must be sent to the lab to determine the specific radionuclides present.

6.2.2.2 Fixed Conductivity Probes

Description These probes are permanently mounted on three trees spaced 120° apart around the annulus of some DSTs. The probes are placed at 17 elevations ranging from 1/8 in. to 6 ft. The detectors will activate when liquid leaking into the annulus fills the gap between the annulus bottom and the electrical probe. This completes an electrical circuit which then activates an alarm.

Each of the three annulus positions has a 17-position selector switch in order to determine the liquid level. Only the bottom probe is needed to monitor for leaks. The other 16 probes on a tree could be used to track the height of liquid in the annulus. There were maintenance problems with this type of installation, and many have been replaced by the newer adjustable conductivity probes.

Accuracy/Precision The measuring precision is the same as the distance off the tank floor. Assuming the bottom probe on each tree is set at the 1/8 in. off the bottom of an annulus as shown on the installation drawings, 35-45 gal of waste could leak out of a tank and spread into an "even" layer in the annulus before a leak detector would alarm.

All annulus leak detector alarms have to be investigated to determine whether there is a false alarm or the primary tank is leaking.

6.2.2.3 Adjustable Conductivity Probes

Description An adjustable conductivity probe is located at each of three 120° locations around the annulus in all DSTs except in SY farm, which has only one adjustable probe in each tank annulus. These are adjustable for verification of operation, but are otherwise kept at the 1/8-in. elevation. These gauges are similar to the manual tape Flake boxes used for liquid level measurements described in 6.1.1.1. Each gauge is connected to an alarm which is activated when liquid fills the gap between the annulus bottom and the probe.

Accuracy/Precision These probes have the measurement precision of $\pm 1/8$ in. stated as the theoretical precision of manual tapes in 6.1.1.1. Unlike the latter, these probes should meet this precision if set properly. This is due to the nature of the contact surface and the in-tank conditions being more consistent in the annulus when compared with the surface level in the primary tank. Assuming the probe on each Flake box is set at 1/8 in. off the bottom of the annulus, about 35-45 gal could leak out of a tank and spread into an "even" layer in the annulus before a leak detector would alarm.

Each adjustable leak detector should be set as close as practical to the annulus bottom, without causing frequent false alarms by activating due to thermal expansion, occasional condensation or some other problem not related to a primary liner leak. They are normally set at 1/8 in. off the annulus bottom. The specification limit should be set at a maximum of $+1/2$ in. above the annulus bottom to allow room for variations in conditions. This limit is arbitrary, but based on engineering judgement after considering thermal expansion and potential errors with setting the plummet depth.

All annulus leak detector alarms have to be investigated to determine whether there is a false alarm or the primary tank is leaking.

6.2.3. External Tank Measurements

The only leak detection equipment exterior to the secondary containment of a double shell tank are the leak detection pits associated with each DST or group of DSTs.

6.2.3.1 Leak Detection Pits

Leak detection pits for DSTs serve no purpose in leak detection from the primary tank, they would be used to monitor for leaks from the secondary tank should a primary tank leak into the annulus. Leak detection pits collect any liquid which might accumulate beneath the bottom of the secondary liner of a DST. Liquid is collected in channels under the tank which drain to a collection pit for each tank or group of tanks. These pits are monitored for weight factor, specific gravity and gamma activity. Either a significant level rise, a SpG above 1.0 or an increase in gamma levels could indicate a possible secondary liner leak, once the latter contained solution.

Description The pit consists of a tall pipe section that extends from grade level to a point adjacent to and below the DST secondary liner foundation. At the bottom of the tall pipe section is an expanded section for liquid

collection. Below the secondary liner of the DST is a concrete foundation with an interconnected grid of channels to collect any leakage. This will drain to the pit through a 6-in. schedule 40 drain pipe. Additionally, a vertical "radiation dry well" extends from grade level and terminates adjacent to the bottom of the leak detection pit. Each leak detection pit collects drainage from a specific tank foundation, or (for 241-AP Farm) four tank foundations. A typical leak detection pit configuration is shown in Figure 6.2.2.

The two modes of leak detection are: 1) weight factor/specific gravity instrumentation located in the large vertical pipe and 2) a GM sensor in the 6-in. radiation dry well. When problems occur with the dip tube instrumentation the level is checked with a zip cord. The liquid level is usually maintained above a minimum in each leak detection pit with periodic water additions so that small changes in the weight factor reading can be spotted. Maximum level limits exist for the leak detection pits because of structural considerations with the annulus wall. These are unrelated to leak detection and are covered in OSD-TI-151-00007.

The sensor at the bottom of the radiation well consists of two GM detectors with a functional range of about 10 uR/h to 300 R/h.

Accuracy/Precision The weight factor instrumentation in most of the DST leak detection pits consists of a transmitter and an indicator. Vendor data for AN farm instrumentation shows both of these have $\pm 0.5\%$ accuracies and 0-100" H₂O ranges. This calculates to a loop accuracy of about ± 0.7 in. for each pit, per the formula given in 6.1.1.6.

The detection limit for the GM tubes is 0.5 c/s and the measurement precision is ± 1.7 c/s. These are empirical values.

Until an annulus contains solution (excluding nominal amounts of water), the leak detection pits are not useful for assessing the integrity of the annulus liner. In order for a leak detection pit to effectively monitor the integrity of the annulus wall, while the primary tank wall is still sound, the annulus would have to be kept partially filled with water. This would negate the usefulness of the annulus conductivity probes, cause disruption of the annulus exhaust flow, and could cause structural problems with the primary tank wall.

For the leak detection pits to monitor the primary tank for a leak, there would have to be a breach in the annulus wall which would permit solution leaking from the primary tank to pass directly to the ground without being detected by either of the annulus leak detectors.

Should an annulus contain radioactive liquids, specification limits for leak detection will be "activated" for the leak detection pits. A weight factor rise of 8.0 in. for AN, AP, AW, AY, and AZ tank farms and 4.0 inches for SY farm will be set as the specification limit for level rise. These values are empirically set based not on equipment accuracy, but on past experience with water intrusions in order to minimize false alarms.

Should an annulus contain radioactive liquids, specification limits will be "activated" for the radiation monitors. Three different maximum radiation levels would be set as specification limits. These are:

For AN, AP, AW, AY, AZ tank farms-

- 1) 3 times normal background or,
- 2) 2 times normal background and an increase of >20 c/s

For SY tank farm-

- 1) an increase of >0.2 R/hr

The limit for a rise of three times normal background is based upon an observed yearly variation of ± 1.5 -2 times the baseline for the applicable pits. The other two limits are based on a change of one dial division on the pit radiation indicators. This represents the maximum sensitivity of the equipment used.

Section 5.4.2 discusses IOSR requirements for DST leak detection pit operability. These requirements were not implemented at the time this technical bases document was written.

39310053.1

Figure 6.2-1. Typical Double Shell Tank Annulus CAM Installation.

38306014.4

Figure 6.2-2. Typical Double Shell Tank Leak Detection Pit Arrangement

6.3 Catch Tanks and Receiver Tanks

Table 3-3 lists the catch tanks and receiver tanks subject to the leak detection requirements of this document. These tanks are all equipped with surface level measurement devices. Some of these tanks are designed with a sump area to collect tank leakage. Leak detection monitoring for these tanks includes in-tank surface level in all the tanks, and level measurement and/or conductivity probes in the sump area for those tanks with secondary containment monitoring.

6.3.1 Double Contained Receiver Tanks

Description For DCRTs, the primary means of leak detection is buildup in the sump area. Like DSTs, all sump alarms or evidence of a liquid increase must be investigated to determine if the tank is leaking or not. Should a sump leak detector system be out of service, there are not always the redundant backup systems like are present in DST annuli. As a result, a decrease in liquid level in the primary tank is used as a backup means of leak detection for DCRTs, when the primary monitoring method is out of service.

NOTE: Assuming no wording changes are made, when LCO 3.5.2 of WHC-SD-WM-OSR-005 is implemented, it will no longer be acceptable to use DCRT primary tank liquid level measurement as a backup leak detection method.

Equipment used for level detection or sump monitoring are the same types as discussed in sections 6.1-6.2. See these sections for a discussion of the equipment. Because the DCRTs only contain water or liquid wastes, with sometimes sludge being present, many of the problems with accuracy or precision of level measurements that occur with SSTs and DSTs due to solid or semi-solid surfaces in the tank are not as much of a concern.

Accuracy/Precision When a leak detector alarms in a sump area, the alarm has to be investigated to determine the reason. If FICs, manual tapes or zip cords are used to measure the sump level, the specification limits discussed in 6.1 for these instruments will apply to determine when an investigation needs to be done. For a sump area where the level is measured with dip tubes, the instrument accuracy is a function of the transmitter and recorder/indicator used, as discussed in 6.1.1.6. This calculated error would be slightly different for every sump, depending upon instrument characteristics and range. Since in most instances the calculated error would likely be in the 0.5-1.5 inch range, the specification limit to use when dip tubes are used to measure a DCRT sump should be set at the same value as for manual tape measurements. This will provide better consistency with application of specification limits, with negligible loss of leak detection monitoring capability.

Where sump measurement equipment is out of service, the level detection equipment in the primary tank can be used for backup leak detection. If FICs, manual tapes or zip cords are used to measure the primary tank level, the limits discussed in 6.1 for these instruments will apply to determine when an investigation needs to be done. Where the tank level is measured with dip tubes, the limit used should be the same as for a manual tape, for the reasons given in the above paragraph.

6.3.2 Catch Tanks with Secondary Containment

Description For catch tanks with secondary containment monitoring, the primary means of leak detection is buildup in the sump area. Like DSTs, all sump alarms or evidence of a liquid increase must be investigated to determine if the tank is leaking or not. Should a sump leak detector system be out of service, there are not always the redundant backup systems that are present in DSTs annuli. As a result, a decrease in liquid level in the primary tank is used as a backup means of leak detection for catch and receiver tanks with secondary containment monitoring, when the primary monitoring method is out of service.

Equipment used for level detection or sump monitoring are the same types as discussed in sections 6.1-6.2. See these sections for a discussion of the equipment. Because the catch tanks only contain water or diluted wastes, many of the problems with accuracy or precision of level measurements that occur with SSTs and DSTs containing salt cake are not as much of a concern.

Accuracy/Precision When a leak detector alarms in a sump area, the alarm has to be investigated to determine the reason. If FICs, manual tapes or zip cords are used to measure the sump level, the specification limits discussed in 6.1 for these instruments will apply to determine when an investigation needs to be done. For a sump area where the level is measured with dip tubes, the accuracy is a function of the transmitter and recorder/indicator used, as discussed in 6.1.1.6. This calculated error would be slightly different for every tank or sump, depending upon instrument characteristics and range. Since in most instances the calculated error would likely be in the 0.5-1.5 inch range, the specification limit to use when the sump level is sensed by dip tubes should be the same value as for manual tape measurements. This will provide better consistency with application of specification limits, with negligible loss of leak detection monitoring capability.

Where sump measurement equipment is out of service, the level detection equipment in the primary tank can be used for leak detection. If FICs, manual tapes or zip cords are used to measure the primary tank level, the limits discussed in 6.1 for these instruments will apply to determine when an investigation needs to be done. Where the tank level is measured with dip tubes, the limit used should be the same as for a manual tape, for the reasons listed in the previous paragraph.

6.3.3 Catch Tanks without Secondary Containment

Description For catch tanks without secondary containment monitoring, the only means of leak detection is a decrease in liquid level in the primary tank.

Equipment used for level detection are the same types as discussed in sections 6.1. See these sections for a discussion of the equipment. Because the catch tanks normally only contain water or diluted wastes, many of the problems with accuracy or precision of level measurements that occur with SSTs and DSTs containing salt cake are not as much of a concern.

Accuracy/Precision If FICs, manual tapes or zip cords are used to measure the primary tank level, the limits discussed in 6.1 for these instruments will apply to determine when an investigation needs to be done. Where the tank

level is measured with dip tubes or some other type of gauge, the accuracy is a function of the transmitter or sensing unit and recorder/indicator used. For ease of application, and to be conservative, the limits to use when the primary tank level is sensed by dip tubes or some other type of gauge should be the same as for a manual tape.

6.4 Transfer Lines

Description Transfer line leak detection varies with the type of transfer line. These lines are either direct buried, concrete encased, or pipe-in-pipe encased. Most transfer lines terminate in various pits where pipe jumpers are used to connect different lines together. Transfer lines may leak either from the line itself due to line failure, or at one of the jumper connections in a pit due to connector or connector gasket failure.

The method used for leak detection for direct buried lines is a yearly pressure test for lines in service. The requirements for this are specified in OSD-T-151-00010. Certain lines such as pit drain lines, condensate drain lines and several other lines which cannot readily be pressure tested are exempted from pressure testing requirements. At the time this technical basis document was written, the OSD requires a one hour pressure test at permitted 110% of the maximum operating pressure of the system, with <5% pressure drop in 30 minutes. The details and the justification for this requirement are given in WHC-SD-WM-TEEM-001.

Concrete encased lines include the cross-site transfer lines between east and west area and a number of lines within each area. Each of the lines is checked for leaks during transfers by having leak detection available for the pit the tank drains to. In addition, the cross-site transfer lines (which are concrete encased) are required to be pressure tested annually per OSD-T-151-00010. (An exception to this pressure test is permitted for pumping contaminated water from the E/W vent station catch tank down the transfer lines.) At the time this technical basis document was written, the OSD requires a one hour test between 250 and 350 psig with 0% pressure drop for systems without valves, and <5% pressure drop for systems with valves. The details and the justification for this requirement are given in RHO-SD-RE-OCD-001.

Pipe-in-pipe encased lines have leak detection on the outer encasement lines (as well as being monitored by the leak detector for the pit the encasement drains to). The outer pipe encasements drain to a pit. The encasement discharge line has a 3 way ball valve that can be turned to a HYDRO, OPERATE or DRAIN position. In the HYDRO position the encasement can be sealed off for pressure testing. In the OPERATE position, any drainage from the encasement is forced to back up and fill a seal loop before overflowing to the pit floor.

When the seal loop fills with liquid, a leak detector for the encasement alarms, indicating a potential leak into the encasement. In the DRAIN position, liquid in the encasement drains to the pit floor and thus may not set off the encasement leak detector. Whether the encasement drain valve is set in the DRAIN or OPERATE position, encasement drainage will go to the pit floor and should set off the pit leak detector.

There are two types of encasement leak detectors. Most encasements have conductivity probes which complete an electrical circuit when wet, and alarm.

Some encasements have a slow air purge which passes down the encasement. For these type of leak detectors, when the seal loop fills with liquid the back pressure caused by the seal loop resistance is sensed and sets off an alarm.

Transfers should not be made with the encasement drain valve in the HYDRO position. If this were done and an encased line leaked, the encasement could fill with waste solution, assuming the leak detector failed or the transfer was not shut down quickly.

Valve pits or diversion boxes which contain pipe jumpers and/encasement drains have a conductivity probe in the bottom of the pit. There are several different designs for these leak detectors. They all work by completing an electrical circuit when liquid fills the gap between two electrodes. Some of these detectors are designed to sit in the bottom of a pit and sense when liquid is backing up because of a plugged drain in the pit. Some detectors are designed to sit over or in the pit drain. A seal around the detector causes liquid to buildup in the pit and wet the electrodes to cause an alarm. The detector electrodes are set at between 1/8 in. to 1+ inches above the pit floor. These detectors are reset by raising them up with a hook and line via an access port in the cover block above to allow backed up liquid to drain to the pit catch tank.

Leak detection for transfer lines is also provided by the level instrumentation in the catch tank to which a pit drains. These instruments are discussed in sections 6.1-6.3.

The final form of leak detection used for many transfers is a material balance. This does not directly consist of instrumentation, but calculations which are done during and after many transfers that compares sending volume with receiving volume and comparing any difference with a predetermined allowable material balance discrepancy.

The requirements for leak detection during transfers are given in sections 5.4.1 and 5.4.2. The conductivity probe leak detectors used for a transfer must be verified as operable prior to a transfer, or the applicable diversion boxes/catch tanks provided with constant surveillance during the transfer. Encasement drain leak detectors are not required to be operable as long as the encasement drains to a pit with an operable leak detector. These requirements meet the basic safety needs associated with transfers. However, several additional guidelines should be followed, as procedural requirements only. These include providing a material balance for most transfers (except those transfers where not practical) and monitoring the liquid levels in all catch tanks along the transfer route. Both of these will provide backup leak detection capability in case any of the electronic leak detectors fail to perform as required.

Accuracy/Precision Accuracy and precision are not directly applicable to pressure testing, except for those associated with the test pressure itself. The intent of pressure testing is to stress the system to more than it will experience during normal operation, and if no leaks occur it is assumed the line is sound. Should a leak occur with a direct buried line that has been pressure tested, and the leak was not in a pit, the material balance would be relied upon to detect the leak.

Leakage from encasements into pits with leak detectors that seal around the pit drain should cause an alarm after about 8-50 gallons have built up in the pit. If the detector does not provide a seal around the drain, and the drain is not plugged, the leak volume which would cause an alarm will be whatever it takes to wet the electrodes. In some instances, this detector may not alarm during a relatively small leak, and the leak would not be spotted unless detected by buildup in the pit catch tank.

Leakage into pipe-in-pipe encasements, if the encasement leak detector is working properly, should cause an alarm with a 0.5-2 gallon buildup in the seal loop.

The volume of leakage into a catch tank which can be spotted will vary with the diameter of the catch tank and the accuracy of the level monitoring equipment. A 5 ft. diameter catch tank with a level measurement device with an accuracy of ± 0.25 in. should be able to show a volume increase of 3 gallons. If the catch tank was a 75 ft diameter waste tank with a level measurement device with an accuracy of ± 0.5 in., up to 1375 gallons could leak into the tank before it was noticed, assuming no other form of leak detection was used.

A material balance discrepancy will be dependent upon line holdup, if any, and the size and accuracy of the measurement devices in the sending and receiving tanks. The allowable material balance discrepancy is usually specified in the transfer procedure. An allowable discrepancy could range from 200 gallons to 2000 gallons depending upon these factors. If the tank being pumped out of or into contains salt cake, the allowable discrepancy may be even higher.

7.0 MEASUREMENT FREQUENCIES

This section provides the bases for frequency of monitoring tanks for leak detection, using the equipment described in sections 6.1-6.4. The definitions to use for frequencies, including any allowable extension are assumed to be the same as given in WHC-SD-WM-OSR-005.

7.1 Single Shell Tanks

Monitoring frequencies for leak detection methods are set at frequencies that are felt to provide the earliest detection practical. Each of the leak detection systems has an associated measurement error and for this reason has an associated minimum detectable leak. Monitoring frequencies are based on this minimum detectable leak and on the maximum assumed leak rate from SSTs. Smaller leak rates than the maximum estimated leak rate would take proportionately longer to discover.

The maximum assumed leak rate from an SST was studied based on past history. Excluding 106-T and 110-SX which experienced significant leakage rates due to problems believed due to structural or other related problems, the maximum leak rate was estimated to be <0.03 gal/min (Isaacson 1981) at a 95% confidence level. This equates to a leak rate of about 0.016 in./day for a 75 ft diameter tank (2750 gal/in.) with a liquid surface, or 0.045 in./day for the same tank with a solid surface and a waste porosity of 35% liquid. For a 20 ft diameter tank (196 gal/in.), the maximum estimated leak rate equates to 0.22 in./day for tanks with a liquid surface and 0.63 in./day for the same tank with a solid surface and a waste porosity of 35% liquid.

The 0.045 in./day (75 ft diameter tanks) and 0.63 in./day (20 ft diameter tanks) rates for ILL changes assume the interstitial liquid is distributed uniformly in solid waste of 35% porosity. Porosity values for solid waste have generally ranged from 35% to 50%. The lower value is more accepted and is a more conservative value for this calculation.

7.1.1 Internal Tank Level Measurement

7.1.1.1 Surface Level Measurement

For a SST with a liquid surface, the primary level measurement device is a manual tape, FIC, ENRAF gauge or zip cord. Based on the assumed precision of $\pm 1/4$ in. for an FIC, liquid level readings should be taken at least once every 16 days for a 75 ft diameter tank to maximize the possibility of discovering a 0.016 in./day leak ($0.25 \text{ in} \div 0.016 \text{ in/d} = 16 \text{ d}$). The maximum leak volume in this case would be about 700 gallons. If the stated vendor precision for the FIC of ± 0.03 in. is assumed, surface level readings could be taken every two days and enable the same leak rate to be discovered after only about 85 gallons had leaked out.

For a 20 ft diameter tank, liquid level readings should be taken at least once every day to maximize the possibility of discovering a 0.22 in./day leak ($0.25 \text{ in} \div 0.22 \text{ in/d} \sim 1 \text{ d}$). The maximum leak volume in this case would be about 45 gallons.

Readings obtained from manual tape or zip cord measurements have higher specification limits than FIC readings as discussed in section 6.1, so a

calculated measurement frequency based on either of these would be longer than for an FIC. It is not practical to have different frequencies for the different surface level measurement devices, nor is it reasonable to base the monitoring frequency on the less precise instruments. Thus, the calculated monitoring frequency is based on the FIC.

The required monitoring frequency for SSTs with a liquid surface is once per day. This frequency meets legal requirements (see sections 5.1 and 5.2), provides a conservative frequency for 75 ft diameter tanks, a reasonable frequency for 20 ft diameter tanks, and provides for the collection of a number of data points on which to spot trends. The formal monitoring frequency period is set at least once per 36 hrs. This is based on data collection on the same shift each day, but permits variation in the time the data is obtained within the shift, and for the occasional occurrence when data is not obtained until the next shift. Setting the monitoring frequency limit at this value does not mean that data is only required twice every three days.

7.1.1.2 Interstitial Liquid Level Measurement

Although the the overall specification limit for ILL measurement using a neutron probe was originally set at ± 3.6 in., with the revised method currently used for data interpretation resolution may eventually be shown to be better than this. The limiting factor for the LOW equipment is the 0.60 in. resolution of the shaft encoder. Assuming a ± 0.60 in. value instead of the previous ± 3.6 in. specification limit, LOW neutron probe scans taken every 13 days ($0.60 \text{ in.} + 0.045 \text{ in./day}$) in a 75 ft diameter tank would spot the maximum reference leak in the minimum practical time. In this case, the leak volume at the time of discovery would be about 580 gallons.

For a 20 ft diameter tank, LOW neutron probe scans would theoretically have to be taken daily ($0.60 \text{ in.} + 0.63 \text{ in./day}$) to spot the maximum reference leak in the minimum practical time. This would result in a 45 gallon leak at the time of discovery. A daily LOW neutron probe scan frequency is impractical with current staffing and equipment, but is irrelevant at the time this document was written since none of the 16 200 series tanks currently has an LOW. Ten of the 16 tanks are scheduled to have them installed. When LOWs are installed in the 200 series tanks, monitoring frequencies for them will have to be evaluated taking into consideration the specific characteristics of each tank and possibly less conservative assumptions than were used for this basis document.

The needed LOW scan interval will depend on the resolution ability of the LOW and leak rate size. The more precise the LOW ILL data measurement and interpretation, the sooner it can spot a leak, so the shorter the monitoring frequency can be to find a leak. The dependence of neutron probe scan interval on leak rate and detection limit is shown graphically in Figure 7.1-1 for a 75-ft diameter tank. The LOW scan interval is conservatively set at weekly for a 75 ft diameter (100 series) SST. The formal monitoring frequency period is set at at least once per 7 days. This will be more difficult to meet than a weekly monitoring period, but there is no other monitoring period defined in WHC-SD-WM-OSR-005 between 7 days and 31 days.

Gamma scans from LOWs are done on request, there is no set monitoring frequency for them.

Level readings from saltwell dip tubes, when the latter are used as a means of leak detection for a tank should also be taken on a 7 day basis. This is based not on the ± 2.7 in. specification limit from 6.1.1.6, but on engineering judgement. Dip tube measurements only take a few seconds to obtain during routine surveillance, but saltwell dip tubes frequently plug, resulting in the need to ram them out. This takes time, and obtaining daily readings, while desirable, is impractical in light of the problems with maintaining the dip tubes operational on a daily basis. Since the saltwell dip tubes will be measuring an ILL equivalent to that which would be obtained using neutron probe data from an LOW, it is reasonable to use the same monitoring frequency for dip tubes as for LOWs.

7.1.1.3 In-Tank Photography

In-tank photographs, when used to support SST leak detection, are intended to show that for tanks where surface level measurements are being made, the measurement device is still contacting a liquid surface. Photographs are also used to look for tank intrusions, for investigating potential tank leaks, or to assess tank stabilization efforts.

The time period for taking photos to support leak detection or look for intrusions is set arbitrarily at every two years, or when conditions are known or believed to have occurred which may make the surface level reading suspect.

Excluding C-106 which experiences about a two inch per month evaporation rate, the maximum evaporation rate seen in SSTs is in the 0.75-1.0 in./yr range. Thus, in two years some SSTs may evaporate up to two inches. In tank photographs can not be used to realistically spot level changes much less than this, nor is it felt that a tank surface would undergo a significant change in less than this time, without the liquid leaking or being pumped out. A two year photograph frequency therefore is felt to be a reasonable time period for checking whether the surface level sensing instrumentation is still contacting a liquid or moist surface.

In tanks with a solid, non conductive surface, and less than two feet of waste, in-tank photographs are taken primarily to look for intrusions. Surface level and LOW measurements are not useful for leak detection in these tanks if they contain just sludge or salt cake. Photograph frequency is recommended at the same two year frequency as for tanks with a conductive surface.

The two year limit is not a requirement. It is a guideline as to what would be desirable to support a good leak detection program.

Figure 7.1-1. Effect of Leak Detection Capability on Time to Spot a Leak (Assumes ILL and 35% Waste Porosity).

7.1.2 External Leak Detection

7.1.2.1 Drywells

A study in 1981 (Isaacson and Gasper 1981) developed an equation which was to be used to provide a calculated basis for a monitoring interval for each external dry well. The basis for the calculations was that the count rate in an uncontaminated dry well would not increase by more than 160 c/s between successive readings. A monitoring frequency was then set as one of the following categories: every week, every 2 weeks, every 3 weeks, every quarter, or annually. A detailed study (Isaacson, 1982) used the Dry Well Radioactivity Response Equation to set the monitoring frequency for most of the drywells then in the 200 areas. The equation was a complex one based on the concentration of Ru^{106} in the waste, size of leak rate, soil characteristics, detector response, distance from drywell to tank leak source, and geometry of waste plume. The maximum assumed leak rate of 0.03 gpm was used, along with an assumed concentration of 0.4 mCi Ru^{106} /lit in the waste in the waste plume. Determining the monitoring frequencies were based on:

- 1) An alert limit of 20 c/s above baseline. At this point, a decision would be made as to increasing the monitoring frequency for the well.
- 2) An action limit of 160 c/s above baseline. At this point the liquid in the tank would be pumped.
- 3) Monitoring intervals would be established so that:
 - a) The maximum waste which could leak from a tank (75 ft diameter) in the period from the preceding reading and one with 20 c/s above baseline is 1375 gal (1/2 in.), and;
 - b) the count rate would not exceed the action limit within the period between successive readings for more than 10% of leaks within the range of the drywell.

Based on these requirements, the minimum drywell monitoring frequency was set at two weeks for east area tanks and one week for west area tanks. Monitoring frequencies less than this would provide little improvement in leak detection ability. It was calculated that if the additional guideline was placed on the monitoring frequencies that 90% of all leaks would be detected before the alert limit was reached, the maximum suggested drywell monitoring frequency would be four weeks in east area, and two weeks in west area.

In the time since the 1982 report, the drywell monitoring frequencies have been altered due to pumping of liquid from many of the tanks, installation of LOWs, and much empirical experience. All drywell monitoring frequencies were eventually set at either 1, 2, 4, 12, or 52 weeks for the various gamma probes, and at 52 weeks for the neutron probe.

The basis for past drywell monitoring frequencies are not very applicable any more due to stabilizing over two thirds of the SSTs since the late 1970s, installing LOWs in about one third of the SSTs, the recent revision of the tank leak detection strategy, and the fact that the primary radionuclide the calculations were based upon, Ru^{106} , has decayed off to negligible quantities.

[Any Ru^{106} present in an SST was discharged from a reactor prior to 1972. With a one year half-life, less than $5 \times 10^{-3}\%$ of the Ru^{106} present in 1972, and less than $3 \times 10^{-2}\%$ of that present in 1981, is still there.] The most prevalent radionuclide contribution to drywell scans now is Cs^{137} . Because of

the ion exchange affinity for the Hanford soils for Cs^{137} , it was not selected in 1981 as a basis for the drywell frequency monitoring calculations.

Evaluating all the above factors, it is apparent than new guidelines are needed for drywell monitoring. Specification limits for SST drywell monitoring frequencies are thus revised to the following:

- 1) Except for Tank C-106, for tanks where drywell scans are a backup means of leak survey and the primary monitoring equipment for leak detection is in service, drywell monitoring shall be done on request.
- 2) Except for Tank C-106, for tanks where drywell scans are a backup means of leak survey and the primary monitoring equipment for leak detection is out of service, drywell scans shall be performed on a monthly basis.
- 3) For tanks where drywell scans are not a backup leak survey method, drywell monitoring shall be done on request.
- 4) For Tank C-106, drywell scans shall be done every month.

The monthly monitoring period for tanks requiring drywell scans is an arbitrary value based on the past "calculated" drywell monitoring frequencies and an assessment of how applicable the bases for these past "calculated" values are today. The formal monitoring frequency for tanks requiring drywell scans is set at at least once per 31 days, to be consistent with WHC-SD-WM-OSR-005. See 8.1.1.3 for the basis for requiring Tank C-106 drywell scans.

7.1.2.2 Laterals

The laterals are similar to drywells, but provide a better means of monitoring for the presence of activity in the soil around a tank. Past recommendation from WHC-SD-WM-TI-357 was to perform lateral scans on the same frequency (weekly) as drywells for nonstabilized tanks, quarterly for interim stabilized/partially isolated tanks, and annually for stabilized an isolated tanks. With the recommendation in this technical bases document to do drywell monitoring on a monthly basis, where drywell monitoring is required, it is recommended that lateral scans also be obtained on the same frequency of at least once per 31 days, when lateral scans are required.

7.1.2.3 Leak Detection Pits

Calculation of a monitoring frequency based on the time for waste buildup in a leak detection pit would require a number of assumptions, and the results would be approximate at best. Due to the relative ease of obtaining level readings, and the fact that there are only 4 SST leak detection pits, all in the same farm, it is recommended that the pit level readings be required to be taken daily (at least once per 36 hours), when the leak detection pit level readings are used as a backup means of leak detection. When the radiation measurement equipment in the leak detection pit is used as the backup means of leak detection, it must be operable and the alarm must be working or radiation readings obtained on a daily basis.

7.2 Double Shell Tanks

7.2.1 Annulus Monitoring

7.2.1.1 Continuous Air Monitors

Requirements for CAM operability are given in 5.4.1 and 5.4.2. For a CAM to be operating it must have a functioning alarm and be within calibration. There is no monitoring frequency requirement since the unit is in constant operation, when operable. Readings of the CAM radiation levels are taken on a daily basis to provide background baseline information, and to provide a potential early warning to shift management of an upward trend in the annulus CAM radiation levels before a CAM alarms. The daily requirement is based on engineering judgement.

7.2.1.2 Conductivity Probe Leak Detectors

Requirements for annulus leak detector operability are given in 5.4.1 and 5.4.2. For a detector to be operating it must have a functioning alarm and be within calibration, or local surveillance be provided. There is no monitoring frequency requirement since the unit is in constant operation, when operable.

The depth of the adjustable conductivity probes is set during routine calibrations. When one alarms, it is checked and then reset per directions in procedure TO-040-590 when it is verified the primary tank is not leaking.

7.2.2 Leak Detection Pits

There are no frequency monitoring requirements for either the leak detection pit level measurement equipment or radiation detectors at this time. See section 5.4.2 for operability requirements which may be applicable when new IOSRs are formally implemented.

7.3 Catch Tanks and Receiver Tanks

7.3.1 Double Contained Receiver Tanks

These tanks receive transfers of liquid wastes from generator facilities or other waste tanks. If empty, there is no requirement to monitor these tanks for leak detection, but they should be monitored for intrusions. If they contain liquid, they must be monitored for leak detection. These tanks also need to be monitored as required by procedure during transfers, if they can receive leakage from a line used during the transfer.

The primary leak detection monitoring method is that present in the secondary containment. This equipment or a backup must be operable whenever liquid is present in the primary tank. Per section 5.2, leak detection monitoring is required on a daily basis. Thus, the sump level readings should be taken daily (at least once per 36 hours) or the electronic leak detector and alarm must be operable. The backup leak detection measurement is the liquid level measurement instrumentation in the primary tank. Liquid levels in these tanks are monitored either with instruments which work constantly or are read on a periodic basis. Thus, the surface level readings should be taken daily (at least once per 36 hours) when the sump level monitoring equipment is out of service.

NOTE: Assuming no wording changes are made, when LCO 3.5.2 of WHC-SD-WM-OSR-005 is implemented, it will no longer be acceptable to use DCRT primary tank liquid level measurement as a backup leak detection method.

7.3.2 Catch Tanks with Secondary Containment

These tanks collect rainwater that leaks into pits and diversion boxes, condensates or potential leakage from transfer lines. If empty, there is no requirement to monitor these tanks for leak detection, but they should be monitored for intrusions. If they contain liquid, they must be monitored for leak detection. These tanks also need to be monitored as required by procedure during transfers, if they can receive leakage from a line used during the transfer.

The primary leak detection monitoring method is that present in the secondary containment. This equipment or a backup must be operable whenever liquid is present in the primary tank.

Per section 5.2, leak detection monitoring is required on a daily basis. Thus, the sump level readings should be taken daily (at least once per 36 hours) or the electronic leak detector and alarm must be operable. The backup leak detection measurement is the liquid level measurement instrumentation in the primary tank. Liquid levels in these tanks are monitored either with instruments which work constantly or are read on a periodic basis. Thus, the surface level readings should be taken daily (at least once per 36 hours) when the sump level monitoring equipment is out of service.

7.3.3 Catch Tanks without Secondary Containment

These tanks collect rainwater that leaks into pits and diversion boxes, condensate from active vent systems or potential leakage from transfer lines. If empty, there is no requirement to monitor these tanks for leak detection, but they should be monitored for intrusions. If they contain liquid, they must be monitored for leak detection, and surface level measurement provides the only practical means of doing so. These tanks also need to be monitored as required by procedure during transfers, if they can receive leakage from a line used during the transfer.

Liquid levels in these tanks are monitored either with instruments which work constantly or are read on a periodic basis. Per section 5.2, leak detection monitoring is required on a daily basis. Thus, the specification limit for leak detection monitoring of these tanks is set at daily (at least once per 36 hours), when liquid is in the tank, and as necessary during transfers.

7.4 Transfer Line Leak Detection

A transfer line only has to be monitored for leak detection during the time a transfer is being made through it. All instruments used for leak detection must be verified as operable (see 5.4.1 and 5.4.2) before a transfer.

8.0 BASELINES FOR LEAK DETECTION COMPARISON

Reference baselines can be either fixed values or linear data trends which are used as a basis for comparison against current readings to help determine when a tank may be leaking. WHC-IP-0842, Section 12.4 provides the general requirements for setting and modifying liquid level or radiation level baselines used for tank leak detection.

8.1 Single Shell Tanks

For Single Shell Tanks (SSTs) baselines are established for surface level measurements; however, the baselines are only used for purposes of leak detection when the tank waste surface has sufficient moisture to provide ample conductivity for valid surface level readings. As ENRAF gauges replace FIC and MT's conductivity will not be required to obtain valid surface level readings. In these cases, the baselines may also be used for leak detection purposes. Baselines are also established and used for leak detection purposes for all interstitial liquid level measurements when the tank is equipped with a Liquid Observation Well (LOW). Liquid level baselines may be either a constant value reference or a trend line with an increasing or decreasing slope.

New tank readings are compared to the baseline to help determine whether the tank liquid level is changing with time. Deviations above the baseline could indicate an intrusion, while deviations below the baseline could indicate a leak. Because of the potential for changes to occur in the liquid level besides that due to leakage, as well as variations in liquid level readings due to monitoring equipment parameters, (accuracy, sensitivity, repeatability, or reading interpretations), the baselines must be reviewed and updated regularly. General requirements for surface liquid level data review and comparison to baseline values are given in WHC-IP-0842, Section 12.5. General requirements for LOW data review and comparison to baseline values are given in WHC-IP-0842, Section 12.6.

Radiation scan baselines are a past radiation vs. depth plot for a given drywell or lateral which has been selected as a reference plot. Later scans from the same drywell or lateral are compared visually and/or electronically to the baseline scan. Significant deviations from baseline values indicate possible leaks or contamination spread. Increases above the specification limit, at a given depth when compared to the previous scan, or the presence of radioactivity at a lower level than in the previous scan, are investigated, and may indicate a tank leak or other form of external contamination, or migration of past leakage. General requirements for drywell and lateral scan data review and comparison to baseline values are given in WHC-IP-0842, Sections 12.7 and 12.8.

Baselines for radiation levels for leak detection pit radiation detectors are empirical values set for that instrument based on historical data. Baselines are also set for the leak detection pit liquid level. For the 102-AX leak detection pit there is no level reading baseline since the pit leaks. General requirements for leak detection pit data review and comparison to baseline values are given in WHC-IP-0842, Section 12.9.

8.1.1 Liquid Level Baselines

When monitoring a tank for leak detection using liquid level measurement, the liquid level is periodically located relative to a reference point on the tank and then compared to a reference baseline level. The change in volume of solution in the tank is calculated by adding any observed volume change to any other known or potential changes to the volume or calculated volume. This method can be expressed as follows for a liquid:

$$\Delta V = Ax\Delta L + A\Sigma\delta l_v \quad 8-1$$

where: V is the waste volume, L is the waste surface level, A is the cross section area (assumed constant, here), and δl_v are level or level reading changes not related to waste leakage.

L is the value obtained during level measurement. This reading is compared to the reference baseline level (L_B) to determine any change, or ΔL . The term δl_v includes such things as evaporation, condensation, transfers of solution into or out of the tank, changes in waste characteristics, tank chemistry effects, changes in tank or waste dimensions due to temperature, or variations in level gauge characteristics or data taking. See (Dunford, 1988) for a discussion of the effects of these other factors.

When the liquid waste is present in the interstitial voids in a porous solid waste, the volume of liquid and it's surface level response to a leak is also a function of the porosity of the solid. If all of the liquid is interstitial liquid, and it is evenly distributed, Equation (8-1) can be expressed as:

$$\Delta V = PAx\Delta L + PA\Sigma\delta l_v \quad 8-2$$

where: P is the porosity of the solid (considered uniform here), and the other terms are as previously identified.

This ignores any surface tension or capillary forces which resist the flow of liquid from the interstitial void cavities.

To simplify things, Equations 8-1 and 8-2 can be modified to give, within the limits of equipment accuracy, for a tank not leaking or experiencing intrusions:

$$|\Delta L| < |\Sigma\delta l_v| \quad 8-3$$

When the term $\Sigma\delta l_v$ is assumed to only include the variation in level measurement reading, Equation 8-3 reduces to:

$$|L - L_B| < |Specification Limit| \quad 8-4$$

This represents the method which has traditionally been used to routinely measure the integrity of SSTs with a surface or interstitial liquid level, using a fixed value baseline.

8.1.1.1 Fixed Value Baselines

A fixed baseline for a tank is a constant value, which is shown mathematically as:

$$L_B = \text{Constant}$$

8-5

When Equation 8-4 is used and ΔL is within the level measurement specification limit the tank can be inferred to be sound within the resolution abilities of the equipment. However, when ΔL is greater than the level measurement specification limit, investigations are required to determine if the tank is leaking or the level difference is caused by another factor.

A fixed liquid level baseline is established for a tank based on the apparent average value of recent measurement data, with some fluctuation around this value considered normal. Permitted level measurement deviations from the baseline value are based on the accepted specification limit for the measurement equipment used (see section 6.1).

While this approach is reasonable in extremely stable situations, it has led to data interpretation problems where tanks are experiencing evaporation, condensation, or other dynamic phenomena. These situations cause liquid level changes, leading to level readings which eventually exceed the permitted decrease or increase limit from the baseline. Other problems such as instrument error and stability, waste characteristics, temperature changes, and calibration shifts have also caused data interpretation problems, leading to questions as to whether the level in a tank was changing, and to occasional resetting of tank baselines. Figure 8.1-1 is a plot of the liquid level in a tank with a fixed baseline which has had to have the baseline reset several times.

8.1.1.2 Trend Baselines

A trend baseline is indicated by a baseline value which changes with time at a constant rate and is determined using a linear least-squares fit of actual data.

A trend baseline is shown mathematically as:

$$L_B = mt + L_o$$

8-6

where: t = time
 m = slope
 L_o = a baseline value at an arbitrarily selected $t = 0$

A fixed baseline is a special case of a trend baseline, where $m = 0$. When plotting tank liquid levels against time, very rarely does the surface level slope stay perfectly flat with time. This has led to investigations of tanks with fixed value baselines for leakage or intrusion when Equation 8-4 was exceeded.

By using trend lines as baselines instead of a fixed baseline, Equation 8-6 is used and such concerns as evaporation, condensation, waste physical changes or equipment reading variables which could be causing changes in an observed tank level are incorporated into a new, variable baseline. Thus, a more realistic baseline is set for each tank when a trend line is used. It allows for a natural, constant change in the observed baseline of a tank, and considers more than just equipment measurement characteristics.

Figures 8.1-2 and 8.1-3 are examples of two tanks with decreasing and increasing LOW trend lines.

Preparing a liquid level trend baseline for a tank is based upon a more rigorous analysis of the tank liquid level data than for a fixed baseline, and allows for a naturally occurring increasing or decreasing trend. This analysis includes the expected statistical variation in the observed data. The past tank liquid level data are examined statistically to determine a least-squares fit linear trend through the data. A statistically valid trend line is generated on a tank-by-tank basis and prepared as follows:

- 1) All valid measurements for a relatively stable, linear time period are plotted against time using linear coordinates.
- 2) A linear least-squares fit trend line is made through the data and a $\pm 2\sigma$ (and/or $\pm 3\sigma$) band is constructed around the trend line. (The term " σ " represents "Sigma", or "Standard Deviation Units" and is used for engineering evaluation purposes only.)
- 3) The distribution of the data about the trend line is compared to the typical distribution for that device under similar tank conditions. If the distribution is considered "reasonable," (i.e., recent readings show similar distribution to older readings or the distribution in similar tanks), the trend line is deemed valid.

Trend lines are prepared in a similar fashion from data obtained either by surface level detection or from interstitial liquid level measurements.

For tanks with surface level measurement as the primary means of leak detection, the condition of the surface (liquid, floating solid, conductive solid, or non-conductive solid) and the type of measuring device (manual tape or FIC) and not the method of baseline calculation determine the tank specification limit for a given tank. The alert criteria for a tank is 50% of the specification limit for that tank.

During engineering evaluation of anomalous level readings, a statistical analysis should be used, to clarify the validity of data approaching fixed specification limits. The data scatter around the sloping baseline is analyzed using the standard deviation approach. Whether or not data has exceeded 2 or 3 standard deviations (2σ or 3σ) helps to determine whether or not the data deviation is statistically significant.

For LOW readings, a $\pm 2\sigma$ band is prepared as an "alert level" to enhance early identification of potential problems, while a $\pm 3\sigma$ band provides the specification limit criteria.

A few tanks with a liquid surface also demonstrate significant seasonal variations in the observed liquid level. Figure 8.1-4 shows the observed level in a tank experiencing these changes. The actual reasons for these observed changes are unknown at this time, but temperature, humidity, and barometric pressure changes are suspected. These fluctuations are apparent on both the FIC/manual tape readings and on the LOW plots. Because of the cyclical nature of these changes, consecutive readings may be below a -3σ band based on a trend line drawn through the statistical average of the observed data points. It isn't felt to be warranted at the time this document was written to attempt to fit sinusoidal curves or sophisticated polynomial functions to observed data points to more accurately assess the variation in readings. For tanks exhibiting significant seasonal variations in observed liquid levels, a value of ± 1.0 in. will be used as the minimum specification limit. This value is based upon engineering assessment of the observed seasonal variation in these tanks. This value is only applicable to tanks exhibiting a yearly fluctuation in tank level.

For a sound tank, the linear trend line should have a fairly normal distribution of data points about the line, and may possibly contain seasonal variations or other explainable data trends. For a suspected leaking tank, the distribution about the trend line would be expected to drop sharply below normal with a continuing decreasing trend, or the data trend may be dropping too quickly to be explainable by evaporation or other natural causes. This can be determined from an engineering evaluation when a data point exceeds 50% of the decrease criteria.

The statistical indicator most commonly accepted to identify allowable deviations from a trend line is "confidence level" rather than a "standard deviation". Confidence level calculations are normally set for a 95% or a 99% confidence interval. Confidence level calculations are not linear and diverge from the baseline as new data is added. This results in an allowable tolerance which is constantly changing (typically increasing), making administration of a leak detection monitoring system based on confidence interval more difficult. Although using a confidence level is a more statistically rigorous means of data analysis, standard deviation lines are used to approximate the confidence level curves as they have the benefit of being constant and linear. Because standard deviations are constant with each trend line, they are more conservative than if an increasing confidence interval was used. Figure 8.1-5 demonstrates the difference between confidence interval and standard deviation when used for a typical trend line analysis. The difference between $\pm 2\sigma$ and a 95% confidence interval is negligible and can't be seen on the normal scaled plot for SX-105 on the top plot. The calculated difference can only be noted when the much expanded scale shown in the lower plot is used. Surveillance Engineering is responsible for developing SST trend lines and for reviewing and approving them for use. For LOW readings, if a statistically valid increasing/decreasing trend line has been formally approved for use on the tank, $\pm 3\sigma$ is used as the specification limit for leak detection or

intrusion. For surface level readings the ± 0.5 , ± 1.0 , ± 2.0 , or ± 3.0 in. fixed limits (depending on the type of measurement gauge and the condition of the tank surface) are used as described in sections 6.1.1.1 to 6.1.1.4. For surface level readings the $\pm 2\sigma$ or $\pm 3\sigma$ values will be used only for engineering investigations.

When a trend is well established and the data is normally distributed about the trend, about 99% of measurements from a sound tank will be within the $\pm 3\sigma$ specification limit. This follows from Table IV of Wapole (1972). About 95% of the measurements from a sound tank will be within the $\pm 2\sigma$ specification limits.

When a reading falls below a -3σ or -2σ value, there are three possibilities.

- 1) The new reading is valid and simply a statistical outlier of the trended data population. On average, this occurs once in every 100 observations for a 3σ limit, or once in every 20 observations for a 2σ limit.
- 2) The new reading is invalid due to operator error or equipment malfunction. FICs often exhibit this problem following a new calibration, which can lead to data shifts. For ILL data, cable slippage leading to off-depth surveys is the most common offender.
- 3) The new reading is valid, but not part of the trended data population. This occurs when the repeated data points consistently fall below the -3σ tolerance. The data is truly anomalous, and indicates a possible leak.

For Interstitial Liquid Level measurements, readings between -2σ and -3σ below the baseline trend line may be repeated at the discretion of Surveillance Engineering depending on the trend of previous readings, appearance of the neutron scan, or other subjective factors relating to the tank and equipment. Values below -3σ must be repeated to verify or confirm the apparent level drop.

If a repeat reading yields a value within the -3σ specification limit, then 1) or 2) applies, and the repeat reading is considered more indicative of true level than the original. The tank is still considered to be sound. If the repeat reading yields a second value below -3σ , the first reading is validated (confirmed) and the out of specification reading is reported.

The chance of two consecutive data points being outside of the -3σ trended data population is about 1 in 10,000. The chance of two consecutive data points being outside of the -2σ trended data population is about 1 in 400. This assumes only normal statistical variations are involved with the readings, and no equipment malfunctions, data taking errors or legitimate changes in tank levels are responsible.

Trend lines and error bands can be prepared manually, but are normally prepared and analyzed automatically by computer. Manual techniques, PC-based

spreadsheets, or mainframe programs may be used as long as the correct mathematical formulas are applied.

Not all tanks have had trend lines and developed. Until a tank has a trend line established, the existing constant value baseline will be maintained.

8.1.1.3 Tank 241-C-106 Baseline

This tank represents a special leak detection case which must be evaluated differently than other tanks. It is a high heat tank that experiences an evaporation rate of about 2-2.5 inches/mo. Water is added to the tank on about a nominal monthly basis to maintain the liquid level within required limits. The tank has a liquid surface which is measured by an FIC. Because of the significant rate of change of the liquid level, it is impractical to directly use this rate of change for leak detection.

The method which has been selected for C-106 leak detection is to calculate the evaporation rate on a monthly basis and compare this to a baseline evaporation rate. Drywell scans will also be necessary around this tank to provide backup leak monitoring information due to the less precise method of leak detection provided by evaporation rate calculations when compared to liquid level measurements in other tanks.

The evaporation rate (assuming no leakage) is calculated by:

$$\text{Evaporation Rate} = \frac{\text{Volume Water Added During Time Period} + (2750 \times \Delta L)}{\text{Time Period}}$$

8-7

The evaporation rate (independent of leakage) can also be estimated from psychrometric and stack flow data.

To determine the historical average evaporation rate for C-106, each significant time interval between water additions since 1990 was analyzed, and the average evaporation rate calculated for each period. These values, and the C-106 liquid level, are plotted in Figure 8.1-6. Evaporation rates that varied from the average by more than $\pm 3\sigma$ were considered non-typical and were conservatively excluded from the data set when calculating the final average. Three calculated values were in this category. The ventilation system was out of service or the tank temperature elevated due to past no-ventilation periods during each of these periods. Data sets with less than 20 values between water additions were also excluded as being too small to give a solid basis for a calculated evaporation rate. The baseline evaporation rate for C-106 calculates to 198 gal/day as of May, 1994, with a standard deviation of ± 38 gal/day. A $\pm 2\sigma$ band will be used as an alert basis to initiate an internal investigation as to what could be causing the change in evaporation rate, and a $\pm 3\sigma$ band set as the specification limit. Based on assuming all the heat in the tank is generated by Sr^{90} with a half life of 28.4 years, the evaporation rate should drop by about 2.5%/yr. The slope of the line in Figure 8.1-6 is a little over -3%/yr.

S 106

Figure 8.1-1. Liquid Level in a Tank with a Fixed Value Baseline

Figure 8.1-2. Trend Line for Tank Experiencing an Increasing ILL Level Change

Figure 8.1-3. Trend Line for Tank Experiencing a Decreasing ILL Level Change

U 109

Figure 8.1-4. Trend Line for a Tank Exhibiting Significant Seasonal Variation in Observed Level Reading.

Figure 8.1-5. Comparison of Confidence Interval and Standard Deviation.

Figure 8.1-6. Tank 241 C-106 Level Data and Calculated Evaporation Rates

8.1.2 Radiation Baselines

A radiation baseline is set differently than a level baseline. For each drywell or lateral, a number of initial scans were taken. One of these initial scans was selected as the reference for each drywell or lateral, so that each location has its own, unique, baseline scan. The selection of which scan to use as the baseline was subjective. Each baseline was selected manually after comparing the initial scans for that location. The selected baseline was the one which appeared to be most typical.

Successive scans from a lateral or drywell are compared to the reference to see if radiation levels are increasing or the distribution in the soil is changing. Radiation scans used to be compared visually with the reference for that drywell or lateral. Most of the radiation baselines are now stored on computer. Counts within a given depth or lateral window for a scan are compared automatically with the baseline for that scan, and against a set specification limit.

Should a change occur in the radiation scan outside the specification limits, the change is investigated. If the investigation confirms that a permanent change has taken place, the new scan becomes the baseline, with future scans compared to it to identify additional increases.

8.2 Double Shell Tanks

Liquid level baselines are established and maintained for DSTs, but for purposes other than leak detection. The primary leak detection devices in DSTs are the annulus CAMs and the annulus conductivity probe leak detectors. A DST liquid level baseline will be used to confirm and quantify leaks identified by the primary leak detection devices, but is not required for initial leak detection.

Baseline values are not applicable to conductivity probes. They are an "on/off" type alarm.

Radiation data are kept for annulus CAM readings. These are total count readings which provide baseline values for comparative purposes. They vary somewhat from tank to tank due to the presence of natural decay products in the annulus air. WHC-IP-0842, Section 12.10 provides the guidelines for reviewing annulus CAM data and comparing it to baselines.

8.3 Catch Tanks and Receiver Tanks

The levels in many of these tanks can change frequently, so liquid level trend baselines with error bands are not useful for leak detection. Fixed value baselines are established for these tanks and liquid level data review done per WHC-IP-0842, Section 12.5. The information in 8.1.1.1 on fixed value baselines for SSTs is applicable to catch tanks and receiver tanks.

8.4 Transfer Lines

Baselines are not applicable to leak detectors for transfer lines. They are an "on/off" type alarm.

9.0 SPECIFICATION LIMITS AND GUIDELINES

This section provides the specification limits which are recommended to be used for leak detection monitoring. Reference is given following each specification limit to the location in this document where the basis for the specification limit can be found. This section also provides guidelines which are recommended to be used as good practices or to improve the quality of leak detection within tank farms, but which are not meant to be treated with the same degree of authority, as a specification limit.

Where applicable, these specification limits are formally implemented by OSD-T-151-00031, the Tank Farm Leak Detection Operating Specification Document. This OSD is to be the official document for implementing tank farm leak detection criteria, and for providing the appropriate response to take when a specification limit is exceeded. Where differences exist between the OSD and these technical bases, the OSD will remain the official interpretation.

9.1 Single Shell Tanks

9.1.1 Internal Tank Level Measurements

9.1.1.1 Manual Tapes

Specification Limits

- O Specification limits for single shell tank liquid levels, which have been measured with manual tapes, for tanks whose primary leak detection method is surface level detection using a manual tape, are ± 1.0 in. for tanks with a liquid surface, ± 2.0 in. for tanks with floating solids and ± 3.0 in. for tanks with a solid, conductive surface which is at least partially suspended on a liquid layer. These limits are measured from the reference baseline liquid level established for that tank. The lower limit shall apply to leak detection and the upper to intrusion.
- O Tanks with a liquid surface measured by a manual tape as the primary means of leak detection shall have the surface level measured at least once per 36 hours.

Basis The bases for the specification limit for level reading deviations are found in sections 6.1.1.1, 8.1.1.1, and 8.1.1.2. Section 7.1.1.1 provides the basis for the monitoring frequency.

9.1.1.2 Automatic Gauges (FIC)

Specification Limits

- Excluding Tank C-106, specification limits for single shell tank liquid levels, which have been measured with FICs, for tanks whose primary leak detection method is surface level detection using an FIC are ± 0.5 in. for tanks with a liquid surface (for tanks exhibiting significant seasonal observed level change, the minimum specification limit shall be ± 1.0 in.), ± 1.0 in. for tanks with floating solids and ± 3.0 in. for tanks with a solid, conductive surface which is at least partially suspended on a liquid layer. These limits are measured from the reference baseline liquid level established for that tank. The lower limits shall apply to leak detection and the upper limit shall apply to intrusion.
- Tanks with a liquid surface measured by an FIC as the primary means of leak detection shall have the surface level measured at least once per 36 hours.

Guidelines

- Single shell tanks equipped with FICs which do not use surface level measurement as the primary means of leak detection shall have the FIC set in the intrusion mode at 1 inch above the solid waste surface.

Basis The bases for the specification limit for level reading deviations are found in sections 6.1.1.2, 8.1.1.1, and 8.1.1.2. Section 7.1.1.1 provides the basis for the monitoring frequency. Section 6.1.1.2 provides the basis for the guideline for setting FICs in the intrusion mode.

9.1.1.3 Automatic Gauges (ENRAF)

Specification Limits

- Specification limits for single shell tank liquid levels measured with an ENRAF gauge shall be the same as those for FICs.

Basis ENRAF gauges are just being installed on SSTs at the time this document was being written. The gauges appear to be at least as accurate as FICs. Until sufficient data are available to derive new specification limits based upon the ENRAF gauge operability, it is reasonable to assume the values established for FICs can conservatively be applied to ENRAF operation as well.

9.1.1.4 Zip Cords

Specification Limits

- Specification limits for single shell tank liquid levels, which have been measured by zip cords are set at the same as those stated in 9.1.1.1 for manual tapes.

Basis Zip cord readings are normally used when manual tape or FIC readings are unavailable or in question. The accuracy of zip cord readings will normally be no greater than that provided by manual tape readings. Setting the limits the same as for manual tape readings is conservative.

9.1.1.5 In Tank Photography

Guidelines

There are no specification limits for in tank photography. However, it is recommended that the following be used as guidelines in determining when a tank should be photographed.

- For SSTs using surface level measurement as the primary means of leak detection, in tank photographs should be taken every two years, or when conditions are known to have occurred which could affect the ability of the surface level sensing device to correctly contact the surface.
- For SSTs with a non conductive surface and less than or equal to two feet of waste, in tank photographs should be taken every two years.
- For tanks with a non conductive surface and greater than two feet of waste, photos should be taken on request.

Basis The bases for these guidelines are given in 7.1.1.3.

9.1.1.6 Dip Tubes

Specification Limits

- Specification limits for single shell tank liquid levels, which are measured with saltwell dip tubes, for tanks whose leak detection method is liquid level measurement using dip tubes, are ± 2.7 in. This limit is measured from the reference baseline liquid level established for that tank. The lower limit shall apply to leak detection and the upper limit shall apply to intrusion.
- Tanks with a liquid level measured by dip tubes as the means of leak detection shall have the surface level measured at least once per 7 days.

Basis The basis for the level specification limit is given in 6.1.1.6. The monitoring frequency is discussed in 7.1.1.2.

9.1.1.7 Neutron Probe

Specification Limits

- O Single shell tank liquid levels, which have been calculated from data obtained with a neutron probe inside an LOW, and for which a trend line and $\pm 3\sigma$ error bars have been established shall have a specification limit set at $\pm 3\sigma$ from the trend line value. The lower limit shall apply to leak detection and the upper limit shall apply for intrusion.
- O Specification limits for single shell tank liquid levels, which have been calculated from data obtained with a neutron probe inside an LOW, and which have not had a trend line established, are ± 3.6 in.
- O The frequency for for monitoring 100 series SST LOWs with a neutron probe is set at at least once per 7 days. Gamma scans from LOWs are done on request. No LOW monitoring frequency is set at this time for 200 series SSTs.

Basis The basis for the specification limits for tanks without a trend line established is provided in sections 6.1.1.7 and 8.1.1.1. The basis for tanks with a trend line established is provided in 8.1.1.2. The basis for the monitoring frequency is provided in 7.1.1.2.

9.1.1.8 Gamma Probe

Specification Limits

There are no specification limits for using a gamma probe in an LOW.

Basis The gamma probe is only used in LOWs when trying to obtain additional data which may aid in interpretation of neutron probe data. As such, there are no formal requirements. See 6.1.1.8 for further information.

9.1.1.9 Tank C-106

Specification Limits

- O The specification limit for Tank C-106 evaporation rate shall be $\pm 3\sigma$ from the baseline evaporation rate.
- O The Tank C-106 evaporation rate shall be calculated at least once per 92 days.

Basis The evaporation rate basis is discussed in 8.1.1.3. WHC-SD-WM-OSR-005 lists no defined monitoring frequency between 31 and 92 days. It is not expected that 92 days shall elapse between calculation periods for the evaporation rate. The procedure for calculating the evaporation rate shall call for its calculation on a nominal monthly basis. The frequency requirement is set at at least once per 92 days rather than the nominal monthly basis it will actually be checked at, to allow for periods when the exhaustor may be down or when temperature changes/level fluctuations make calculation of an evaporation rate impractical or of questionable value.

9.1.2 External Tank Leak Detection

9.1.2.1 Drywells

Specification Limits and Guidelines

The items listed below shall only apply as specification limits when drywell monitoring is being used as a formal means of leak survey for a tank. At all other times these items shall be used as guidelines. When drywell monitoring shall be used for formal means of leak survey for a tank shall be specified in OSD-T-151-00031.

- When using the Gross Count Scintillation "#4 or S Probe" to monitor drywells which have previously shown low baseline radiation levels, the specification limit/guideline is that the radiation count rate within a reference depth interval should double the baseline value and be above 200 c/s. This assumes a reference depth interval of approximately 12 in.
- When using the High Sensitivity Geiger-Muller "Type 1 or Green Probe" to monitor drywells where the baseline radiation levels exceed the operating range of the "#4 or S Probe", the specification limit/guideline is that the radiation count rate within a reference depth interval must triple for baseline count rates <1,000 c/s, and double for baseline count rates above 1,000 c/s. This assumes a reference depth interval of approximately 12 in.
- For tanks where drywell scans are required as a formal means of leak survey, scans shall be obtained at least once per 31 days in both east and west area, unless the tank contains less than two feet of waste, in which case scans shall be done yearly. For tanks where drywell scans are not required as a formal means of leak survey, drywell monitoring shall be done on request.

Basis The bases for the probes to use and recommended sensitivities are found in 6.1.2.1. The basis for the monitoring frequency is given in 7.1.2.1. Reference baselines are covered in 8.1.2.

9.1.2.2 Laterals

Specification Limits and Guidelines

The items listed below shall only apply as specification limits when lateral monitoring is being used as a formal means of leak survey for a tank. At all other times these items shall be used as guidelines. When lateral monitoring shall be used for formal means of leak survey for a tank shall be specified in OSD-T-151-00031.

- When using the the Geiger-Muller "Green or Type 1" Probe to monitor laterals which have previously shown background or very low radiation levels, the specification limit/guideline is that if the normal baseline is <12 c/s the radiation count rate, within a reference depth interval, must increase by 10 c/s and exceed 12 c/s. When the baseline exceeds 12 c/s, the radiation count rate, within a reference depth interval, must increase by 50%. This assumes a reference depth interval of approximately 12 in.

- For tanks where lateral scans are required as a formal means of leak survey, scans shall be obtained at least once per 31 days. For tanks where lateral scans are not required as a formal means of leak survey, scans shall be performed on request.

Basis The bases for the probes to use and recommended sensitivities are found in 6.1.2.2. The bases for the monitoring frequency guidelines are given in 7.1.2.2. Reference baselines are covered in 8.1.2.

9.1.2.3 Leak Detection Pits

Specification Limits and Guidelines

The items listed below shall only apply as specification limits when leak detection pit monitoring is being used as a formal means of leak survey for a tank. At all other times these items shall be used as guidelines. When leak detection pit monitoring is required as a formal means of leak survey for a tank shall be specified in OSD-T-151-00031.

- Either a level indicator or the radiation probe shall be operational in each AX farm leak detection pit.
- A rise in an AX farm leak detection pit liquid level of >8 in. shall be investigated.
- A rise in an AX farm leak detection pit radiation level ≥ 3 times the background for that pit shall be investigated.
- When being used as a formal means of leak survey the level in an AX farm leak detection pit shall be read at least once per 36 hours.
- When used as a formal means of leak survey the radiation alarm for an AX farm leak detection pit shall activate remotely or the radiation level must be read daily.

Basis The bases for changes in the liquid or radiation level are given in 6.1.2.3. Monitoring frequencies are covered in 7.1.2.3.

9.2 Double Shell Tanks

9.2.1 Internal Tank Measurements

There are no specification limits for DST leak detection based on internal tank measurements.

9.2.2 External Tank Measurements

9.2.2.1 Annulus CAMs

Specification Limit

- Filter papers removed from an annulus CAM following a verified alarm shall be counted for radionuclides. If the filter paper shows the presence of long lived radionuclides which may be indicative of a tank leak, it shall be analyzed for specific radioisotopes present.

- Requirements for equipment operability shall be as called for in WHC-SD-WM-SAR-016 and WHC-SD-HS-SAR-010 until superceded by those in WHC-SD-WM-OSR-004 and WHC-SD-WM-OSR-016.

Basis The bases for the annulus CAM radiation level alarm point and response to an alarm is discussed in 6.2.2.1. The operability requirements are covered in 5.4.1 and 5.4.2.

Guidelines

- Annulus CAM radiation levels should be read and recorded on a daily basis. Readings above 3X normal background for that annulus CAM should be reported to operations management.

Basis The surveillance guideline is from 6.2.2.1. Baseline radiation levels for annulus CAMS are described in 8.2. The frequency requirement is covered in 7.2.1.1.

9.2.2.2 Annulus Conductivity Probes

Specification Limits

- All annulus variable height conductivity probes shall be set at 0.125 in. (-0.125 in., +0.375 in.) off the annulus bottom.
- All unplanned annulus conductivity alarms or evidence of unexpected liquid in an annulus shall be investigated.
- Requirements for equipment operability shall be as called for in WHC-SD-WM-SAR-016 and WHC-SD-HS-SAR-010 until superceded by those in WHC-SD-WM-OSR-004 and WHC-SD-WM-OSR-016.

Basis The basis for the probe heights is covered in 6.2.2.3. Response to unplanned alarms is covered in 6.2.2.2 and 6.2.2.3. The operability requirement is covered in 5.4.1 and 5.4.2.

9.2.2.3 Leak Detection Pits

Specification Limits and Guidelines

There are no annulus leak detection pit specification limits, for leak detection, until a DST is confirmed to be leaking. See OSD-TO-151-00007 for requirements not related to leak detection. When a DST is known to contain waste leaked from the primary tank, the operability requirements of WHC-SD-WM-OSR-004 and WHC-SD-WM-OSR-004 shall apply, and the specification limits discussed in 6.2.3.1 shall be "activated".

9.3 Catch Tanks and Receiver Tanks

9.3.1 Double Contained Receiver Tanks

Specification Limits

- Leak detection equipment in the secondary containment shall be operable whenever liquid is in the primary tank, or level detection equipment in the primary tank must be operable. (See note below.)
- Specification limits for sumps measured with an FIC is +0.5 in. above the baseline value. Specification limits for all other sump level measurement methods is +1.0 in. above the baseline value.

- All sump leak detector alarms or level increases exceeding the specification limits must be investigated.
- When sump level measurement is done, readings shall be taken at least once per 36 hours.
- When leak detection equipment in the secondary containment is out of service, and liquid is present in the primary tank, primary tank surface level measurements shall be taken at least once per 36 hours. (See note below.)
- Where primary tank surface level measurement is used for leak detection, the specification limit is -0.5 in. below the baseline value for levels measured with an FIC, and -1.0 in. below the baseline value for all other level measurement methods. (See note below.)

NOTE: Assuming no wording changes are made, when LCO 3.5.2 of WHC-SD-WM-OSR-005 is implemented, it will no longer be acceptable to use DCRT primary tank liquid level measurement as a backup leak detection method.

Basis The bases for the measurement limits and requirements are given in 6.3.1. Frequency requirements are given in 7.3.1. Section 8.3 discusses baselines.

9.3.2 Catch Tanks with Secondary Containment

Specification Limits

- Leak detection equipment in the secondary containment shall be operable whenever liquid is in the primary tank, or level detection equipment in the primary tank must be operable.
- When sump level measurement is done, readings shall be taken at least once per 36 hours.
- Specification limits for sumps measured with an FIC is +0.5 in. above the baseline value. Specification limits for all other sump level measurement methods is +1.0 in. above the baseline value.
- All sump leak detector alarms or level increases exceeding the specification limits must be investigated.
- When leak detection equipment in the secondary containment is out of service, and liquid is present in the primary tank, surface level measurements shall be taken at least once per 36 hours.
- Where primary tank surface level measurement is used for leak detection, the specification limit is -0.5 in. below the baseline value for levels measured with an FIC, and -1.0 in. below the baseline value for all other level measurement methods.

Basis The bases for the measurement limits and requirements are given in 6.3.2. Frequency requirements are given in 7.3.2. Section 8.3 discusses baselines.

9.3.3 Catch Tanks without Secondary Containment

Specification Limits

- O Level detection equipment for the tank shall be operable whenever liquid is present in the tank.
- O When liquid is present in the primary tank, surface level measurements shall be taken at least once per 36 hours.
- O The specification limit is -0.5 in. below the baseline value for levels measured with an FIC, and -1.0 in. below the baseline value for all other level measurement methods.
- O All level decreases exceeding the specification limits shall be investigated.

Basis The bases for the measurement limits and requirements are given in 6.3.3. Frequency requirements are given in 7.3.3. Section 8.3 discusses baselines.

9.4 Transfer Lines

Specification Limits

- O Requirements for equipment operability shall be as called for in WHC-SD-WM-SAR-016 and WHC-SD-HS-SAR-010 until superceded by those in WHC-SD-WM-OSR-004 and WHC-SD-WM-OSR-016.
- O See OSD-T-151-00010 for pressure testing requirements for direct buried lines and the cross-site transfer line.
- O Transfers should not be made through a pipe-in-pipe encasement with an encasement drain valve in the HYDRO position.

Basis See 5.4.1 and 5.4.2 for operability basis. Section 6.4 discusses pressure testing and valving requirements.

Guidelines

- O Transfer procedures should include material balance checks where practical during transfers.
- O The liquid level in all catch tanks along a transfer route should be monitored during a transfer.

Basis See section 6.4.

10.0 Glossary of Terms

ATG Displacer Gauge

Enraf-Nonius 854 Advanced Technology Gauge used to measure in-tank surface level. When weight (displacer) on end of stainless steel wire reaches surface, change in wire tension and length of released wire determines distance to surface.

Automatic Gauge

See FIC Gauge below, and ATG Displacer Gauge above.

CAM

Continuous Air Monitor installed on DST annulus to detect waste leakage by continuously monitoring the air flow for the presence of gamma radiation emitters.

CASS

Computer Automated Surveillance System which receives and processes data from surveillance instruments, such as, thermocouples, radiation alarms, waste surface levels, dry well scans, lateral scans, and LOW scans.

Catch Tanks

Tanks installed on tank farms to collect water, snow melt, and transfer piping leakage from diversion boxes. Also known as auxiliary tanks.

Conductivity Probe

Leak detection device used to measure liquid surface level of waste in a tank or monitor for the presence of liquid waste in a leak detection facility. The liquid must be electrically conductive, since it completes the electrical circuit.

DCRT

Double Containment Receiver Tank. Steel tank located underground and surrounded by a concrete containment vault with an integral sump. Used as temporary storage during tank-to-tank transfer of liquid waste.

Detection Limit

The smallest change in the measurable quantity which is discernable by the instrument or device.

Dip Tubes

Three metal pipes of differing lengths used in weight factor determination of specific gravity and liquid level in a tank or sump. Difference in pressure required to transmit air through the pipes is used to calculate desired data.

Drywells

Vertical boreholes in the ground near the underground waste storage tanks that range up to 250-ft deep, but do not penetrate the water table. Gamma and neutron probes are lowered into the dry wells to monitor the surrounding soil for liquid waste leakage.

DST

Double Shell Tank used to store liquid waste underground and designed with a secondary containment shell to hold the tank inventory in the event of primary tank leak or rupture, and to allow the detection and removal of waste leakage.

EPA

The United States Environmental Protection Agency.

FIC Gauge

Automatic liquid level measuring gauge manufactured by the Food Instrument Company (FIC) and now manufactured by Robertshaw. Gauge is permanently installed to a dedicated tank riser and automatically raises and lowers a conductivity electrode (plummet) which completes an electrical circuit when contacting a conductive surface and transmits surface level measurement to CASS.

Flake Gauge

A permanently installed, but manually operated, liquid level gauge utilizing a housing (Flake housing design) for the tape reel which incorporates a sight glass to read the tape. See Manual Tape Gauge definition, below.

Floating Crust

A waste condition within the storage tank where the solid phase is unstable and floats on the liquid. The surface level may still be responsive to a leak event and can be used for leak detection surveillance.

Gamma Probe

A number of Geiger-Muller or scintillation designs that are used to monitor gamma radiation in the soil around and beneath the underground storage tanks, via dry wells and laterals, and in the stored waste, via in-tank liquid observation wells (LOW's), as part of the leak detection surveillance program.

Gross Count Scintillation Probe

A detector with optimum sensitivity to gamma emitters which is used as the primary tool for dry well monitoring.

In-tank Photography

Periodic photographic monitoring of the condition of the waste surface inside a tank to validate the type of surface level monitoring being used.

Interstitial Liquid

In-tank liquid waste which is held within the open interstitial regions of a porous solid waste phase. Most estimates of the open porosity of solid waste have ranged from 35% to 50%.

Interstitial Liquid Level

The average level of the interstitial liquid in a tank as determined by neutron and gamma probes lowered into Liquid Observation Wells (LOW's) which penetrate the waste mixture.

Laterals

Horizontal drywells located beneath some underground waste storage tanks and accessible through a vertical shaft adjacent to the tank. Radiation probes are lowered into the laterals to monitor the surrounding soil for waste leakage.

Leak Detection Pit

A vertical large-diameter waste-collection shaft located adjacent to an underground waste storage tank for the collection of any liquid accumulating on the concrete base beneath the tank (outermost shell of a DST). The accumulated waste flows along a pattern of grooves in the base and through a pipe connected to the pit where its presence is detected by weight factor instrumentation and a radiation monitor.

LOW

Liquid Observation Well. A closed-bottom tube which is installed through a riser and extends to within a nominal one inch of the tank bottom. Neutron and gamma probes are lowered into the LOW to provide a measurement of the interstitial liquid level in the tank.

Manual Tape Gauge

A waste surface level measurement device consisting of a conductivity electrode, a calibrated steel tape and a tape reel. Tape readings are obtained manually using a portable electrical conductivity meter to indicate surface contact.

Measurement Precision

Repeatability of measuring and reporting a value. The degree of agreement within a set of observations.

Neutron Probe

Combined fast neutron source and thermal neutron detector used to determine moisture content of soil surrounding drywell or of waste surrounding LOW as a measurement of the interstitial liquid level. Operates on principle that hydrogen contained in the liquid waste produces thermal neutrons when bombarded by fast neutrons.

OSD

Operating Specification Document

Plummet

A metal weight suspended on the calibrated tape of a manual or automatic gauge which acts as the surface-contacting electrode. Can also be the weight suspended on the zip cord.

Receiver Tanks

Tanks used for the interim holding of waste during tank-to-tank transfers. These can be tanks designed for this purpose, such as the DCRT's, or other tanks simply used as receivers.

Reference Baseline Level

A reference baseline level for a waste storage tank must be established after pumping into or out of the tank. This then becomes the level against which readings are compared to determine if leakage, in or out of the tank, has occurred. If waste transfers are made, a new reference must be established, and so on.

Salt Cake

A dry salt compound which has precipitated from the stored liquid waste and remains in the tank.

Salt Cake Porosity

The interconnected, open porosity of the precipitated salt compound inside the waste storage tank. The porosity estimates have ranged from 35% to 50%, by volume. If a liquid phase is contained in this void matrix, it is called interstitial liquid waste.

Slack Tape Reading

The measurement of the level of a solid waste surface using a zip cord, a manual tape gauge, or an FIC. This is the tape reading when the tape "goes slack" as the weight becomes supported by the solid surface as it is lowered.

Sludge

Insoluble waste solids contained in a waste storage tank. The sludge is heavier than the liquid and settles to the bottom.

SST

Single Shell Tank used to store waste underground. At Hanford, these are the older tanks constructed prior to 1965 having a single steel liner encased in reinforced concrete.

Tank Riser

Access pipes penetrating the top of the waste storage tank and extending to above ground. Virtually all tank activities utilize these risers.

Technical Bases

The essential principles (scientific, or otherwise) which are cited to support the use of or to establish specification limits or frequencies for a leak detection method or device.

USDOE

United States Department of Energy. The department of the federal government having responsibility and authority for the Hanford facility and operations.

Weight Factor

See Dip Tubes

WSDOE

Washington State Department of Ecology. The state department having jurisdiction for the environmentally safe storage and handling of waste at Hanford.

Zip Cord

A portable device used to measure the liquid level in the waste storage tanks. A weight, a premarked conductive cord, and a portable conductivity meter are used to determine the liquid level.

11.0 References

Peters, T.J., Park, W.R., and Cuta, F.M., June 1993. Evaluation of Methods to Measure Surface Level in Waste Storage Tanks. PNL-8687.

Isaacson, R.E. September 1982. Supporting Information for the Scientific Basis for Establishing Dry Well Monitoring Frequencies. RHO-RE-EV-11.

Walker, C.M., September, 1982. Development of an Interstitial Liquid Level Measurement Technique for Use in the In-Tank Liquid Observation Wells (LOW). SD-WM-PTR-001.

Walpole, R.E., and Myers, R.H., Probability and Statistics for Engineers and Scientists, The Macmillan Company, New York, NY 1972.

Stong, F.S., 1986 Drywell Van In-Tank Observation Well Surveillance Data Interpretation. RHO-RE-WM-TI-237.

Isaacson, R.E., and Gasper, K.A., December 1981, A Scientific Basis for Establishing Dry Well-Monitoring Frequencies. RHO-ST-34.

Godfrey, S.D. to J. K. Kaspar, July 21, 1993. SST Leak Detection Work Plan. Internal Memorandum 7C240-93-050.

Johnson, M.G. to Distribution, May 23, 1994. User Manual for Interstitial Liquid Level Interpretation Software. Internal Memorandum 7CF60-94-005.

United States Department of Health, Education and Welfare, January 1970. Radiological Health Handbook.

G.L. Dunford, April 25, 1988. Bases for Response Action Criteria Applied to the Surveillance of Underground Waste Storage Tanks. WHC-SD-WM-TI-332.

Appendix A

Table A-1 **Manual Tape Gauge**
Surface Level Measurements

Technical Basis Tables

<p>Type of Surveillance:Waste Volume in Tank</p> <p>Method: Surface Level Measurement</p> <p>Device: Manual Tape Gauge or Level Indicator (LI)</p> <p>Principle of Operation: Probe is lowered until contact with electrically conductive surface completes circuit.</p> <p>Indicating Event: DC meter deflection for conductive surface.</p> <p>Manual Reading: Nearest 1/4 in. on steel tape</p> <p>Automatic Reading: N/A</p> <p>Technical Basis for using device for leak detection</p> <p>Proven technology, uncomplicated, direct measurement, good backup to automated device, adequate precision</p>		
Applications	Precision (±) Possible Actual	Specification Limits
1. Liquid surface 2. Floating solids 3. Moist solid 4. Monitoring frequency	1/8 in. 1/2 in. 1/8 in. 1 in. 1/8 in. ---	1. -1.0 in. 2. -2.0 in. 3. -3.0 in. 4. Daily
<p style="text-align: center;">Basis Statements</p> <p>1. The earliest "actual" precision (for liquid) was set at ±1/4 in., but resulted in many false calls. Data from all individuals, all tanks, and all conditions showed a "spread" of ±1/2 in. which has been used as a measurement precision ever since. The limit is twice the precision.</p> <p>2. For a floating crust, combining in-tank photography with the fluctuations in "liquid level" data for all conditions showed a spread of ±1 in. which has since been the established measurement precision.</p> <p>3. For a moist conductive surface, the limit was set based on in-tank photography and subjective observation of reading variations.</p>		

Table A-2 **FIC Gauge**
Surface Level Measurement

Technical Basis Tables

Type of Surveillance: Waste Volume in Tank Method: Surface level measurement Device: Automatic Level Gauge or FIC or Level Indicating Transmitter (LIT) Principle of Operation: Probe is lowered until contact with electrically conductive surface completes circuit. Indicating Event: Downward motion of plummet automatically stops during break/re-make contact cycle Manual Reading: Nearest 0.05 in. from xxx.xx counter after two consecutive readings agree Automatic Reading: CASS automatically records: IN. LIQUID LEVEL FOR TANK (ID) is xxx.xx inches (date) (time) Technical Basis for using device for leak detection Proven technology, uncomplicated, unattended automated measurement capability over manual tape device			
Applications	Precision $\pm$		Specification Limits
	Possible	Actual	
1. Liquid surface	0.01 in.	0.25 in.	1. -0.5 in.
2. Floating solids	0.01 in.	0.5 in.	2. -1.0 in.
3. Moist solid	0.01 in.	---	3. -3.0 in.
4. Monitoring frequency			4. Daily
<p style="text-align: center;">Basis Statements</p> 1. The vendor claimed a precision (for liquid) of 0.01 in. and a limit of -0.03 in. was first used but resulted in many false calls. After considering the effects of known variables on the gauge readings, the actual precision was established to be ± 0.25 in.. which has been used as a measurement precision ever since. The limit is twice the precision. 2. For a floating crust, combining in-tank photography with the fluctuations in "liquid level" data for all conditions showed a spread of ± 0.5 in. which has since been the established measurement precision. 3. For a moist conductive surface, the limit was set based on in-tank photography and subjective evaluation of reading variations.			

Table A-3 Zip Cord
Surface Level Measurements

Technical Basis Tables

<p>Type of Surveillance: Waste Volume in Tank</p> <p>Method: Surface Level Measurement</p> <p>Device: Zip Cord</p> <p>Principle of Operation: Operator watches DC meter as probe is lowered</p> <p>Indicating Event: DC meter deflection for conductive surface</p> <p>Manual Reading: Nearest 1/4 in. measured from closest incremental mark on cord.</p> <p>Automatic Reading: n/a</p> <p>Technical Basis for using device for leak detection</p> <p>Proven technology, uncomplicated, direct measurement, only backup to other devices, very reliable</p>		
Applications	Precision ± Possible Actual	Specification Limits
<p>1. Liquid surface</p> <p>2. Floating solids</p> <p>3. Moist solid</p> <p>4. Monitoring frequency</p>	<p>1. Undocumented</p> <p>2. "</p> <p>3. "</p>	<p>1. -1.0 in.</p> <p>2. -2.0 in.</p> <p>3. -3.0 in.</p> <p>4. Daily</p>
<p>Basis Statements</p> <p>1.-3. The technical bases for the specification limits are the same as for the manual tape.</p>		

**Table A-4 Displacer Gauge
 Surface Level Measurement**

Technical Basis Tables

Type of Surveillance: Waste Volume in Tank

Method: Surface level measurement

Device: Enraf-Nonius 854 Advanced Technology Gauge (ATG)

Principle of Operation: Bouyancy of suspended weight (displacer) changes tension in 0.007-inch stainless steel wire.

Indicating Event: Displacer is immersed in liquid or touches solid surface.

Manual Reading: Digital readout in field to nearest 0.1 in. or 0.01 in.

Automatic Reading: Data acquisition system automatically records surface level at preset times and compensates for crystal buildup on displacer.

Technical Basis for using device for leak detection

Surface level measurement does not depend on conductivity, can measure either solid or liquid surface, unattended measurement is possible, highly accurate.

Applications	Precision $\pm$		Specification Limits
	Possible	Actual	
1. Liquid surface	0.01 in.	TBD	1. same as FIC
2. Floating solids	TBD	TBD	2. same as FIC
3. Moist solid	TBD	TBD	3. same as FIC

Basis Statements

1.-3. Based on vendor data and early experience with installed unit, it appears unit will be as least as accurate as FIC.

Table A-5 **LOW - Neutron Probe**
Interstitial Liquid Measurement

Technical Basis Tables

Type of Surveillance: Waste Volume in Tank Method: Interstitial liquid measurement Device: Neutron Probe Principle of Operation: Hydrogen in aqueous solutions slows fast neutrons to produce thermal neutron flux. Indicating Event: Thermal neutron profile shows interstitial liquid level Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection Utilizes existing equipment & procedures, data previously unavailable, accommodates future waste conditions.		
Applications	Precision $\pm$ Possible Actual	Specification Limits
1. Interstitial liquid 2. Scan Interval	1.2 in. 2.4 in.	1. -3.6 in. (*) 2. Series 100: weekly Series 200: TBD
<p align="center">Basis Statements</p> <p>1. The total system capability of ± 2.4 in. was established by adding system errors (± 1.2 in.) and interpretation errors. The interpretation precision (± 1.2 in.) was derived from 5 individuals interpreting the same 14-scan sets of randomly selected scans. The limit is based on 1.5 times the actual precision obtainable.</p> <p>(*) Alternatively, the limit may be set at -2X std deviation from trend line for alert limit and -3X std deviation for specification limit.</p>		

Table A-6 **LOW - Gamma Probe**
Interstitial Liquid Measurement

Technical Basis Tables

Type of Surveillance: Waste Volume in Tank Method: Interstitial liquid measurement Device: Gamma Probe Principle of Operation: Detects gamma emitters which are in the liquid phase Indicating Event: Gamma profile shows interstitial liquid level Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection Utilizes existing equipment & procedures, data previously unavailable, accommodates future waste conditions.		
Applications	Precision ± Possible Actual	Specification Limits
1. Interstitial liquid 2. Scan Interval	1.2 in. 2.4 in.	1. n/a 2. As requested
<p align="center">Basis Statements</p> 1. The Gamma Probe is used to provide supporting information for the routine Neutron Probe scans. The basis for relegation to a support status is that the interpretation of the air/liquid interfaces in gamma scans is normally not as exact as those for neutron scans.		

Table A-7 **Probe Type 4 - Scintillation**
 Dry Well Leak Detection

Technical Basis Tables

Type of Surveillance: External Leak Detection Method: Drywell soil scan Device: Probe Type 4: Scintillation "S Probe" Principle of Operation: Detects gamma emitters which are prevalent in liquid waste and move with the migrating leakage. Indicating Event: Scan profile of radiation vs depth shows presence of liquid waste Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection: Utilizes existing equipment & procedures, high signal to background ratio, earliest dry well detection of leak event.		
Applications	Precision $\pm$ Possible Actual	Specification Limits
1. Soil scan for liquid waste leak migration 2. Monitoring frequency	10 c/s 20 c/s	1. Radiation level must double and exceed 200 c/sec. 2. Monthly if required, or on request.
<p style="text-align: center;">Basis Statements</p> 1. <u>Radiation Level.</u> The criteria is based on an increase of two times the normal background or a level of existing contamination. In the case of a doubling of level without reaching 200 c/s, then all pertinent surveillance information will be reviewed to determine the need for an increased monitoring frequency. Criteria based on factors which are not all applicable anymore, but criteria is still useful within the limits used.		

Table A-8 Geiger-Muller Green Probe (Type 1)
Dry Well Leak Detection

Technical Basis Tables

Type of Surveillance: External Leak Detection Method: Drywell soil scan Device: Probe Type 1: High Sensitivity Geiger-Muller Green Probe Principle of Operation: Detects gamma emitters which are prevalent in liquid waste and move with the migrating leakage. Indicating Event: Scan profile of radiation vs depth shows presence of liquid waste. Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection: Utilizes existing equipment & procedures, more range than the Scintillation probe.		
Applications	Precision $\pm$ Possible Actual	Established Limits
1. Soil scan for liquid waste leak migration 2. Monitoring frequency	5 c/s 10 c/s	1. Radiation level must triple. 2. Monthly, when required.
Basis Statements These statements are the same as for the Scintillation Probe. 1. <u>Radiation Level.</u> The criteria is based on an increase of three times the normal background or a level of existing contamination. The provision of a count limit above a definable change is to provide for a data trend analysis during a preliminary investigation.		

Table A-9 **Geiger-Muller Red Probe (Type 2)**
Dry Well Leak Detection

Technical Basis Tables

Type of Surveillance: External Leak Detection Method: Drywell soil scan Device: Probe Type 2: High Level Geiger-Muller, "Red GM" Principle of Operation: Gamma emitters are prevalent in liquid waste and move with the migrating leakage. Indicating Event: Scan profile of radiation vs depth shows increased presence of liquid waste. Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection: Used for leak plume monitoring, not leak detection. Highly shielded and tailored for a high radiation field. Has a functional range of >300 R/hr.		
Applications	Precision ± Possible Actual	Established Limits
1. Soil scan for leak plume monitoring	7 c/s Not provided	1. None.
Basis Statements		
There are no basis statements provided for this probe.		

Table A-10 **Neutron Soil Moisture Probe (Type 3)**
Dry Well Leak Detection

Technical Basis Tables

Type of Surveillance: External Leak Detection Method: Drywell soil scan Device: Probe Type 3: Soil Moisture Monitor-Neutron Probe Principle of Operation: Hydrogen in aqueous solutions slows fast neutrons to produce thermal neutron flux. Indicating Event: Scan profile of radiation vs depth shows presence of moisture indicative of liquid waste. Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection: Utilizes existing equipment & procedures, provides back-up to the gamma probes.		
Applications	Precision $\pm$ Possible Actual	Established Limits
1. Soil scan for moisture content	not provided	none
<p style="text-align: center;">Basis Statements</p> There are no basis statements for this probe. 1. <u>Monitoring Frequency.</u> Alternate scans with this probe and a gamma probe are sometimes specified.		

Table A-11 Geiger-Muller Green Probe (Type 1)
Lateral Leak Detection

Technical Basis Tables

Type of Surveillance: External Leak Detection Method: Lateral drywell soil scan Device: Probe Type 1: High Sensitivity Geiger-Muller Green Probe Principle of Operation: Detects gamma emitters which are prevalent in liquid waste and move with the migrating leakage. Indicating Event: Scan profile of radiation shows presence of liquid waste. Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection: Utilizes existing equipment & procedures, most sensitive probe for lateral leak detection		
Applications	Precision $\pm$ Possible Actual	Established Limits
1. Soil scan for liquid waste leak migration 2. Frequency	5 c/s 10 c/s	1. Radiation level must increase by 10 c/s and exceed 12 c/s. At high background, must increase by 50%. 2. Monthly, when required
Basis Statements These specification limits were empirically derived to indicate that a significant change has occurred and to provide time for a preliminary investigation.		

Table A-12 **Geiger-Muller Green Probe (Type 2)**
Lateral Leak Detection

Technical Basis Tables

Type of Surveillance: External Leak Detection Method: Lateral drywell soil scan Device: Probe Type 2: Geiger-Muller Green Probe Principle of Operation: Gamma emitters are prevalent in liquid waste and move with the migrating leakage. Indicating Event: Scan profile of radiation shows presence of liquid waste. Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection: Utilizes existing equipment & procedures, Used primarily to monitor activity when considerable gamma radiation is present.		
Applications	Precision (+/-) Possible Actual	Established Limits
1. Soil scan for liquid waste leak migration	undocumented N/A	none
<p align="center">Basis Statements</p> <p>There are no basis statements provided for this probe.</p>		

Table A-13 **Geiger-Muller Red Probe**
Lateral Leak Detection

Technical Basis Tables

Type of Surveillance: External Leak Detection Method: Lateral drywell soil scan Device: Geiger-Muller Red Probe Principle of Operation: Gamma emitters are prevalent in liquid waste and move with the migrating leakage. Indicating Event: Scan profile of radiation shows presence of liquid waste. Manual Reading: n/a Automatic Reading: Compilation of profile data Technical Basis for using device for leak detection: Utilizes existing equipment & procedures, Used primarily to monitor migration of existing contamination.		
Applications	Precision $\pm$ Possible Actual	Specification Limits
1. Soil scan for liquid waste leak migration	undocumented N/A	none
Basis Statements		
There are no basis statements provided for this probe.		

Table A-14 **Weight Factor/Specific Gravity Gauge
Saltwell Screens and Leak Detection Pits**

Technical Basis Tables

Type of Surveillance: Internal Leak Detection-Selected SSTs with Saltwell Screens and Certain Catch Tanks or Other Vessels.

Method: Surface level measurement

Device: Dip Tube Gauge for weight factor and specific gravity

Principle of Operation: Difference in bubbling pressure among 3 tubes depends on weight factor (liquid level) and specific gravity.

Indicating Event: Converted pressure readings show liquid level changes in saltwell screen or liquid level and SpG changes in leak detection pit.

Manual Reading: Within 0.1" for saltwell screen recorder printout, 0.5" reading (one half dial increment) for leak detection pit.

Automatic Reading: Pressure differences automatically converted to inches of liquid and specific gravity readings.

Technical Basis for using device for leak detection:
Proven technology, all sensors outside of leak detection area.

Applications	Precision $\pm$ Possible Actual	Specification Limits
1. Saltwell screen level drop or leak detection pit level and SpG rise.	Varies with errors associated with transmitter/recorder, and instrument ranges	1. Saltwell dip tubes -2.7 in. 2. Leak Detection Pit +8.0 in.

Basis Statements

1. Saltwell screen limits based on vendor data for transmitter and recorder, and instrument range.
2. Leak Detection Pit limit based upon past experience with water intrusions.
3. There is no limit or basis statement provided for specific gravity readings.

Table A-15 **Radiation Monitor**
Leak Detection Pits

Technical Basis Tables

Type of Surveillance: External Leak Detection Method: Leak Detection Pit Device: Geiger-Muller Gauge in radiation dry well Principle of Operation: GM sensor will detect increase in radiation level of liquid in pit which would indicate a leak. Indicating Event: Increased level of gamma radiation. Manual Reading: n/a Automatic Reading: Radiation level is continuously monitored. Technical Basis for using device for leak detection: Proven technology, only direct measurement in pit, 2-sensor probe has large range.		
Applications	Precision ± Possible Actual	Specification Limits
1. Monitors gamma radiation in pit	(unknown) 100 c/min	1. 3X background
Basis Statements		
1. Specification limit based on past experience with background varying by ±50% over a year.		

Table A-16 **CAM-Continuous Air Monitor**
Annulus Leak Detection

Technical Basis Tables

Type of Surveillance: Annulus Leak Detection Method: Air Monitor Device: Gamma radiation monitor Principle of Operation: Detects airborne radioisotopes in annulus, if present. Indicating Event: Level of gamma radiation. Manual Reading: n/a Automatic Reading: Radiation level is continuously monitored. Technical Basis for using device for leak detection: Proven technology, direct measurement, straight forward maintenance requirements.		
Applications	Precision $\pm$ Possible Actual	Established Limits
1. Monitors gamma radiation in annulus	(unknown) (unknown)	1. 3X background for notification. 2. Count filter paper following CAM alarm
<p style="text-align: center;">Basis Statements</p> <p>Data from the radiation monitors in the various tank annuli were used to set the specific limits. Normal fluctuations were found to be $\pm$ two times the background. High airborne reading requires a filter count.</p>		

Table A-17 **Fixed Conductivity Probes**
Annulus Leak Detection

Technical Basis Tables

Type of Surveillance: Annulus Leak Detection Method: Detection of liquid waste on annulus floor Device: Conductivity Probes Principle of Operation: Presence of electrically conductive liquid completes circuit at electrodes. Indicating Event: Alarm annunciation or closed circuit for multi-position switch. Manual Reading: 17-position selector switch to determine liquid level. Automatic Reading: Annunciator sounds if liquid is present. Technical Basis for using device for leak detection: Proven technology, direct measurement, wide range, uncomplicated circuitry.		
Applications	Precision (+/-) Possible Actual	Specification Limits
1. Monitors presence of liquid in annulus	+/- 1/16 in. (unknown)	1. 1/8 in. off floor
<p style="text-align: center;">Basis Statements</p> <p>1. This is the lowest elevation off tank floor readily attainable.</p>		

Table A-18 Adjustable Conductivity Probes
Annulus Leak Detection

Technical Basis Tables

Type of Surveillance: Annulus Leak Detection Method: Detection of liquid waste on annulus floor Device: Adjustable Conductivity Probes Principle of Operation: Presence of electrically conductive liquid completes circuit at electrodes. Indicating Event: Alarm annunciation. Manual Reading: n/a level. Automatic Reading: Annunciator sounds. Technical Basis for using device for leak detection: Proven technology, direct measurement, adjustment allows preventative maintenance check, uncomplicated circuitry.		
Applications	Precision $\pm$ Possible Actual	Specification Limits
1. Monitors presence of liquid in annulus	+/- 1/16 in (unknown)	1. 1/8 in. off floor
Basis Statements 1. This is the lowest elevation off tank floor readily attainable. Annunciator sounds for immediate action.		