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Acceptance and Operational Test Report for Neutron and Gamma Probe Application to Tank 241-SY-101 MITs

N. S. Cannon

COGEMA Engineering Corporation, Richland, WA 99352
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Abstract: This Operational Test Report (OTR) presents the results of the ATP/OTP testing performed to verify that newly procured neutron and gamma probes (reduced diameter design modifications) for operation in the Tank 241-SY-101 MITs are compatible with existing LOW van instrumentation and hardware. This verification was accomplished and a set of moisture data versus elevation were obtained from the Tank 241-SY-101 MITs as part of this testing program.

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ACCEPTANCE AND OPERATIONAL TEST REPORT FOR NEUTRON AND GAMMA PROBE APPLICATION TO TANK 241-SY-101 MITs

N. Scott Cannon
COGEMA Engineering Corporation

June 1999

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LIST OF ACRONYMS AND ABBREVIATIONS

ATP	acceptance test procedure
ATR	acceptance test report
ETP	engineering task plan
ILL	interstitial liquid level
LOW	liquid observation well
MIT	multifunction instrument tree
OTP	operational test procedure
OTR	operational test report
PVC	polyvinyl chloride

1.0 PURPOSE AND SCOPE

1.1 BACKGROUND

Recent surface level measurements in tank 241-SY-101 indicate a continuing increase in the crust surface level. To support investigation of this phenomenon, an adaptation of the liquid observation well (LOW) equipment already in use at Hanford was accomplished by redesigning and acquiring smaller diameter neutron and gamma probes able to fit down the multifunctional instrument trees (MITs) installed at SY-101. The new MIT probes were procured fully compatible with the existing LOW instrumentation; thus, no changes in procedures or LOW van hardware were required, resulting in a relatively low cost application of this technology to the SY-101 tank.

A combined acceptance test procedure (ATP) and operational test procedure (OTP), provided in document HNF-3838, Rev. 1 was performed for the new MIT probes; this document reports the results of that testing.

References relevant to both this report and to the ATP/OTP are given in Section 2.

1.2 PURPOSE AND SCOPE

The objective for performing the HNF-3838 MIT probe ATP/OTP was to confirm that the new reduced diameter neutron moisture probe and gamma probe (1) complied with the purchase specifications, (2) were compatible with the existing LOW system, and (3) are ready for operational field deployment. This combined acceptance test report/operational test report (ATR/OTR) presents the results of the ATP/OTP testing and addresses how these results demonstrate that the objectives of the ATP/OTP have been met.

2.0 REFERENCES

- Barnes, D. A., 1996, WHC-SD-WM-OTP-201, Rev. 0, *Field Operational Test Procedure for the New Liquid Observation Well (LOW) Vans*, Westinghouse Hanford Company, Richland, Washington.
- Barnes, D. A., 1997, HNF-SD-WM-OTR-201, Rev. 0, *Operational Test Report for the New Liquid Observation Well (LOW) Vans*, Westinghouse Hanford Company, Richland, Washington.
- Cannon, N. S. and Barnes, D. A., 1999, HNF-3838, Rev. 1, *Acceptance and Operational Test Procedure for Neutron and Gamma Probe Application to Tank 241-SY-101*, COGEMA Engineering Corporation for Fluor Daniel Hanford, Inc.
- Cannon, N. S., 1998a, *Engineering Task Plan for Determining the Interstitial Liquid Level in Tank 241-SY-101 Utilizing a Neutron Probe in the Multifunction Instrument Tree* HNF-3322, Rev. 0, COGEMA Engineering Corporation for Fluor Daniel Hanford, Inc.
- Cannon, N. S., 1998b, *Test Plan for Neutron Probe Application to Tank 241-SY-101 MITs*, HNF-3595, Rev. 0, COGEMA Engineering Corporation for Fluor Daniel Hanford, Inc.
- LMHC, 1998, *Liquid Observation Well (LOW) Surveillance Van Startup and Operation Procedure*, TO-040-333, Rev. A-4, Lockheed Martin Hanford Corporation for Fluor Daniel Hanford, Inc.
- LOW Surveillance Van Maintenance Manual, Rev. A-3, 1998, Greenspan, Inc., Houston, Texas.

3.0 RESPONSIBILITIES

Table 3.1 outlines the functional responsibilities for the ATP/OTP and this ATR/OTR.

TABLE 3-1. Functional Responsibilities for Neutron/Gamma Probe ATP/OTP

Personnel	Responsibility
Cognizant Engineer	<ul style="list-style-type: none"> ● Approves ATP/OTP ● Witnesses tests (optional) ● Approves changes to tests as necessary ● Signs off upon completion of ATP/OTP
Test Engineer	<p>NOTE: The Test Engineer and the Cognizant Engineer may be the same individual.</p> <ul style="list-style-type: none"> ● Designated by Cognizant Engineer ● Witnesses tests ● Provides field guidance to operators as needed ● Recommends modifications to tests, if required
Operations Representative	<ul style="list-style-type: none"> ● Witnesses tests (optional) ● Signs off upon completion of ATP/OTP to certify that equipment is acceptable and ready for field use
Quality Assurance Representative	<ul style="list-style-type: none"> ● Witnesses tests (optional) ● Writes test exceptions, as necessary ● Assists with defining recovery actions, as appropriate ● Signs off upon completion of ATP/OTP
Safety Representative	Approves ATP/OTP
LOW Van Operators	<p>A minimum of one lead operator should be present during testing.</p> <ul style="list-style-type: none"> ● Perform majority of physical operations ● Guided by Cognizant/Test Engineers, as required ● Witnesses tests
Health Physics Technologist	<ul style="list-style-type: none"> ● Provide dose-rate survey of 3 Ci neutron probe source, if this source is required ● Provides dose-rate surveys for calibration tests, as required

4.0 DESCRIPTION OF SYSTEM

The systems tested in the ATP/OTP consisted of:

- An MIT neutron moisture probe, including the detector and utilizing an existing source, Neutron Probe #9.
- A gamma probe, including the detector, Gamma Probe #9.

These newly acquired, smaller diameter probes will also be referred to as the “MIT neutron probe” and the “MIT gamma probe”, or the “MIT probes”.

The MIT probes were interfaced and tested with existing onsite LOW vans previously purchased from Greenspan, Inc. of Houston, Texas.

5.0 SAFETY AND QUALITY ASSURANCE

This ATP/OTP was assigned the approval designators "Q" and "S."

All safety precautions noted in tank farm plant operating procedure TO-040-333 (LMHC 1998) were applied as appropriate during the use of those procedures during the ATP/OTP. The LOW van system has a safety designation of general service (GS), and this designation also applies to the new MIT probes.

Since only the standard LOW 1.5 Ci neutron source was used with the new MIT neutron probe during performance of the ATP/OTP procedures, there were no significant differences between operation of the MIT and LOW probes with respect to safety. Thus, the safety precautions of procedure TO-040-333 (Rev. A-4) were adequate to provide protection for this testing.

The ATP/OTP was reviewed by Quality Assurance per HNF-PRO-233, as will be this ATR/OTR. Data quality objectives and calibration requirements are the same as those for the existing LOW van system (WHC-SD-WM-OTP-201, TO-040-333, LOW Maintenance Manual).

6.0 ACCEPTANCE/OPERATIONAL TEST RESULTS

The individual procedures given in the ATP/OTP testing document (HNF-3838, Rev. 1), including major section heading numbers, are summarized as follows:

- 6.1 Bench Testing Procedure
(Optional - Not performed)
- 6.2 Neutron Source Dose Rate Survey
(Required only if 3 Ci neutron source used - Not performed)
- 6.3 Depth and Weight Calibration
(Performed 3-12-99)
- 6.4 Count Rate Determination
(Performed 3-12-99)
- 6.5 Neutron Probe Barrel Test
(Performed 3-12-99)
- 6.6 Gamma and Neutron Probe Tests in the Tank 241-AX-101 LOW
(Optional - Not performed)
- 6.7 Gamma and Neutron Probe Tests in the Tank 241-SY-101 MITs
(Performed 3-11-99)

The order in which these individual procedures were performed during the ATP/OTP testing could be altered at the discretion of the cognizant engineer. The bench testing, the neutron source dose rate survey and the AX-101 LOW tests were optional, and were in fact deleted from the actual performance of the ATP/OTP at the discretion of the cognizant engineer. The reasons for deleting these tests will be discussed further in the individual test sections.

For procedures that required a neutron source, the ATP/OTP allowed either the 1.5 or the 3 Ci source (or both) to be used at the cognizant engineer's discretion. In fact, only the 1.5 Ci source was used during the ATP/OTP testing.

Note that in this Section 6 'Results' section, the individual procedure major heading numbers also correspond to those of Section 6 in the ATP/OTP. Although the actual testing procedures are not reproduced here, they can easily be cross-referenced with the ATP/OTP document.

6.1 BENCH TESTING

Bench testing was to be performed at the 272WA instrument shop. A set of mechanical tests and a set of electrical tests were outlined in the ATP/OTP. However, this optional testing was not performed.

6.1.1 Purpose

The purpose of the bench testing was to verify the mechanical and electrical compatibility of the MIT probes with the LOW van.

6.1.2 Results

At the discretion of the cognizant engineer, this optional bench testing was not performed. The quality assurance (QA) inspection of the neutron and gamma probes at receiving (see a copy of the green tags in Figure 6.1) verified that the probe diameters, lengths, and weights were within the purchase order specifications; thus the mechanical portion of the bench testing was redundant. Since the probe diameters were within specification, there was no risk that the probes would bind up in the MIT validation tube, and it was possible to go directly to Section 6.7 of the ATP/OTP and perform a test run of both probes in the SY-101 MITs. Electrical compatibility of the MIT probes with the LOW van was verified during these SY-101 runs at no risk to the LOW van instrumentation, since the LOW van was designed to prevent power up of a probe if an over current condition existed. Thus, at the successful completion of the SY-101 runs of Section 6.7, the bench test electrical compatibility testing also became redundant.

Figure 6.1-1. Copy of Green Tags for the MIT Neutron and Gamma Probes Following the QA Inspection at Receiving.

EXCEPTION SHEET # 1 OF 7 (Reproduce this form as necessary)

Recorder: N. S. Cannon	Date: 3-12-99	
Procedure Step Number: 6.1		
Description: <p>The optional bench testing (ATP/OTP procedure 6.1) was not preformed at the discretion of the cognizant engineer. Mechanical and electrical compatibility were verified by the successful completion of the SY-101 runs of Section 6.7.</p>		
<i>N. S. Cannon</i>	<i>N. S. Cannon</i>	<i>3-12-99</i>
Test Engineer (sign)	(print)	Date

Exception Resolution Description:			
No action required. This step was optional.			
Cognizant Engineer	Date	Operations Representative	Date
<i>David Barnes</i>	<i>3/12/99</i>	<i>[Signature]</i>	<i>3/12/99</i>

6.2 NEUTRON SOURCE DOSE RATE SURVEY

6.2.1 Purpose

The purpose of this test was to determine the dose rate at various points in (and at) the LOW van with the 3 Ci neutron source in the probe holder (both with the source attached to the probe, or unattached to the probe). A qualified health physics technologist (HPT) was to perform the dose rate survey and record the survey results on the provided dose rate survey datasheet.

6.2.2 Results

This testing was listed as optional in the ATP/OTP, depending upon the need to use the new 3 Ci neutron source to obtain adequate results in SY-101. However, the SY-101 run of the MIT neutron probe on 3-11-99 (see Section 6.7) demonstrated that the 1.5 Ci neutron source was adequate for programmatic needs. Since a dose rate survey has already been performed for the 1.5 Ci neutron source (see HNF-SD-WM-OTR-201), the cognizant engineer deleted this testing, and avoided the additional cost and schedule delay of developing the 3 Ci source for application at tank SY-101.

However, the 3 Ci neutron source shall not be used with either the MIT or LOW van probes until an adequate dose rate survey for this source has been completed.

EXCEPTION SHEET # 2 OF 7

(Reproduce this form as necessary)

Recorder: N. S. Cannon	Date: 3-12-99
Procedure Step Number: 6.2	
Description: <p>The optional dose rate survey (ATP/OTP procedure 6.2) was not performed at the discretion of the cognizant engineer. It was not necessary to perform this procedure since the 1.5 Ci neutron source was found adequate (see Section 6.7), and a dose rate survey has already been performed for this 1.5 Ci source (see HNF-SD-WM-OTR-201).</p>
<i>N. S. Cannon</i>
Test Engineer (sign)	(print)
	Date

Exception Resolution Description:			
No action required. This step was optional.			
Cognizant Engineer	Date	Operations Representative	Date
<i>3/12/99</i>		<i>3/12/99</i>

6.3 DEPTH AND WEIGHT CALIBRATIONS

6.3.1 Purpose

The depth measurement system of the LOW vans has already been tested and accepted (see HNF-SD-WM-OTR-201). The purpose of the Section 6.3 depth and weight calibrations for the new MIT probes was to verify that the system still operated correctly while utilizing these new tools. To make this verification, the depth test well at the 272WA garage (known at 97.975 ft) was remeasured several times using the MIT neutron probe and an LOW van. The results were then checked for accuracy and repeatability.

Also, the digital “weight” of the probe system (probe, boom, etc.) was to be measured from the van computer. This number must fall between 260 and 270 digits for the probe to function properly with the LOW van system. This number is a function of the probe weight and other factors; a limited adjustment of its value can be made electronically.

6.3.2 Results

The results of performing the ATP/OTP depth and weight calibrations procedure are given in Table 6.3-1.

In obtaining the data of Table 6.3-1, three changes were made from the applicable ATP/OTP procedure. Use of the ‘spider’ assembly called for in the ATP/OTP was deleted with the approval of the cognizant engineer, since all calibrations are performed in ‘drive-up’ mode. Secondly, an additional depth/weight run of the MIT neutron probe (without the ballast) was substituted for the scheduled MIT gamma probe run. This substitution was done at the recommendation of the cognizant engineer to determine if the probes could be operated without the extra ballast weight, which would reduce operations time. Since the difference in weight between a probe with and without a ballast was significantly greater than between the two probes, this test was more conservative in determining the LOW van’s weight sensitivity for the two probes. Lastly, the van software did not automatically adjust the initial probe run to match the known well depth (97.975 ft) due to a narrow band setting; although this calibration step was not performed, repeatability can be determined from the Table 6.3-1 data. These exceptions are documented in Exception Sheet 3 at the end of this section.

When the neutron probe was run with the ballast, the computer ‘digital’ number was ideal at 265, without adjustment. Without the ballast, the digital number was easily adjusted to 264 electrically. There is slightly more scatter in the depth readings without the ballast, although repeatability (referenced to the average of 98.0167 ft) was better than ± 0.25 inches, which is acceptable (HNF-SD-WM-OTR-201, Rev. 0). The omitted calibration steps were simple algorithm adjustments (scaling) to convert the 98.008 ft to 97.975 ft (scale factor = 0.999663) or 98.017 ft to 97.975 ft (scale factor = 0.999572), and inclusion of these scale factors would actually (slightly) improve repeatability. Thus, the data in Table 6.3-1 demonstrates that the MIT probes functioned properly during both depth and weight calibrations.

TABLE 6.3-1

Depth and Weight Calibration Results

DATA SHEET FOR DEPTH/WEIGHT TEST PROCEDURE 6.3.4				
Test Date: 3-12-99		Signed/Date N. S. Cannon <i>NS Cannon</i> 3-12-99 M.D. Herman <i>MD Herman</i> 3-12-99 B.D. Wright <i>B.D. Wright</i> 3-12-99		
LOW Van No. <u>2</u>				
Probe	Digital Reading	Run #	Raw Depth (ft)	Pulses per Inch
MIT Gamma Neutron MIT Without Ballast	264 * *adjusted electronically	1	98.017 <i>NK</i>	139.836
		2	98.033	139.859
		3	98.000 <i>NK</i>	139.835
MIT Neutron WITH Ballast	265	1	98.008	139.036
		2	98.017	139.836
		3	98.017	139.836

4th

5th

6th

1st

2nd

3rd

No "spider" authorized by Dave Barnes per telecom. *NK*

Replacing MIT Gamma runs with MIT Neutron (no ballast)
authorized by Dave Barnes per telecom. *NK*

Note that the order in which depth runs were made is handwritten on the right side of the data sheet.

EXCEPTION SHEET # 3 OF 7 (Reproduce this form as necessary)

Recorder: N. S. Cannon	Date: 3-12-99	
Procedure Step Number: 6.3.4, 6.3.4.1 and 6.3.4.1.5		
Description: <p>The 'spider' assembly required by procedure Step 6.3.4 was not used because all depth calibrations are performed in 'drive-up' mode, and do not use the spider assembly.</p> <p>Use of the neutron probe without a ballast was substituted for the gamma probe in Step 6.3.4.1 at the request of the cognizant engineer. This substitution tests a wider range of tool weights than the original plan. Also, Step 6.3.4.2 was performed before Step 6.3.4.1.</p> <p>As part of 6.3.4.1.5, the 'known depth' adjustment was not performed.</p>		
<i>N. S. Cannon</i>	<i>N. S. Cannon</i>	<i>3-12-99</i>
Test Engineer (sign)	(print)	Date

Exception Resolution Description:			
<p>Step 6.3.4: No action is required since the requirement to use the spider assembly was an error in the ATP/OTP, and deleting its use does not affect the quality of the data obtained.</p> <p>Step 6.3.4.1 No action is required. Substituting the lighter probe assembly provided better information on the sensitivity of the equipment settings to probe weight. Also, the order of the two procedures was unimportant.</p> <p>Step 6.3.4.1.5 No action is required. Lack of a 'known depth' adjustment has no impact on the results since the repeatability of the depth measurements were well within requirements. (All values were within 0.25 inches of the average.)</p>			
Cognizant Engineer		Date	
<i>David Banno</i>		<i>3/12/99</i>	
Operations Representative		Date	
<i>J. N.</i>		<i>3/12/99</i>	

6.4 COUNT RATE DETERMINATION

6.4.1 Purpose

The MIT neutron probe was tested in the 272WA neutron calibration fixture to verify that the probe functioned properly with the LOW van electronics and to establish the response of the probe in this fixture. After probe warmup, a series of count rate measurements were made to establish an average that can be used in the future to verify correct probe operation prior to an MIT measurement run.

The MIT gamma probe was also tested at 272WA in the gamma calibration fixture to verify that the probe functioned properly with the LOW van electronics and to establish the response of the probe in this fixture. After probe warmup, a series of count rate measurements were made to establish an average that could be used in the future to verify correct probe operation prior to an MIT measurement run.

6.4.2 Results

The results of performing the ATP/OTP Count Rate Determination Procedure are given in Table 6.4-1.

The average count rate for the MIT neutron probe is determined from Trials 6-10 as 1175.7 counts per second (CPS), utilizing the 1.5 Ci neutron source. Per procedure, the first five trials for the neutron probe are not used for the average because the count rate increased with each successive trial until Trial 6, indicating that probe warm-up had not been completed until that point.

The MIT gamma probe was warmed up 10 minutes before the first trial was run, per procedure, and the average count rate is determined from all five trial runs as 541.2 CPS.

The MIT neutron probe average of 1175.7 CPS and the MIT gamma probe average of 541.2 CPS will be used in the LOW van software for pre-run calibrations per the latest revision of procedure TO-040-333.

TABLE 6.4-1

Count Rate Results for MIT Neutron and Gamma Probes

DATA SHEET FOR NEUTRON PROBE COUNT-RATE TEST PROCEDURE 6.4.4						
Test Date(s): 3-12-99						
Operator Name (sign/print):		BERT Wright / <i>Bert Wright</i>				
Operator Name (sign/print):		Joe Rodriguez / <i>Joe Rodriguez</i>				
Test	Van No.	Initial and date each box as each trial is completed				
		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
272WA Garage Calibration Fixture	2	1140.797	1158.098	1165.631	1166.181	1166.648
		3-12-99	3-12-99	3-12-99	3-12-99	3-12-99
		<i>n/c</i>	<i>n/c</i>	<i>n/c</i>	<i>n/c</i>	<i>n/c</i>
		Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
		1166.448	1175.582	1171.865	1181.948	1182.532
		3-12-99	3-12-99	3-12-99	3-12-99	3-12-99
		<i>n/c</i>	<i>n/c</i>	<i>n/c</i>	<i>n/c</i>	<i>n/c</i>

Count-rate

DATA SHEET FOR GAMMA PROBE COUNT-RATE TEST PROCEDURE 6.4.5						
Test Date(s): 3-12-99						
Operator Name (sign/print):			BERT Wright
Operator Name (sign/print):			Joe Rodriguez
Test	Van No.	Initial and date each box as each trial is completed				
		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
272WA Garage Calibration Fixture	2	520 3-12-99 n/c	549 3-12-99 n/c	544 3-12-99 n/c	547 3-12-99 n/c	546 3-12-99 n/c

Total Count

EXCEPTION SHEET # 4 OF 7

(Reproduce this form as necessary)

Recorder: N. S. Cannon	Date: 3-12-99	
Procedure Step Number: 6.4		
Description:		
No exceptions noted.		
<i>M. S. Cannon</i>	<i>N. S. Cannon</i>	<i>3-12-99</i>
Test Engineer (sign)	(print)	Date

Exception Resolution Description:			
Cognizant Engineer		Date	
<i>David Bannard</i>		<i>3/12/99</i>	
Operations Representative		Date	
<i>J. A.</i>		<i>3/12/99</i>	

6.5 NEUTRON MOISTURE PROBE BARREL TEST

6.5.1 Purpose

The purposes of this test were to (1) determine the location of the measurement point (probe offset) of the neutron probe and (2) determine the vertical resolution and maximum count rate expected. Three tests were to be performed on the probe: (1) the (essentially) bare probe in water, (2) the probe in a simulated MIT, and (3) the probe in a simulated LOW (optional test). In the first test, the probe was to be inserted directly into a 55-gallon container of water. For this test, it was allowable for the probe to be encased in a thin plastic shroud for additional protection from water ingress into the probe electronics. In the second test, the probe was inserted into a closed-end stainless steel pipe submerged in water to simulate a short section of an MIT. In the third optional test, the probe was to be inserted into a closed-end polyvinyl chloride (PVC) pipe submerged in water to simulate an LOW. In each test, the count rate signal was to be recorded as the probe was withdrawn from the test apparatus. The computer on board the LOW van controlled the count rate data collection and probe movement.

6.5.2 Results

The data sheet for the barrel tests is given in Table 6.5-1; the optional LOW simulation test was deleted by the cognizant engineer. The 1.5 Ci neutron source was used to obtain this data. Three barrel test runs inside the simulated MIT were performed, as well as one run with the probe immersed directly in the water (no MIT). A sketch of the stainless steel MIT simulation tube (which approximately reproduces tubing diameters for a short section of an SY-101 MIT) is given in Figure 6.5-1.

The data was downloaded to the Surveillance Analysis Computer System (SACS) database and treated as normal production data. The location of the liquid interface was analyzed using the production Interstitial Liquid Level (ILL) analysis software in SACS. Three analysis methods were used on each scan, consisting of the derivative method, the count rate method, and the sigmoid method. The resulting "probe offset" results are summarized below (in feet):

	Run 1 (MIT)	Run 2 (MIT)	Run 3 (MIT)	Run 4 (Water only)
Derivative	0.492	0.482	0.482	0.482
Count Rate	0.482	0.461	0.478	0.472
Sigmoid	0.481	0.471	0.490	0.475

The probe offset is defined as the distance from the bottom of the probe (when the count rate is one half the maximum) to the surface of the water.

TABLE 6.5-1

Barrel Test Data Sheet

DATA SHEET FOR BARREL TEST PROCEDURES 6.5.4 - 6.5.6				
Test Date: 3-12-99				
LOW Van No. 2				
Operator Name (sign/print):		MIKE HERMAN <i>Mike Herman</i> 3-12-99		
Procedure Step Number	Test	Measurement	Distance (inches - to nearest 1/32 inch)	Comments
6.5.4.1.4	Wet Barrel	Top of 1x4 to surface of water	26 1/2"	used the simulated MIT zero. Performed after simulated MIT test
6.5.5.1.3	Simulated MIT	Top of 1x4 to surface of water	26 1/2"	Performed 1st, before Wet Barrel Test
6.5.6.1.3	Simulated LOW (optional)	Top of 1x4 to surface of water		Deleted this test

Witnessed:

Test Engineer *N Scott Cannon* 3-12-99 N. Scott CannonCoop. Engineer *Mike Banner* 3/12/99QC (LMHC) *K. Willoughby / K. Willoughby* 3/12/99

* used 6.5.5.1.3 zero

NOTE: USCO ZEROING RATE INSTEAD OF 1X4
KN 3-12-99

MIT SIMULATION TUBE

304 SS

Three top
hooks at
120 degrees
(not shown)

Figure 6.5-1. Sketch of the MIT Simulation Tube which approximately reproduces tubing diameters for a short section of an SY-101 MIT, as used for Barrel Testing.

If this were true production data, all three methods would be evaluated until the best method was statistically determined, and then only that one method would be used on a routine basis. In general, the three methods do not work equally well, and the shape of the raw data curve will determine which is the best method for any given case. In the case of the barrel test, the derivative and sigmoid methods appeared to perform well, while the count rate method offset was a little smaller due to a slightly asymmetrical curve shape. As such, the derivative and sigmoid results better represent the true probe offset.

In addition, Run #2 experienced some minor difficulty with obtaining the zero point above the barrel, and the probe was slightly tilted when the computer zero was set. As such, the depth control for that run was slightly suspect. Run #2 computed interface values that were slightly lower (about 0.01 ft.) than the other two runs. The average value for Runs #1 and #3 using both the derivative and sigmoid methods was 0.486 ft (5.83 inches), and this is the value that has been adopted as the best estimate for the probe offset.

For comparison, the barrel test data was also 'fit' using least squares regression techniques for the curve

$$CPS = A + B * \tanh(k * [X - X_o]) \quad (1)$$

where CPS is the measured counts per second, X is the bottom of probe depth, and X_o is the depth of the water surface (26.5 inches) plus the probe offset. The constants A, B, k, and X_o are determined by a least squares regression algorithm applied to the data from a given run. The least squares regression algorithm (software program) used for this analysis is given in Appendix A. When only Runs #1 and #3 are used and the data restricted to between 10 to 90 percent of the maximum count rate, the average value of the probe offset is determined as 0.484 ft, which is in relatively good agreement with the value of 0.486 ft determined with the SACS analysis using the same data set restrictions. If all three MIT runs are used for the least squares fit, and all the data from each run is included, the average value for the probe offset is 0.469 ft (5.63 inches).

A plot of all four barrel test runs is made in Figures 6.5-2 through Figure 6.5-5. Included in these plots is a simplified curve fit in the form of

$$CPS = A * (1 + \tanh(k * [X - X_o])) \quad (2)$$

for both the SACS determination ($X_o = 32.33$ inches) corresponding to a probe offset of 0.486 ft and for the least squares determination ($X_o = 32.13$ inches) corresponding to a probe offset of 0.469 ft. Overall, the least squares technique applied to the entire data set for each run appears to give a slightly better fit to the barrel data, although there is only a 0.2 inch difference between the probe offset for these two very different correlations.

It is important to note that in production, the absolute value of the probe offset is less important

than the repeatability of the output. An error of 0.1 to 0.25 inches in absolute level makes little difference to the final interpretation, as long as the same value is used each time. The most useful evaluation results from trend analysis, and if each scan is analyzed with the same method and the same probe offset, this trend analysis can be very accurate. Since the SACS analysis technique is the accepted method for evaluating LOW probe offsets, the value of 0.486 ft determined by this technique will be used as the probe offset for the MIT neutron probe (Neutron Probe # 9). Using the SACS derivative and sigmoid scatter for all three MIT simulation barrel test runs, the repeatability (vertical resolution) of the ILL determination is expected to be better than ± 0.015 ft (0.18 inches), provided that a 'sharp' liquid interface exists in the tank.

As can be seen from the barrel test plots, count rate saturation (probe well below water surface) is at roughly 625 CPS for the MIT simulation tube runs and at about 1300 CPS for the bare probe run (without a plastic shroud). The reduced count rate recorded for the MIT simulation tube runs is attributed to the extra (air/steel) gap between the probe and water, which reduces the number of back-scattered thermal neutrons returning to the detector. Steel and air are essentially 'invisible' to the neutrons. Thus, the maximum count rate possible in the SY-101 MITs is about 625 CPS. The actual maximum count rate measured in the SY-101 MITs will be less than this value (see Section 6.7) since the waste is not 100 percent water.

Figure 6.5-2. Raw Data from the First Simulated MIT Barrel Test Run, Including SACS and Least Squares Regression Curve Fitting.

Figure 6.5-3. Raw Data from Second Simulated MIT Barrel Test Run, Including SACS and Least Squares Regression Curve Fitting.

Figure 6.5-4. Raw Data from Third Simulated MIT Barrel Test Run, Including SACS and Least Squares Regression Curve Fitting.

Figure 6.5-5. Raw Data from 'Bare' MIT Neutron Probe Barrel Test Run, Including SACS and Least Squares Regression Curve Fitting.

EXCEPTION SHEET # 5 OF 7

(Reproduce this form as necessary)

Recorder: N. S. Cannon	Date: 3-12-99
Procedure Step Number: 6.5.4 and 6.5.5	
Description: Performed ATP/OTP Procedure 6.5.5 before Procedure 6.5.4. Substituted regular 'zeroing plate' used in 272WA garage depth calibrations for 1x4 called out in Procedure 6.5.5 (and 6.5.4). Used 'zero' position determined in Procedure 6.5.5 for Procedure 6.5.4.	
<i>N. S. Cannon</i>	3-12-99 N. S. Cannon
Test Engineer (sign)	Date

Exception Resolution Description:

6.5.5 before 6.5.4: No action required. The order in which these procedures were performed was not significant.

1x4 substitution: No action required. The zeroing plate matched better with the MIT simulation tube than the 1x4.

Reuse of 'zero': No action required. Both Procedures 6.5.5 and 6.5.4 were performed within 30 minutes of each other without a change in probe configuration. It was not necessary to 'rezero' the probe between procedures.

Cognizant Engineer	Date	Operations Representative	Date
<i>David Baur</i>	3/12/99	<i>J. N.</i>	3/12/99
Quality Assurance Representative	Date		

Ker Wilkey 6-24-99

6.6 GAMMA AND NEUTRON PROBE TESTS IN TANK 241-AX-101

6.6.1 Purpose

The new MIT probes and an LOW van were to be used at the Tank 241-AX-101 LOW while utilizing the van offset fixture. At least one run in this LOW was to be performed with both the MIT probes. The MIT neutron probe was to be run again in the LOW without the neutron source in order to quantify background gamma counts. The neutron probe count rate determined without the neutron source installed was to be less than two percent of the count rate determined with the neutron source installed.

Also, this MIT probe data would have allowed a comparison of results between MIT and LOW probes, utilizing LOW probe data obtained on prior occasions. The objective of this comparison would be to show that (at least qualitatively) all major moisture features detected with the LOW probes could also be observed with the new MIT probes.

6.6.2 Results

The tests at AX-101 were listed as optional in the ATP/OTP, and the cognizant engineer has deleted this testing, primarily because the MIT neutron probe count rate with and without the neutron source had already been obtained at SY-101 on February 8, 1999 during a preliminary scoping run at this tank using the 1.5 Ci neutron source. The rest of the data to have been obtained at AX-101 are considered non-essential.

The results of the neutron probe preliminary scoping runs at SY-101 on 2-8-99 in the 17B MIT (only one riser tested) are given in Figure 6.6-1 (with neutron source) and Figure 6.6-2 (without neutron source). In the lower part of the tank, the neutron probe count rates averaged about 450 CPS with the neutron source, while without the source, the count rate was less than 3 CPS. Thus, without the source, the background count rate was only 0.7 percent of the rate with the source installed, which is well within the required 2 percent stated earlier. Establishing the MIT neutron probe background count rate at the SY-101 tank is pertinent, since this is the tank of interest.

The runs of the MIT neutron and gamma probes at the 17B MIT at SY-101 on February 8, 1999 were performed in compliance with the normal LOW procedures, with the exception of the extra neutron probe run without the neutron source. In effect, Step 6.6.4.6 of the ATP/OTP procedure was performed, except at the 17B MIT instead of in the AX-101 LOW.

MIT 17B Neutron: 2-8-99

Figure 6.6-1 Plot of Preliminary MIT Neutron Probe Results from 2-8-99 Run at Tank SY-101, Riser 17B (with neutron source).

Figure 6.6-2 Plot of Preliminary MIT Neutron Probe Results from 2-8-99 Run at Tank SY-101, Riser 17B (without neutron source).

EXCEPTION SHEET # 6 OF 7

(Reproduce this form as necessary)

Recorder: N. S. Cannon	Date: 3-12-99
Procedure Step Number:	
Description: The optional tests in Tank 241-AX-101 (ATP/OTP procedure 6.6) were not performed at the discretion of the cognizant engineer.	
<i>N. S. Cannon</i>	<i>N. S. Cannon</i>
Test Engineer (sign)	Date

Exception Resolution Description:

Cognizant Engineer	Date	Operations Representative	Date
<i>David Barnes</i>	<i>3/12/99</i>	<i>[Signature]</i>	<i>3/12/99</i>

6.7 GAMMA AND NEUTRON PROBE TESTS IN TANK 241-SY-101

6.7.1 Purpose

The purpose of this test was to demonstrate the operability of the MIT probes and LOW van at the Tank 241-SY-101 MITs by obtaining neutron and gamma probe moisture data from this tank at both MITs. The data was to be analyzed to determine the value of this moisture data prior to establishing regular LOW van/MIT probe operations at SY-101.

6.7.2 Results

The ATP/OTP gamma and neutron probe tests were performed at Tank 241-SY-101 on March 11, 1999, in both the 17B and 17C MITs. (See Appendix B for documentation.) The results of the neutron and gamma probe runs in the 17B MIT are given in Figure 6.7-1; the gamma probe count rates are divided by 20 to facilitate combining the two sets of data in a single plot. Similarly, the neutron and gamma probe data obtained from the 17C MIT are given in Figure 6.7-2.

These plots also include identification markers of some of the more obvious waste features. Not only can the top and bottom of the crust layer be defined (particularly from the neutron probe data), but there appears to be detailed information available throughout the crust. Tracking of these features in subsequent test runs will provide invaluable information on crust growth (both top and bottom of the crust), and may provide gas content information in the crust.

It should also be noted that the downward 'spikes' visible particularly in the gamma probe data can be correlated with the MIT bulkheads to within 0.8 inches of elevation. See Appendix C for details.

In summary, these gamma and neutron probe runs in SY-101 have demonstrated the operability of the MIT probes and LOW van together in both MITs at this tank. The value of the probe data has been demonstrated in delineating waste conditions and crust features in the SY-101 tank.

Figure 6.7-1 MIT Gamma and Neutron Probe Results from the APT/OTP SY-101 Run at MIT 17B on 3-11-99.

Figure 6.7-2 MIT Gamma and Neutron Probe Results from the ATP/OTP SY-101 Run at MIT 17C on 3-11-99.

EXCEPTION SHEET # 7 OF 7

(Reproduce this form as necessary)

Recorder: N. S. Cannon	Date: 3-11-99
Procedure Step Number:	
Description: No exceptions noted.	
<i>N. S. Cannon</i>	<i>N. S. Cannon</i>
Test Engineer (sign)	(print)
	Date

Exception Resolution Description:			
Cognizant Engineer	Date	Operations Representative	Date
<i>David Barnes</i>	<i>3/11/99</i>	<i>J. A.</i>	<i>3/12/99</i>

7.0 SUMMARY AND CONCLUSIONS

The required ATP/OTP (HNF-3838, Rev. 1) procedures and testing for the MIT neutron and gamma probes have been performed. These new probes have been found to be fully compatible with the existing LOW van instrumentation and procedures. The probes were used in both of the Tank 241-SY-101 MITs, and the waste feature data obtained is clearly of value to tank surveillance programs. It is concluded that the new MIT probes are ready to be included in normal LOW van operations at SY-101 MITs, and at other waste tanks with MITs of matching geometries (as plug gage verified).

8.0 TEST EXECUTION APPROVAL SHEET

The undersigned certify that all required tests have been completed and that all requirements were either met or an exception was duly noted. If an exception was noted, the appropriate resolution of that exception has also been specified.

N. Scott Cannon N. Scott Cannon 6-10-99
Test Engineer (sign) (print) Date

David Barnes DAVID BARNES 6/10/99
Cognizant Engineer (sign) (print) Date

J. A. Jim Adrian 6/23/99
Operations Representative (sign) (print) Date

Ken Willoughby KEN WILLOUGHBY 6/24/99
Quality Assurance Representative (sign) (print) Date

APPENDIX A

Least Squares Linear Regression Program SFIT_NP.BAS

```

' This program (SFIT_NP.BAS) is designed to fit a tanh function
' (S-curve) to Neutron Probe Data, using least squares techniques.
' Modified from SCURFIT.BAS starting on 5-5-99
' N. S. Cannon

CLOSE

DIM X(200), Y(200), Z(200), X0(200)

CQ1 = 0: ' Uses only single dependent variable (X)
CLS : flagf = 0: CQ2 = 0

1000 FOR J = 1 TO 200: X(J) = 0: Y(J) = 0: Z(J) = 0: NEXT J
    IF flagf <> 0 THEN 1030

1020 PRINT "Enter choice: 1 = Data input from keyboard"
    PRINT "          2 = Data input from data file"
    PRINT "          3 = Produce correlation file"
    INPUT CQ2

1030 IF CQ2 = 1 THEN GOSUB 20000
    IF CQ2 = 2 THEN GOSUB 21000
    IF CQ2 = 3 THEN 6500

    IF CQ2 <> 1 THEN IF CQ2 <> 2 THEN IF CQ2 <> 3 THEN PRINT : GOTO 1020
    FOR J = 1 TO N: X0(J) = X(J): NEXT J: ' Fixes X0 for reference

2000 PRINT : PRINT : IF flagf <> 0 THEN 2010
    PRINT "Charpy data is fit to equation of the form"
    PRINT
    PRINT "      Y = A + B*X   where X = tanh(f*[T-Th])"
    PRINT
    PRINT "The fit is made using least squares methods. You will input"
    PRINT "the range and increment for both f and Th over which the fit"
    PRINT "will be made. The best fit values will be retained."
2010 PRINT : PRINT
    PRINT "Enter the range of f (F0,F9)": INPUT F0, F9
    PRINT "Enter the increment of f in going from F0 to F9": INPUT dF
    PRINT : PRINT "Enter the range of Th (T0,T9)": INPUT T0, T9
    PRINT "Enter the increment of Th in going from T0 to T9": INPUT dT

3000 fv = F0 - dF: Th = T0 - dT: ' Set initial values
    ROLD = 100
3010 fv = fv + dF: IF fv > F9 THEN 5000
3020 Th = Th + dT: IF Th > T9 THEN Th = T0 - dT: GOTO 3010
    FOR J = 1 TO N
        Z = X0(J): q = fv * (Z - Th)

```

```
X(J) = (EXP(q) - EXP(-q)) / (EXP(q) + EXP(-q)); '    X=tanh(q)
NEXT J
```

```
GOSUB 23000: ' Do a fit for this set of values
```

```
A = T: B = R: RES = V
Z = ABS(RES - 1)
IF Z < ROLD THEN ROLD = Z: AOLD = A: BOLD = B: FOLD = fv: TOLD = Th
PRINT ".": GOTO 3020
```

```
5000 CLS : PRINT
PRINT "Best Values were obtained for : "
PRINT
PRINT "A = "; AOLD, "B = "; BOLD, "f = "; FOLD, "Th = "; TOLD
PRINT : PRINT "    Residuals = "; ROLD + 1; "    Note that 1 is perfect"
PRINT
PRINT "f - Range from "; F0; " - "; F9; " -- increments at dF = "; dF
PRINT "To - Range from "; T0; " - "; T9; " -- increments at dT = "; dT
PRINT : flagf = 100

PRINT "To stop, enter 'S'"
PRINT " 'F' creates correlation file in GRAPHER or LOTUS format"
PRINT " ELSE restarts correlation using same data"; : INPUT W$

IF W$ = "S" THEN STOP
IF W$ = "F" THEN 6000
GOTO 1000
```

```
6000 CLS : PRINT "Enter start, end temperature for correlation curve calculation"; : INPUT T0, T9
PRINT "Enter temperature step (degrees) for correlation calculation"; : INPUT TX
PRINT "Enter file name for correlation curve storage"; : INPUT FCOR$
OPEN FCOR$ FOR OUTPUT AS #2
```

```
    TMP = T0
6010  arx = FOLD * (TMP - Th): IF arx < -20 THEN QXZ = -1: GOTO 6020
    IF arx > 20 THEN QXZ = 1: GOTO 6020
    QXZ = (EXP(arx) - EXP(-arx)) / (EXP(arx) + EXP(-arx)); '    X=tanh(q)
6020  Y = AOLD + BOLD * QXZ
    PRINT #2, TMP, Y
    TMP = TMP + TX
    IF TMP > T9 THEN 6050
    GOTO 6010
```

```
6050 CLOSE : PRINT : PRINT "Correlation file complete -- when ready to continue, <CR>"; : INPUT W$
GOTO 1000
```

```
6500 CLS : PRINT : PRINT
PRINT "Enter T = A + B*Tanh[f*(T-T0)] correlation parameters A, B, f and T0";
INPUT AOLD, BOLD, FOLD, Th
GOTO 6000
```

```
20000 PRINT : PRINT : N = 0
20010 N = N + 1: PRINT "Enter ", N; " value for X (note that 'S' stops)"; : INPUT W$: IF W$ = "S" THEN 20500
```

```

X(N) = VAL(W$)
IF CQ1 = 1 THEN PRINT "Enter "; N; " value for Y"; : INPUT Y(N)
PRINT "Enter "; N; " value for Z"; : INPUT Z(N)
GOTO 20010
20500 CLS : N = N - 1
PRINT "Data is as follows:"
PRINT "J=", "Z(J)=", "X(J)=", "Y(J)="
FOR J = 1 TO N
PRINT J, Z(J), X(J), Y(J)
NEXT J
PRINT : PRINT "Enter file name for data storage"; : INPUT F$
OPEN F$ FOR OUTPUT AS #1
PRINT #1, N
PRINT #1, CQ1
FOR J = 1 TO N
PRINT #1, Z(J)
PRINT #1, X(J)
IF CQ1 = 1 THEN PRINT #1, Y(J)
NEXT J
CLOSE
RETURN

21000 IF flagf <> 0 THEN 21010
CLS : PRINT "Enter filename for data"; : INPUT F$
21010 OPEN F$ FOR INPUT AS #2
INPUT #2, N; ' , CQ1 has been used in general, but now in XY format
PRINT "N="; N: PRINT "Ready for next step"; : INPUT W$
' INPUT #2, CQ1
FOR J = 1 TO N
INPUT #2, X(J), Z(J)
' INPUT #2, X(J)
IF CQ1 = 1 THEN INPUT #2, Y(J)
NEXT J

IF flagf <> 0 THEN CLOSE : RETURN
CLS
PRINT "Data retrived from file "; F$; " is as follows:"
PRINT "J=", "Z(J)=", "X(J)=", "Y(J)="
FOR J = 1 TO N
PRINT J, Z(J), X(J), Y(J)
NEXT J
PRINT : PRINT "To continue fit, <CR>"; : INPUT W$
CLOSE : RETURN

22000 PRINT : PRINT "Fit Both X and Y Independent Variables"

A = 0: B = 0: C = 0: D = 0: G = 0
E = 0: F = 0: L = 0: M = 0: P = 0

FOR J = 1 TO N

A = A + X(J) * X(J)
B = B + Y(J) * Y(J)

```

$C = C + Z(J) * Z(J)$

$D = D + X(J) * Y(J)$

$E = E + X(J) * Z(J)$

$F = F + Y(J) * Z(J)$

$L = L + X(J); M = M + Y(J); P = P + Z(J)$

$G = G + 1$

NEXT J

$A1 = (N * A - L^2) * (N * F - M * P)$

$B1 = (N * D - L * M) * (N * E - L * P)$

$S = (A1 - B1) / ((N * A - L^2) * (N * B - M^2) - (N * D - L * M)^2)$

$R = ((N * E - L * P) - S * (N * D - L * M)) / (N * A - L^2)$

$T = (P - S * M - R * L) / N$

$V = (T * P + R * E + S * F - (P^2) / N) / (C - (P^2) / N)$

RETURN

23000' PRINT : PRINT "Fit Only X as the Independent Variable"

$A = 0; B = 0; C = 0; D = 0; G = 0$

$E = 0; F = 0; L = 0; M = 0; P = 0$

FOR J = 1 TO N

$A = A + X(J) * X(J)$

$C = C + Z(J) * Z(J)$

$E = E + X(J) * Z(J)$

$L = L + X(J)$

$P = P + Z(J)$

$G = G + 1$

NEXT J

$A1 = (N * A - L^2)$

$B1 = (N * E - L * P)$

$ZYQ = (N * A - L^2)$

IF ZYQ = 0 THEN PRINT "DIVIDE BY ZERO PROBLEM": STOP

$R = (N * E - L * P) / ZYQ$

$T = (P - R * L) / N$

$ZZQ = (C - (P^2) / N)$

IF ZZQ = 0 THEN PRINT "DIVIDE BY ZERO PROBLEM": STOP

$V = (T * P + R * E - (P^2) / N) / ZZQ$

RETURN

APPENDIX B**ATP/OTP Procedure and Witnesses for 3-11-99 Testing at SY-101****6.7 GAMMA AND NEUTRON PROBE TESTS IN TANK 241-SY-101****6.7.1 Purpose**

The purpose of this test is to demonstrate the operability of the MIT probes and LOW van at the Tank 241-SY-101 MITs and to obtain the first neutron probe moisture data from this tank. The data will be analyzed to determine the value of this moisture data prior to establishing regular LOW van/MIT probe operations at SY-101.

6.7.2 Equipment Needed

Table 6.7 outlines the equipment needed for this test.

Table 6.7. Required Equipment for Gamma and Neutron Probe Tests in Tank 241-SY-101

Item	Quantity	Description
MIT neutron probe	1	Neutron Probe #9, including neutron source (1.5 or 3 Ci)
MIT gamma probe	1	Gamma Probe #9
LOW van	1	LOW van with modified probe holder, including MIT probe software files. All van equipment required to perform a normal field job, including morning cals, spider mode surveys (both gamma and neutron), after survey cals, and data downloading.
Offset Fixture	1	Offset fixture (spider) assembly
Software	1	Script files for Tank 241-SY-101 installed on van computer

6.7.3 Test Location

These tests will be performed at Tank 241-SY-101 in both MITs.

6.7.4 Tank 241-SY-101 Test Procedure

NOTE: This test is essentially a normal neutron/gamma probe run at other LOWs, with a few minor differences, which will be identified in the procedures called out below. All operations to prepare the MIT probes and the LOW van system for operation shall be performed in compliance with the most recent revision of TO-040-333 procedures (Section 5).

6.7.4.1 Perform LOW van log-on as per operating procedure (TO-040-333).

6.7.4.2 Perform depth calibration per operating procedure.

6.7.4.3 Perform neutron calibration for MIT neutron probe per operating procedure.

6.7.4.4 Perform gamma calibration for MIT gamma probe per operating procedure.

- 6.7.4.5 The first scan record of each MIT using the new MIT probes will be used as a reference scan for all subsequent surveys. Loading the reference survey on the PC will be done by the surveillance cognizant engineer, and will need to be done only once.
- 6.7.4.6 At each of the two SY-101 MITs, perform an MIT gamma probe scan and then an MIT neutron probe scan (with neutron source installed).
- 6.7.4.7 After the van has completed these scans, return to the 272WA garage.
- 6.7.4.8 Plug in modem line to computer data pigtail and download data (F6 function key on computer keyboard).

This procedure was performed on 3-11-99 at Tank 241-SY-101.

Operator: JR Maasen Date: 5-3-99
J. R. Maasen

Operator: T. N. Miller Date: 5-3-99
T. N. Miller

Test Engineer: N. S. Cannon Date: 5-5-99
N. S. Cannon

APPENDIX C

MIT Bulkhead Elevations

The 'spikes' observed (particularly) in the MIT gamma probe data as shown in Figures 6.7-1 and 6.7-2 can be correlated to the MIT bulkhead elevations. The bottom of the SY-101 tank has been surveyed at the elevation of 617.22 ft; special surveys were done of the elevations of the top of the valve cover flange (zeroing point for probes) of the two MITs, resulting in 675.91 ft (17B) and 675.92 ft (17C) elevation measurements. Thus, the difference in elevation between the bottom of the tank and the zero point for the probe measuring system is 704.3 inches (17B) and 704.4 inches (17C).

An estimated length of the MITs is made as 701.375 inches based on drawings H-2-85142, H-2-85143, H-2-85144 and H-2-85145; note that a small variation from the drawing length would be expected due to tolerances and welding shrinkage. Relative elevations of some of the bulkheads in the MITs are estimated based on drawing H-2-85145. A correlation of the measured position of the bulkheads from the gamma probe data with estimated elevations of the bulkheads is given in Table C-1. The correspondence is 0.8 inches or better where the sampling resolution is better than 0.8 inches.

TABLE C-1. MIT Bulkhead Elevation Comparison

	17B	17C						
MIT/Tank Bottom Diff.	2.9	3.0	** Run 3-11-99 Gamma 17B **			** Run 3-11-99 Gamma 17C **		
	Expected	Elevation	Resol.	Measured	Difference	Resol.	Measured	Difference
Bulkhead 18	420.66	420.78	0.4	420.1	-0.6	0.4	420.1	-0.7
Bulkhead 17	396.66	396.78	0.4	396.1	-0.6	0.4	395.7	-1.1
Bulkhead 16	372.66	372.78	0.4	372.1	-0.6	0.4	372.1	-0.7
Bulkhead 15	348.66	348.78	0.2	348.1	-0.6	0.2	348.1	-0.7
Bulkhead 14	324.66	324.78	0.2	324.3	-0.4	0.2	324.0	-0.8
Bulkhead 13	300.66	300.78	1.2	299.7	-1.0	1.2	300.1	-0.7
Bulkhead 12	276.66	276.78	1.2	275.7	-1.0	1.2	276.1	-0.7
Bulkhead 11	252.66	252.78	1.2	251.7	-1.0	1.2	252.0	-0.8
Bulkhead 10	228.66	228.78	1.2	227.7	-1.0	1.2	228.0	-0.8
Bulkhead 9	204.66	204.78	1.2	203.7	-1.0	1.2	204.0	-0.8
Bulkhead 8	180.66	180.78	1.2	179.7	-1.0	1.2	180.1	-0.7
Bulkhead 7	156.66	156.78	1.2	155.7	-1.0	1.2	156.0	-0.8
Bulkhead 6	132.66	132.78	1.2	131.7	-1.0	1.2	132.0	-0.8
Bulkhead 5	108.66	108.78	1.2	107.7	-1.0	1.2	108.1	-0.7
Bulkhead 4	84.66	84.78	1.2	83.7	-1.0	1.2	84.0	-0.8
Bulkhead 3	60.66	60.78	1.2	59.7	-1.0	1.2	60.0	-0.8
Bulkhead 2	36.66	36.78	1.2	35.7	-1.0	1.2	36.0	-0.8
Bulkhead 1	12.66	12.78		NA			NA	
MIT End (calculated)	2.90	3.02			-0.8			-0.8
Tank Bottom Set to	0	Note: Resol. is distance between data points.						

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