

## APPENDIX G

### DATA VALIDATION AND QC REVIEW

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## 1.0 OVERVIEW

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The data validation process for the Marsland Expansion Area baseline radiological investigation involved a review of quality assurance (QA) and quality control (QC) data to identify their strengths and weaknesses. The data validation and QA/QC review process is intended to assess the technical reliability and the degree of confidence in the reported analytical data as well as the instrument response. This appendix summarizes the QA/QC analysis results that are used in the data validation process for the Marsland Expansion Area baseline radiological investigation, which includes data validation and QC review for the pre-operational gamma survey program and the pre-operational soil sampling program.

## 2.0 PREOPERATIONAL GAMMA SURVEY PROGRAM QA/QC

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The two primary QC methods for the gamma radiation survey outlined in the report include daily field calibration checks and pre-survey and post-survey calibration checks.

### 2.1 DAILY FIELD CALIBRATION QC ACCEPTANCE LIMITS

Before and after the gamma radiation survey, Tetra Tech Inc. performed QC analysis for the radiation instruments that were used during the Marsland Expansion Area pre-operational gamma survey program. This gamma survey program consisted of the Regulatory Guide (RG) 4.14 direct gamma measurement field investigation and the continuous gamma survey field investigation. The purpose of the QC analysis is to quantify the consistency of gamma exposure readings between detectors and the consistency of readings over the course of the field work and data collection. This section summarizes the results of the QC analysis of detectors used for the project.

The analysis used QC checks under a controlled indoor environment for pre-survey and post-survey checks and daily QC checks during the field work at a designated location at the Site just north of the Marsland permit boundary. These daily checks included static background checks and Cesium 137 ( $^{137}\text{Cs}$ ) source checks. Under these circumstances, all data from any given set of properly calibrated and correctly functioning radiation instruments should follow a normal distribution.

Five detectors, identified as MFG-6, MFG-7, MFG-9, MFG-12 and MFG-13, were used during the Marsland Expansion Area preoperational gamma survey program. Two different conditions were measured under a controlled environment as part of the pre-survey and post-survey QC checks: a background reading, and a  $^{137}\text{Cs}$  source check reading. A minimum of 1,000 background and source level measurements were collected using consistent geometry for each instrument before and after the survey field work.

The pre-survey and post-survey QC measurements were collected at the Tetra Tech radiation laboratory in Fort Collins, Colorado. The pre-survey measurements were performed in May 2014, and the post-survey measurements were performed in June 2014.

### 2.1.1 Ambient Gamma Exposure Rate (Background) Quality Control Results

This section summarizes the QC results for the background measurements for the pre-survey and post-survey. The background checks are summarized in Tables G-1 through Gable G-5 that follow and are shown graphically in Figures G-1 through G-4. The tables and figures show that the QC checks all fall within QC limits.

**Table G-1. Instrument MFG-6 Pre-Survey and Post-Survey Background QC Results**

Survey:	Pre-Survey	Post-Survey	Relative Percent Difference
Date:	May-14	June-14	
Detector ID:	MFG-6	MFG-6	
# of Readings	1,411	1,553	n/a
Mean	15.7	15.8	0.75%
Median	15.7	15.8	0.80%
Standard Deviation	0.82	0.82	0.31%
95 <sup>th</sup> Percentile	17.0	17.2	0.69%
99 <sup>th</sup> Percentile	17.6	17.7	0.92%

**Table G-2. Instrument MFG-7 Pre-Survey and Post-Survey Background QC Results**

Survey:	Pre-Survey	Post-Survey	Relative Percent Difference
Date:	May-14	June-14	
Detector ID:	MFG-7	MFG-7	
# of Readings	1,001	1,385	n/a
Mean	16.1	15.4	4.72%
Median	16.1	15.4	4.70%
Standard Deviation	0.83	0.79	5.88%
95 <sup>th</sup> Percentile	17.5	16.7	4.84%
99 <sup>th</sup> Percentile	18.2	17.1	5.95%

**Table G-3. Instrument MFG-9 Pre-Survey and Post-Survey Background QC Results**

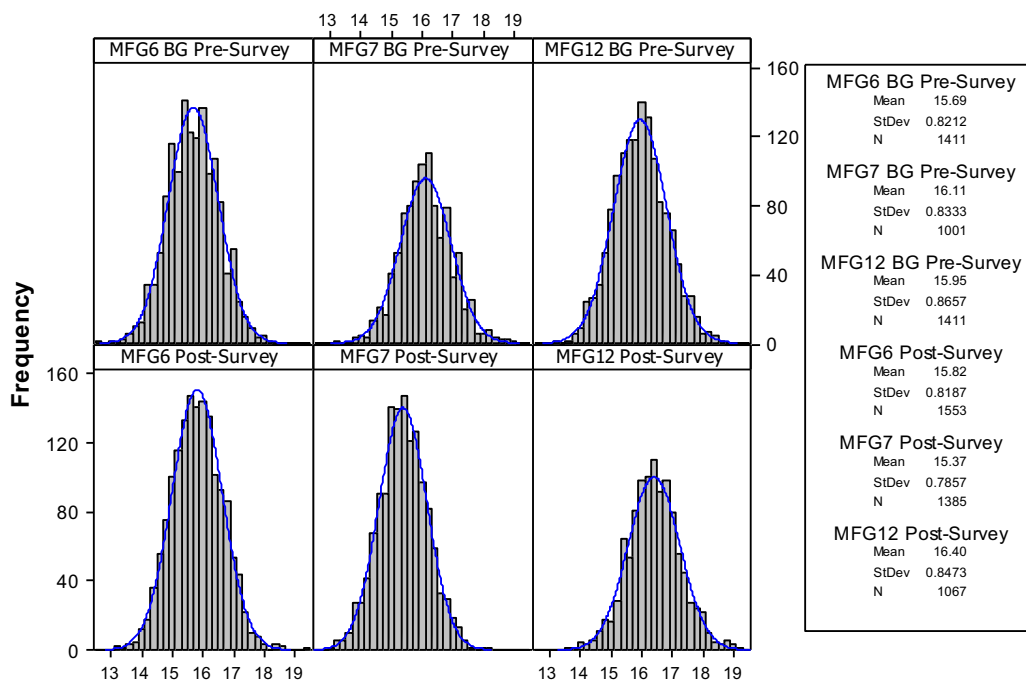
Survey:	Pre-Survey	Post-Survey	Relative Percent Difference
Date:	May-14	June-14	
Detector ID:	MFG-9	MFG-9	
# of Readings	1,390	1,381	n/a
Mean	15	15	0.07%
Median	15	15	0.09%
Standard Deviation	0.79	0.79	0.41%
95 <sup>th</sup> Percentile	17	17	0.08%
99 <sup>th</sup> Percentile	17	17	1.09%

**Table G-4. Instrument MFG-12 Pre-Survey and Post-Survey Background QC Results**

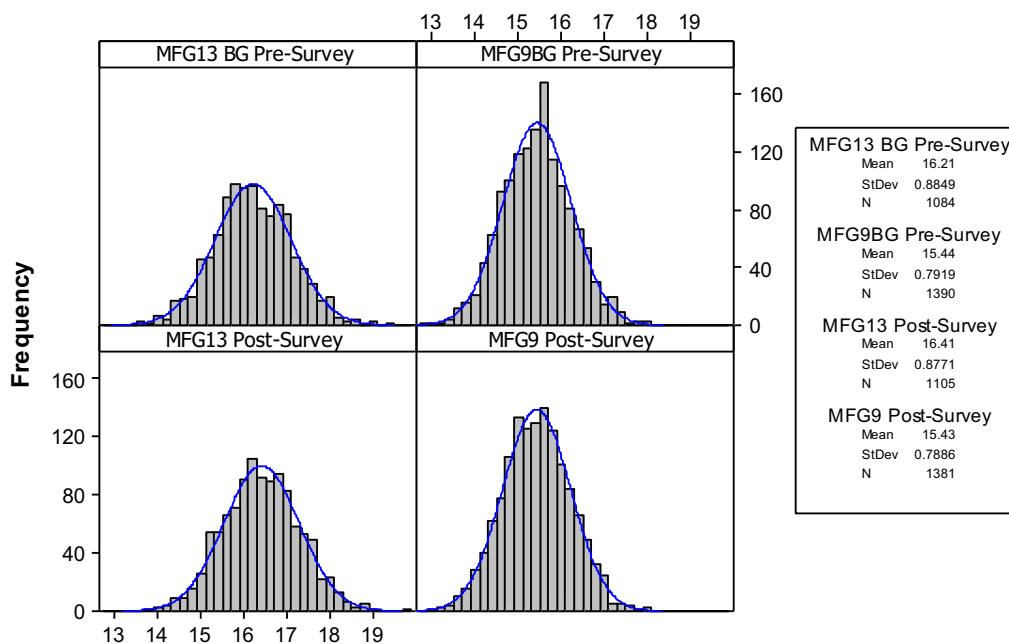
<b>Survey:</b>	<b>Pre-Survey</b>	<b>Post-Survey</b>	<b>Relative Percent Difference</b>
<b>Date:</b>	<b>May-14</b>	<b>June-14</b>	
<b>Detector ID:</b>	<b>MFG-12</b>	<b>MFG-12</b>	
<i># of Readings</i>	1,411	1,067	n/a
<i>Mean</i>	16	16	2.53%
<i>Median</i>	16	16	2.49%
<i>Standard Deviation</i>	0.85	0.85	0.13%
<i>95<sup>th</sup> Percentile</i>	17	18	2.51%
<i>99<sup>th</sup> Percentile</i>	18	19	2.93%

**Table G-5. Instrument MFG-13 Pre-Survey and Post-Survey Background QC Results**

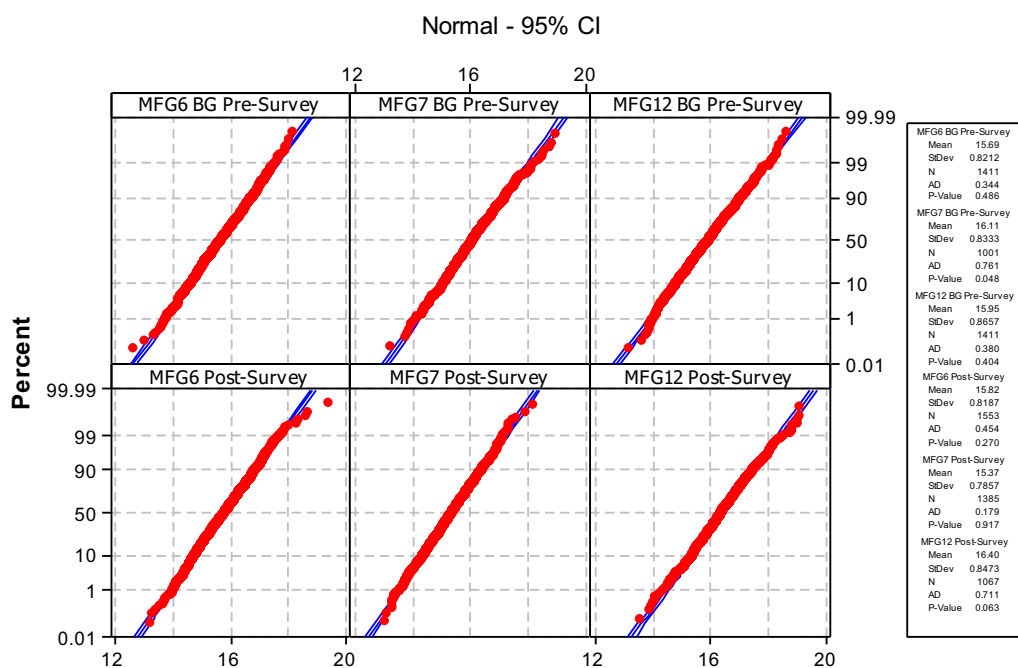
<b>Survey:</b>	<b>Pre-Survey</b>	<b>Post-Survey</b>	<b>Relative Percent Difference</b>
<b>Date:</b>	<b>May-14</b>	<b>June-14</b>	
<b>Detector ID:</b>	<b>MFG-13</b>	<b>MFG-13</b>	
<i># of Readings</i>	1,084	1,105	n/a
<i>Mean</i>	16	16	1.23%
<i>Median</i>	16	16	1.28%
<i>Standard Deviation</i>	0.88	0.88	0.88%
<i>95<sup>th</sup> Percentile</i>	18	18	1.07%
<i>99<sup>th</sup> Percentile</i>	18	18	0.82%



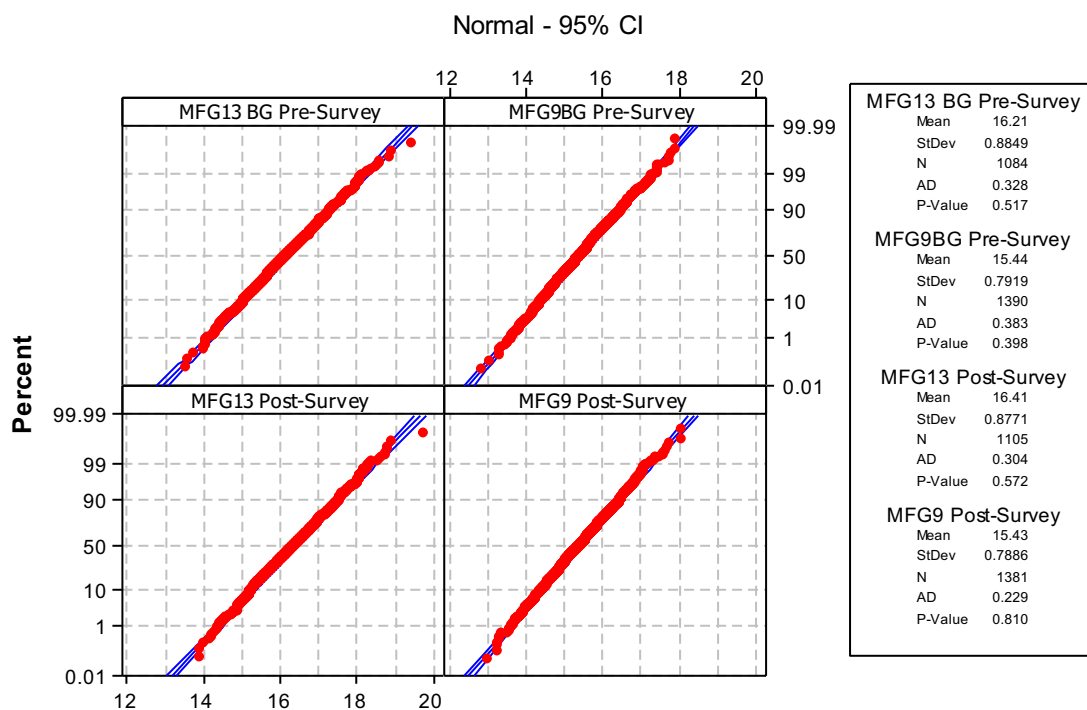
**Figure G-1. Frequency Histograms for Pre-Survey and Post-Survey Background Measurements (MFG-6, MFG-7, MFG-12)**



**Figure G-2. Frequency Histograms for Pre-Survey and Post-Survey Background Measurements (MFG-13, MFG-9)**



**Figure G-3. Normal Probability Plots for Pre-Survey and Post-Survey Instruments Background Measurements (MFG-6, MFG-7, MFG-12)**



**Figure G-4. Normal Probability Plots for Pre-Survey and Post-Survey Instruments Background Measurements (MFG-13, MFG-9)**



## 2.1.2 Cesium-137 SOURCE Exposure Rate Quality Control Results

This section summarizes the QC results for the  $^{137}\text{Cs}$  source check measurements for the pre-survey and post-survey. Again, the results appear in Tables G-6 through Table G-10 and are shown graphically in Figures G-5 through G-8. Source check measurements all fell within QC limits as shown in the tables and figures below.

**Table G-6. Instrument MFG-6 Pre-Survey and Post-Survey  $^{137}\text{Cs}$  Source QC Results**

Survey:	Pre-Survey	Post-Survey	Relative Percent Difference
Date:	May-14	June-14	
Detector ID:	MFG-6	MFG-6	
# of Readings	1,015	1,222	n/a
Mean	171	174	1.84%
Median	171	174	1.93%
Standard Deviation	2.81	2.77	1.49%
95 <sup>th</sup> Percentile	176	179	1.62%
99 <sup>th</sup> Percentile	178	180	1.58%

**Table G-7. Instrument MFG-7 Pre-Survey and Post-Survey  $^{137}\text{Cs}$  Source QC Results**

Survey:	Pre-Survey	Post-Survey	Relative Percent Difference
Date:	May-14	June-14	
Detector ID:	MFG-7	MFG-7	
# of Readings	1,000	1,461	n/a
Mean	159	151	5.22%
Median	159	151	5.24%
Standard Deviation	2.75	2.55	7.22%
95 <sup>th</sup> Percentile	163	155	5.29%
99 <sup>th</sup> Percentile	165	157	5.50%

**Table G-8. Instrument MFG-9 Pre-Survey and Post-Survey  $^{137}\text{Cs}$  Source QC Results**

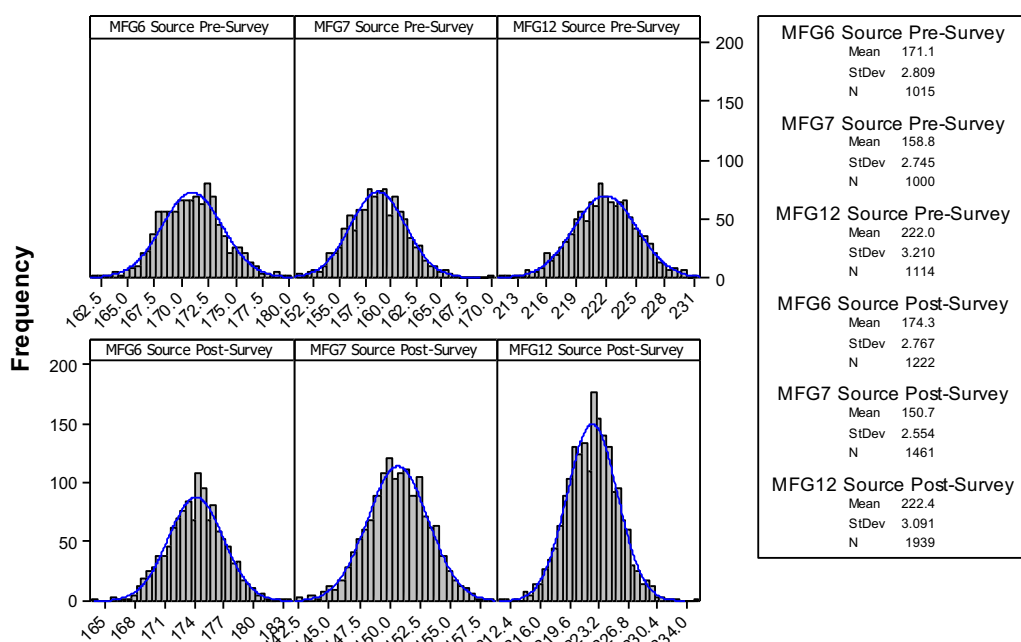
Survey:	Pre-Survey	Post-Survey	Relative Percent Difference
Date:	May-14	June-14	
Detector ID:	MFG-9	MFG-9	
# of Readings	1,498	1,489	n/a
Mean	205	206	0.21%
Median	205	206	0.26%
Standard Deviation	3.11	3.03	2.45%
95 <sup>th</sup> Percentile	211	211	0.14%
99 <sup>th</sup> Percentile	212	213	0.40%

**Table G-9. Instrument MFG-12 Pre-Survey and Post-Survey <sup>137</sup>Cs Source QC Results**

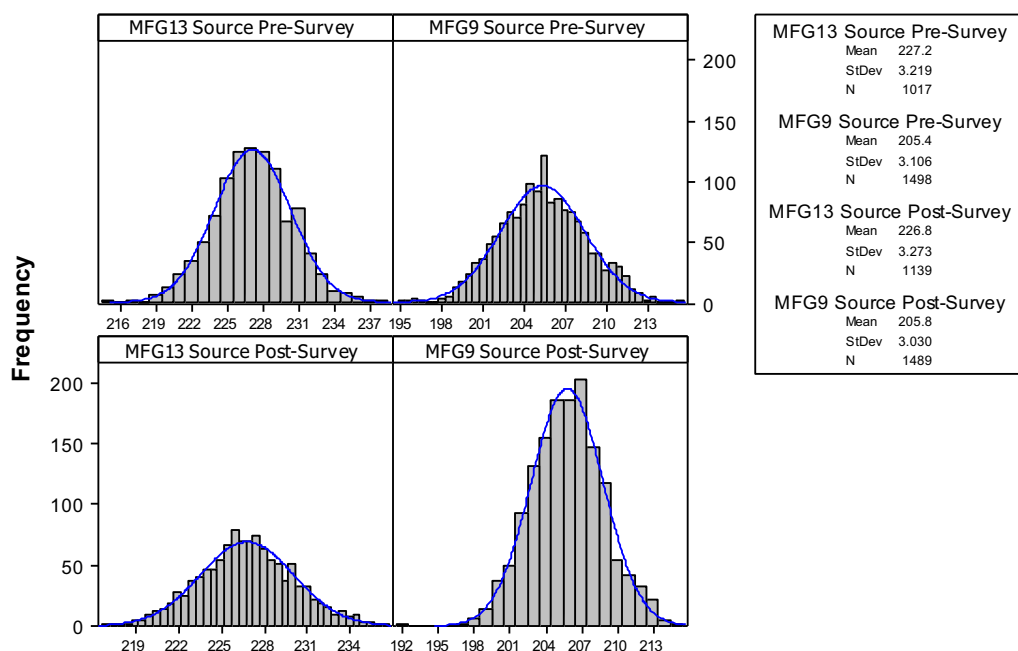
<b>Survey:</b>	<b>Pre-Survey</b>	<b>Post-Survey</b>	<b>Relative Percent Difference</b>
<b>Date:</b>	<b>May-14</b>	<b>June-14</b>	
<b>Detector ID:</b>	<b>MFG-12</b>	<b>MFG-12</b>	
<i># of Readings</i>	1,114	1,939	n/a
<i>Mean</i>	222	222	0.20%
<i>Median</i>	222	223	0.27%
<i>Standard Deviation</i>	3.21	3.09	3.78%
<i>95<sup>th</sup> Percentile</i>	227	227	0.13%
<i>99<sup>th</sup> Percentile</i>	229	230	0.13%

**Table G-10. Instrument MFG-13 Pre-Survey and Post-Survey <sup>137</sup>Cs Source QC Results**

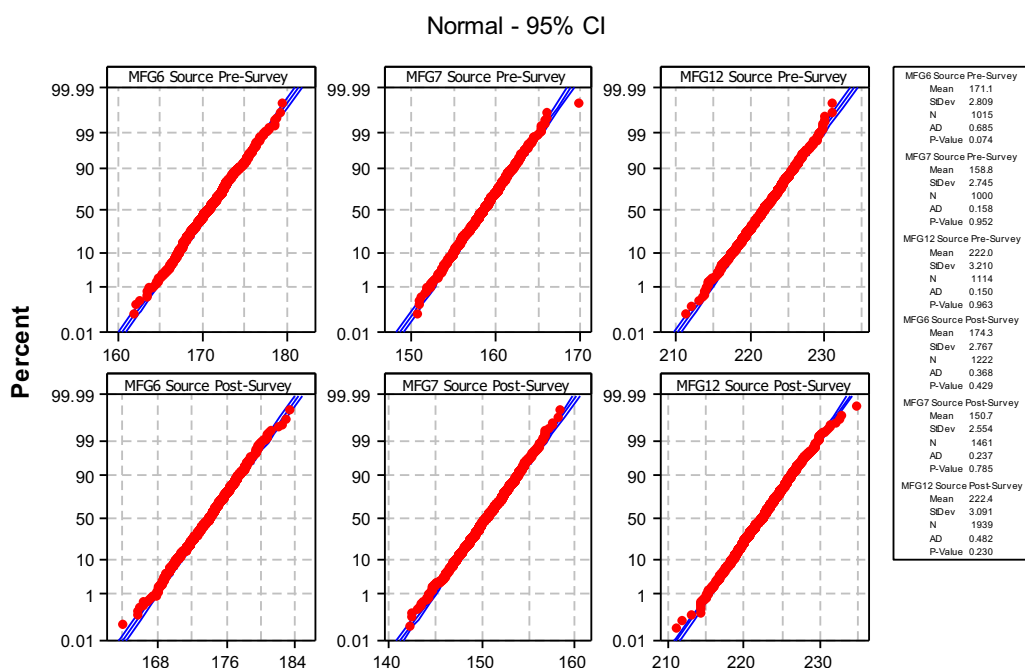
<b>Survey:</b>	<b>Pre-Survey</b>	<b>Post-Survey</b>	<b>Relative Percent Difference</b>
<b>Date:</b>	<b>May-14</b>	<b>June-14</b>	
<b>Detector ID:</b>	<b>MFG-13</b>	<b>MFG-13</b>	
<i># of Readings</i>	1,017	1,139	n/a
<i>Mean</i>	227	227	0.14%
<i>Median</i>	227	227	0.15%
<i>Standard Deviation</i>	3.22	3.27	1.65%
<i>95<sup>th</sup> Percentile</i>	232	232	0.02%
<i>99<sup>th</sup> Percentile</i>	235	234	0.23%



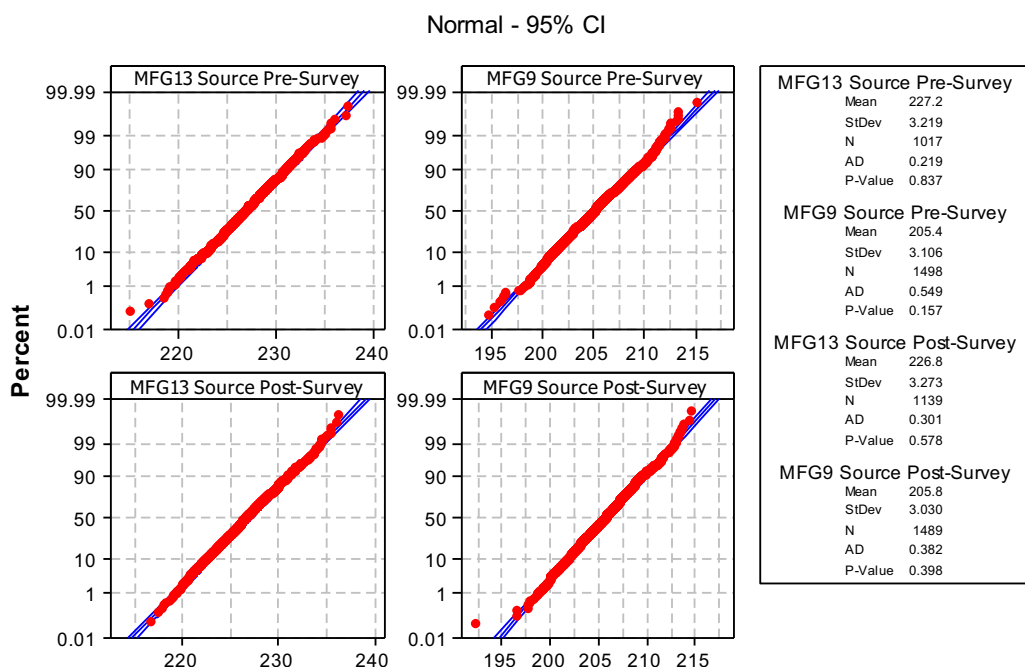
**Figure G-5. Frequency Histograms for Pre-Survey and Post-Survey Source Measurements (MFG-6, MFG-7, MFG-12)**



**Figure G-6. Frequency Histograms for Pre-Survey and Post-Survey Cs-137 Source Measurements (MFG-13, MFG-9)**



**Figure G-7. Normal Probability Plots for Pre-Survey and Post-Survey Instruments Cs-137 Source Measurements (MFG-6, MFG-7, MFG-12)**



**Figure G-8. Normal Probability Plots for Pre-Survey and Post-Survey Instruments Cs-137 Source Measurements (MFG-13, MFG-9)**

## 2.2 DAILY FIELD CALIBRATION QC ACCEPTANCE LIMITS

Five detectors, identified as MFG-6, MFG-7, MFG-9, MFG-12 and MFG-13, were used during the Marsland Expansion Area preoperational gamma survey program. Daily field calibration checks were performed on each of these instruments. For normally distributed data, 99 percent of all measurements are expected to fall within  $\pm 3$  standard deviations from the mean. Background, field strip, and check source standard deviation values were recalculated twice daily throughout the project. Any instrument with a QC measurement that fell outside  $\pm 3$  standard deviations from the mean of all QC measurements on the field check control chart requires investigation. A detector exceeding control limits on any QC check (background, field strip, or source) is to be replaced with a pre-qualified spare detector and returned to the manufacturer for evaluation, repair, and recalibration.

### 2.2.1 Daily Field Check QC Results

This section provides the summary results of the daily field checks, including background, field strip, and source checks. Instruments are considered properly functioning if the QC check falls within 3 standard deviations of the total mean. The results below demonstrate that the instruments used all met this criterion, as shown graphically in Figure G-9 and G-10.



Figure G-9. Daily Background Check QC Chart

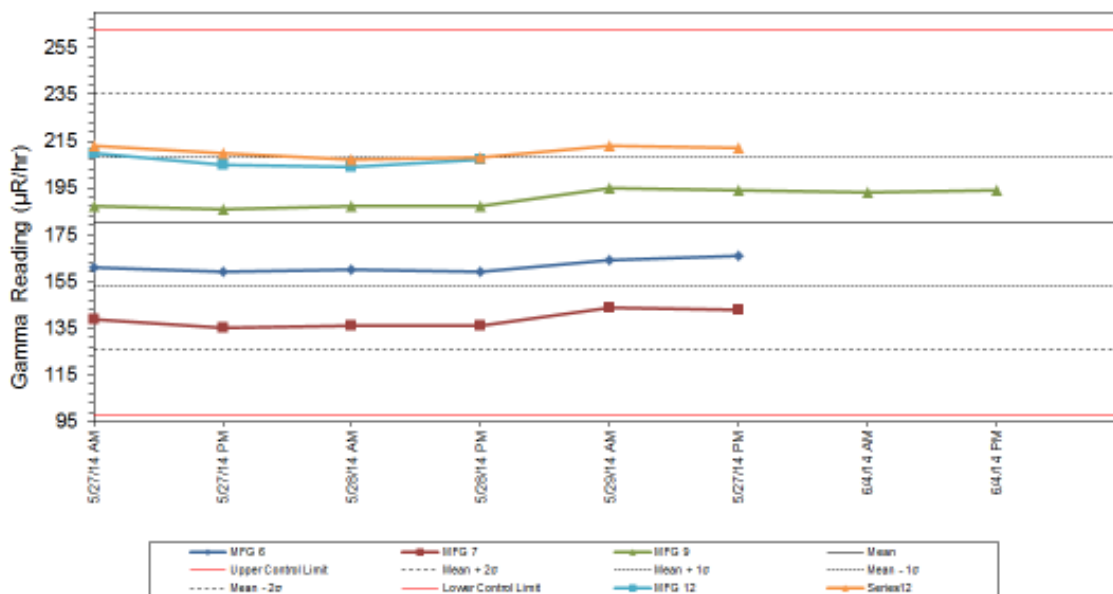


Figure G-10. <sup>137</sup>Cs Source Check QC Chart

## 2.3 GAMMA SURVEY QA/QC CONCLUSION

The data populations for the QC measurements collected during the pre-survey and post-survey analysis exhibited normal (Gaussian) distributions for both background and source conditions and were evaluated by estimating the Anderson-Darling (AD) statistic for each pre- and post-survey distribution. All of the AD values (less than 0.75) and p-values (greater than 0.05) met the criteria to accept the null hypothesis that the data sets followed a Gaussian distribution. Additionally, all of the daily background and source checks by field personnel met the QA/QC criteria set forth by Tetra Tech. When the mean, median, and percentiles are compared between the pre-survey and post-survey, the relative percent difference was minimal for all statistics. Based on this analysis, the data collected with all of the radiation instruments used during the Marsland Expansion Baseline preoperational gamma survey program should be considered of the highest quality, and the daily scan data collected during the field efforts are to be included in the final project database.

## 3.0 PREOPERATIONAL SOIL SAMPLING PROGRAM QA/QC

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QA/QC samples were collected as part of the preoperational soil sampling program. Soil samples were collected according to the SOPs in Appendix A. QA/QC samples were labeled with QA/QC identification numbers and sent to the laboratory with the other samples for analysis. A field duplicate is defined as a second sample (or measurement) from the same location, collected in immediate succession, using identical techniques. Both the primary and field duplicate samples were homogenized in a mixing bowl and split into separate sample containers. A minimum of one field duplicate was submitted for every 20 primary samples collected. Data validation testing was performed on the laboratory results for the primary and duplicate samples as described below.

### 3.1 SOIL SAMPLING QC DATA VALIDATION

The data validation testing between primary and duplicate samples was evaluated where applicable on the soil samples collected and submitted for laboratory analysis. The primary testing methods involved relative percent difference (RPD) for the duplicate error ratio (DER). The DER was used for radiochemistry analytes where an individual precision was reported for the analytes. The data validation by Tetra Tech included the quantitative evaluation of precision between primary and field duplicate samples. Precision can be defined by the amount of scatter or variance that occurs in repeated measurements of a particular analyte. Two types of duplicate equations are used to evaluate the precision between the primary soil sample and the field duplicate soil sample. The first equation for acceptance or rejection of precision for this project is based on the RPD of the field duplicates. The RPD equation is given by:

$$RPD(\%) = \frac{|S - D|}{\frac{(S + D)}{2}} \times 100$$

where:

RPD = relative percent difference, non-detects are excluded

S = concentration of primary sample

D = concentration of duplicate sample

The acceptance criterion used is the DER, which factors in the uncertainties from both the unknown and duplicate sample into the equation. The DER is calculated between duplicates for all samples when precision estimates were provided; the equation for DER is given by:

$$DER = \frac{|S - D|}{\sqrt{\sigma_s^2 + \sigma_d^2}}$$

where:

S = primary sample result

D = duplicate sample result measured field sample concentration;

$\sigma_s$  = primary sample uncertainty

$\sigma_s$  = primary sample uncertainty

$\sigma_d$  = duplicate sample uncertainty

## 3.2 DATA VALIDATION RESULTS

The QC acceptance limits or Data Quality Objectives (DQO) are based on the RPD and DER testing results for all applicable samples. Tetra Tech evaluated the analyte results for the field duplicate soil samples by calculating the RPD and DER between the two samples when both values of the field/ duplicate pair are greater than five times the reporting limit (RL) for a given analyte. The RPD and DER are not calculated for samples where either the primary or duplicate concentration is a non-detect. The project QC acceptance limit is an RPD of less than 30 percent for samples where both the primary and duplicate concentrations are five times greater than the RL. Similarly, the project QC acceptance limit is a DER less than 1.96 where the concentration is five times greater than the RL. Data qualifiers are applied to the data that do not meet the performance acceptance criteria discussed above. Data qualifiers (K, G) are assigned to the analytical data that exceed the RPD (30 percent) and DER (1.96) limits and have a concentration five times greater than the reporting limit; these qualifiers negatively affect the overall project QC acceptance goal. Table G-11 shows a summary of the data QC qualifiers for the project. Data qualifiers (J, H) are also applied to the data that do not meet the RPD (30 percent) and DER (1.96) limits and are also less than five times the RL; however, these qualifiers do not negatively affect the project QC acceptance goal. The overall project QC acceptance goal is that 85 percent of the samples for all analytes meet the QC acceptance criteria.

**Table G-11. Summary of Field QC Soil Samples**

<b>Data Qualifier</b>	<b>Description of Data Qualifier</b>
K	RPD > 30% and the concentration is greater than five times the RL <sup>1</sup>
J	RPD > 30% and the concentration is less than five times the RL
G	DER > 1.96 and the concentration is greater than five times the RL
H	DER > 1.96 and the concentration is less than five times the RL

<sup>1</sup>RL = reporting limit

Table G-12 provides a summary of the field QC soil samples collected as part of the preoperational soil sampling program. Table G-13 through Table G-17 provide the data validation QC analysis results for the individual radionuclides radium-226, lead-210, thorium-230, natural uranium, and potassium-40.



**Table G-12. Summary of Field QC Soil Samples**

QC Sample Set	Client Sample ID	Lab Report ID	Sample Date	Sample Type	Depth	Type
1	MAR3SOIL-01-15	S1406226-016	5/28/14	Air Monitoring Station	0-cm to 15-cm	Primary
	MAR3SOIL-02-15	S1406226-017			0-cm to 15-cm	Duplicate
2	MAR5SOILA-01-5	S1406226-024	5/28/14	Air Monitoring Station	0-cm to 15-cm	Primary
	MAR5SOILA-02-5	S1406226-025			0-cm to 15-cm	Duplicate
3	SW300-01-5	S1406227-027	6/4/14	Radial Surface	0-cm to 5-cm	Primary
	SW300-02-5	S1406227-028			0-cm to 5-cm	Duplicate
4	NW300-01-5	S1406227-038	6/4/14	Radial Surface	0-cm to 5-cm	Primary
	NW300-02-5	S1406227-039			0-cm to 5-cm	Duplicate
5	CENTER-SUB-01-33	S1406228-001	6/4/14	Radial Subsurface	0-cm to 33-cm	Primary
	CENTER-SUB-02-33	S1406228-002			0-cm to 33-cm	Duplicate
6	MARSOILCORR2-01-15	S1406229-002	5/29/14	Soil Correlation	0-cm to 15-cm	Primary
	MARSOILCORR2-02-15	S1406229-003			0-cm to 15-cm	Duplicate
7	MARSS-04-01	S1411189-004	11/11/14	Supplemental Background	0-cm to 15-cm	Primary
	MARSS-04-02	S1411189-005			0-cm to 15-cm	Duplicate
8	MARSS-10-01	S1411189-011	11/11/14	Supplemental Background	0-cm to 15-cm	Primary
	MARSS-10-02	S1411189-012			0-cm to 15-cm	Duplicate

**Table G-13. Summary of Data Validation of Radium-226 QC Samples**

QC Sample Set	Client Sample ID	Type	Radium-226			RPD	RPD Qualifier <sup>1</sup>	DER	DER Qualifier
			Reported Value (pCi/g)	Precision +/- (pCi/g)	Reporting Limit (pCi/g)				
1	MAR3SOIL-01-15	Primary	0.4	0.4	0.2	22%	-	0.2	-
	MAR3SOIL-02-15	Duplicate	0.5	0.3					
2	MAR5SOILA-01-5	Primary	0.2	0.3	0.2	67%	J	0.5	-
	MAR5SOILA-02-5	Duplicate	0.4	0.3					
3	SW300-01-5	Primary	0.6	0.3	0.2	15%	-	0.2	-
	SW300-02-5	Duplicate	0.7	0.3					
4	NW300-01-5	Primary	1.1	0.4	0.2	32%	K	0.5	
	NW300-02-5	Duplicate	0.8	0.4					
5	CENTER-SUB-01-33	Primary	0.6	0.4	0.2	18%	-	0.2	-
	CENTER-SUB-02-33	Duplicate	0.5	0.3					
6	MARSOILCORR2-01-15	Primary	0.7	0.4	0.2	55%	J	0.5	-
	MARSOILCORR2-02-15	Duplicate	0.4	0.4					
7	MARSS-04-01	Primary	0.9	0.4	0.2	20%	-	0.4	-
	MARSS-04-02	Duplicate	1.1	0.4					
8	MARSS-10-01	Primary	0.5	0.4	0.2	46%	J	0.6	-
	MARSS-10-02	Duplicate	0.8	0.3					

Note:

J = RPD > 30% and the concentration is less than five times the reporting limit  
K = RPD > 30% and the concentration is greater than five times the reporting limit  
G = DER > 1.96 and the concentration is greater than five times the reporting limit  
H = DER > 1.96 and the concentration is less than five times the reporting limit

**Table G-14. Summary of Data Validation of Lead-210 QC Samples**

QC Sample Set	Client Sample ID	Type	Lead-210			RPD	RPD Qualifier	DER	DER Qualifier
			Reported Value (pCi/g)	Precision +/- (pCi/g)	Reporting Limit (pCi/g)				
1	MAR3SOIL-01-15	Primary	2.5	0.4	1.0	38%	J	1.6	-
	MAR3SOIL-02-15	Duplicate	1.7	0.3	1.0				
2	MAR5SOILA-01-5	Primary	1.5	0.5	1.0	6%	-	0.1	-
	MAR5SOILA-02-5	Duplicate	1.6	0.5	1				
3	SW300-01-5	Primary	2	0.5	1.0	58%	J	1.3	-
	SW300-02-5	Duplicate	1.1	0.5	1.0				
4	NW300-01-5	Primary	-	-	-	-	-	-	-
	NW300-02-5	Duplicate	-	-	-				
5	CENTER-SUB-01-33	Primary	1.5	1.5	1	-	-	-	-
	CENTER-SUB-02-33	Duplicate	ND		1				
6	MARSOILCORR2-01-15	Primary	2.5	0.6	1	4%	-	0.1	-
	MARSOILCORR2-02-15	Duplicate	2.4	0.6	1				
7	MARSS-04-01	Primary	-	-	-	-	-	-	-
	MARSS-04-02	Duplicate	-	-	-				
8	MARSS-10-01	Primary	-	-	-	-	-	-	-
	MARSS-10-02	Duplicate	-	-	-				

Note:

J = RPD > 30% and the concentration is less than five times the reporting limit  
K = RPD > 30% and the concentration is greater than five times the reporting limit  
G = DER > 1.96 and the concentration is greater than five times the reporting limit  
H = DER > 1.96 and the concentration is less than five times the reporting limit

**Table G-15. Summary of Data Validation of Thorium-230 QC Samples**

QC Sample Set	Client Sample ID	Type	Thorium-230			RPD	RPD Qualifier	DER	DER Qualifier
			Reported Value (pCi/g)	Precision +/- (pCi/g)	Reporting Limit (pCi/g)				
1	MAR3SOIL-01-15	Primary	ND		0.2	-	-	-	-
	MAR3SOIL-02-15	Duplicate	0.3	0.1	0.2				
2	MAR5SOILA-01-5	Primary	0.2	0.1	0.2	-	-	-	-
	MAR5SOILA-02-5	Duplicate	ND						
3	SW300-01-5	Primary	0.4	0.2	0.2	40%	J	0.7	-
	SW300-02-5	Duplicate	0.6	0.2	0.2				
4	NW300-01-5	Primary				-	-	-	-
	NW300-02-5	Duplicate							
5	CENTER-SUB-01-33	Primary	0.5	0.5	0.2	18%	-	0.1	-
	CENTER-SUB-02-33	Duplicate	0.6	0.6	0.2				
6	MARSOILCORR2-01-15	Primary	0.4	0.2	0.2	40%	J	0.7	-
	MARSOILCORR2-02-15	Duplicate	0.6	0.2	0.2				
7	MARSS-04-01	Primary				-	-	-	-
	MARSS-04-02	Duplicate							
8	MARSS-10-01	Primary				-	-	-	-
	MARSS-10-02	Duplicate							

Note:

J = RPD > 30% and the concentration is less than five times the reporting limit

K = RPD > 30% and the concentration is greater than five times the reporting limit

G = DER > 1.96 and the concentration is greater than five times the reporting limit

H = DER > 1.96 and the concentration is less than five times the reporting limit

**Table G-16. Summary of Data Validation of Natural Uranium QC Samples**

QC Sample Set	Client Sample ID	Type	Natural Uranium		RPD	RPD Qualifier	DER	DER Qualifier
			Reported Value (pCi/g)	Reporting Limit (pCi/g)				
1	MAR3SOIL-01-15	Primary	0.3	0.2	0%	-	0.00	-
	MAR3SOIL-02-15	Duplicate	0.3	0.2				
2	MAR5SOILA-01-5	Primary	0.4	0.2	29%	-	0.35	-
	MAR5SOILA-02-5	Duplicate	0.3	0.2				
3	SW300-01-5	Primary	0.4	0.2	22%	-	0.35	-
	SW300-02-5	Duplicate	0.5	0.2				
4	NW300-01-5	Primary			-	-	-	-
	NW300-02-5	Duplicate						
5	CENTER-SUB-01-33	Primary	0.5	0.2	0%	-	0.00	-
	CENTER-SUB-02-33	Duplicate	0.5	0.2				
6	MARSOILCORR2-01-15	Primary	0.5	0.2	18%	-	0.35	-
	MARSOILCORR2-02-15	Duplicate	0.6	0.2				
7	MARSS-04-01	Primary	0.5	0.2	0%	-	0.00	-
	MARSS-04-02	Duplicate	0.5	0.2				
8	MARSS-10-01	Primary	0.5	0.2	95%	J	3.18	H
	MARSS-10-02	Duplicate	1.4	0.2				

Note:

J = RPD > 30% and the concentration is less than five times the reporting limit  
K = RPD > 30% and the concentration is greater than five times the reporting limit  
G = DER > 1.96 and the concentration is greater than five times the reporting limit  
H = DER > 1.96 and the concentration is less than five times the reporting limit

**Table G-17. Summary of Data Validation of Potassium-40 QC Samples**

QC Sample Set	Client Sample ID	Type	Potassium-40			RPD	RPD Qualifier	DER	DER Qualifier
			Reported Value (pCi/g)	Precision +/- (pCi/g)	Reporting Limit (pCi/g)				
1	MAR3SOIL-01-15	Primary				-	-	-	-
	MAR3SOIL-02-15	Duplicate							
2	MAR5SOILA-01-5	Primary				-	-	-	-
	MAR5SOILA-02-5	Duplicate							
3	SW300-01-5	Primary				-	-	-	-
	SW300-02-5	Duplicate							
4	NW300-01-5	Primary				-	-	-	-
	NW300-02-5	Duplicate							
5	CENTER-SUB-01-33	Primary				-	-	-	-
	CENTER-SUB-02-33	Duplicate							
6	MARSOILCORR2-01-15	Primary	26.6	1.9	0.2	18%	-	1.6	-
	MARSOILCORR2-02-15	Duplicate	22.3	1.8	0.2				
7	MARSS-04-01	Primary				-	-	-	-
	MARSS-04-02	Duplicate							
8	MARSS-10-01	Primary				-	-	-	-
	MARSS-10-02	Duplicate							

Note:

J = RPD > 30% and the concentration is less than five times the reporting limit

K = RPD > 30% and the concentration is greater than five times the reporting limit

G = DER > 1.96 and the concentration is greater than five times the reporting limit

H = DER > 1.96 and the concentration is less than five times the reporting limit

### 3.3 SOIL SAMPLING PROGRAM QA/QC RESULTS

A total of 23 analyte sets (eight radium-226, four lead-210, three thorium-230, seven natural uranium, one potassium-40) were analyzed and only one sample was assigned a K or G data qualifier, resulting in a 96 percent acceptance rate. (The acceptance rate is a set where no K and/or G data qualifiers are assigned, where non-detect samples are excluded.) The project QC acceptance goal of 85 percent was met for the Marsland Expansion Area pre-operational soil sampling program. Additionally, the laboratory QA/QC methods involved the review and evaluation of the Inter-mountain (IML) Laboratory Analytical QC Summary Reports included in the IML final laboratory reports, and no deficiencies were identified during the review. Based on these analyses, the soil sample data collected as part of the Marsland Expansion Baseline pre-operational soil sampling program should be considered of the highest quality, and the data collected the field efforts are included in the final project database.

## APPENDIX H

### RADIATION INSTRUMENT FACTORY CALIBRATION DOCUMENTS





Designer and Manufacturer  
of  
Scientific and Industrial  
Instruments

# CERTIFICATE OF CALIBRATION

**LU DLUM MEASUREMENTS, INC.** **MPG-6**

501 Oak Street 10744 Dutchtown Road  
325-235-5494 865-392-4601  
Sweetwater, TX 79556, U.S.A. Knoxville, TN 37932 U.S.A.

CUSTOMER TETRA TECH MFG, INC.

ORDER NO 20229840/396456

Mfg Ludlum Measurements, Inc. Model 2350-1 Serial No 152361

Cal Date 13-Sep-13 Cal Due Date 13-Sep-14 Cal Interval 1 Year Meterface N/A

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. 74 °F RH 41 % Alt 703.5 mm Hg

☐ New Instrument ☐ Instrument Received ☒ Within Toler.  $\pm 10\%$  ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☒ Mechanical check ☒ Input Sens. Linearity

☒ F/S Resp. check ☒ Reset check ☐ Window Operation ☒ Battery check (Min. Volt) 4.4 VDC

☒ Audio check ☒ Alarm Setting check ☒ Recycle Mode check

☒ Ratemeter Linearity check ☒ Integrated Dose check ☒ Scaler Readout check Threshold Dia Ratio 100 = 10 mV

☒ Data Log check ☒ Overload check

☒ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☒ HV Readout (2 points) Ref./Inst. 500 / 50 V Ref./Inst. 2000 / 2000 V

## COMMENTS: Firmware: 37122N24

Resolution for Cs137  $\approx 9.51$  Calibrated with 39" cable. I/O Firmware: 37123K05

Gamma Calibration GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity $\pm 10\%$ *
Detector # 1	LMI44-10	PR121036	1000	100	4 / 2	1.404815E-05	5.565404E+10	<input checked="" type="checkbox"/>
Detector # 2	LMI44-10	PR121036	1000	100	7 / 1	1.404814E-05	1.000000E+00	
Detector # 3	CS137/PK	662KEV	656	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 -- rad, 1 -- Gray, 2 -- rem, 3 -- Sv, 4 -- R, 5 -- C/Kg, 6 -- Disintegrations, 7 -- Counts, 8 -- Ci/cm sq, 9 -- Bq/cm sq

Time Base: 0 -- Seconds, 1 -- Minutes, 2 -- Hours

\* See attached detector documentation, if applica

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400cpm	4003	4003	400cpm	400	400
	40kcpm	4001	4001	40kcpm	400	400
	4kcpm	400	400			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.

The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: ☐ 059 ☐ 280 ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 5105 ☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E551 ☐ E552 ☐ G112 ☐ M565 ☐ S-394 ☐ S-1054 ☐ T-304 ☐ T879 ☐ T10081 ☐ T10082 ☐ Y982

☐ Alpha S/N ☐ Beta S/N ☐ Other

☒ m 500 S/N 63893 ☐ Ra-226 S/N Y982 ☒ Multimeter S/N 93870637

Calibrated By [Signature]  
Reviewed By [Signature]

Date 13-Sep-13  
Date 13-Sep-13



Designer and Manufacturer  
of  
Scientific and Industrial  
Instruments

# LUDLUM MEASUREMENTS, INC.

501 Oak Street

325-235-5494

Sweetwater, TX 79556, U.S.A.



10744 Dutchtown Road

865-392-4601

Knoxville, TN 37932, U.S.A.

## Model 2350 Bench Test Data

Customer TETRA TECH MFG, INC. Date 13-Sep-13 Order # 20229840/396456

Model 2350-1 Serial No. 152361 Detector 44-10 Serial No. PR121036

Source Cs-137 = 3.08 mCi

High Voltage 1000 V As Found 1000 V. Input 10.00 mV As Found 10 mV.

Cal. Constant 5.565404E+10 as found 4.943114E+10

Dead Time 1.404815E-05 as found 1.354840E-05

Alarm Setting: Ratemeter 1000000000.000000 as found 1.0 E+09

Scaler 1000000.000000 as found 1.0 E+06

Integrated dose 1000000000.0000 as found 1.0 E+09

Overload ☐ On ☒ Off as found ☐ On ☒ Off Window 1000 as found 1000

Detector Received: ☒ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

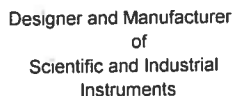
Reference Point	"As Found" Readings: Meter Reading	After Adjustment Readings: Meter Reading
<u>2000 mR/hr</u>	<u>1.24 mR/hr</u>	<u>1.92 mR/hr</u>
<u>1500</u>	<u>1.45</u>	<u>1.50</u>
<u>1000</u>	<u>0.96</u>	<u>1.01</u>
<u>500</u>	<u>4.70 mR/hr</u>	<u>506 mR/hr</u>
<u>200</u>	<u>184</u>	<u>200</u>
<u>150</u>	<u>143</u>	<u>152</u>
<u>100</u>	<u>92.8</u>	<u>102</u>

Other

Signature

Jerry Thompson

Date 13-Sep-13



Knoxville, TN 37932, U.S.A.

Detector Setup Barcodes GENERATED: 9/13/2013 10:49:53 AM  
Model 2350-1 Serial Number: 152361  
Detector Setup Number: 1



\*H1000\$E\*

Set High Voltage: 1000



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F12\$E\*

Set Scaler Count Time: 12



\*SB2\$.\*

Set Readout Time Base: hours



\*SL1.404815E-05\$V\*

Set Dead Time: 1.404815E-05



\*SC5.565404E+10\$T\*

Set Calibration Constant: 5.565404E+10



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR121036\$+\*

Set High Detector Serial #: PR121036



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP1\$7\*

Save Parameters as: D1



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$O\$FF\$6\*

Set Overload: 40.0,OFF



\*SU4\$F\*

Set Readout Units: R



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D1\$A\*

Set Active Detector Setup: 1

Detector Setup Barcodes

GENERATED: 9/13/2013 10:49:53 AM

Model 2350-1 Serial Number: 152361

Detector Setup Number: 2



\*H1000\$E\*

Set High Voltage: 1000



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL1.404814E-05\$U\*

Set Dead Time: 1.404814E-05



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR121036\$+\*

Set High Detector Serial #: PR121036



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP2\$8\*

Save Parameters as: D2



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$O\$FF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D2\$B\*

Set Active Detector Setup: 2

Detector Setup Barcodes GENERATED: 9/13/2013 10:49:53 AM  
Model 2350-1 Serial Number: 152361  
Detector Setup Number: 3



\*H656\$U\*

Set High Voltage: 656



\*W40\$WON\$L\*

Set Window: 40,ON



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL0.000000E+00\$8\*

Set Dead Time: 0.000000E+00



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MCS137/PK\$P\*

Set High Detector Model: CS137/PK



\*N662KEV\$C\*

Set High Detector Serial #: 662KEV



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP3\$9\*



Save Parameters as: D3



\*T642\$.\*

Set Threshold: 642



\*O40.0\$OOFF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D3\$C\*

Set Active Detector Setup: 3

Detector Setup Checklist                      GENERATED: 9/13/2013 10:49:54 AM  
Model 2350-1 Serial Number: 152361  
Detector Setup Number: 1

The following list is stored as detector setup D1 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     27                    

Comments:

User ID	=
High Voltage	= 1000 volts
Threshold	= 100
Window	= 1000,OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 12 seconds
Readout Units	= R
Readout Time Base	= hours
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.404815E-05
Detector Calibration Constant	= 5.565404E+10
Detector Model Number	= LMI44-10
Detector Serial Number	= PR121036
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.8 volts

Detector Setup Checklist                      GENERATED: 9/13/2013 10:49:54 AM  
Model 2350-1 Serial Number: 152361  
Detector Setup Number: 2

The following list is stored as detector setup D2 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     Jr                    

Comments:

User ID	=
High Voltage	= 1000 volts
Threshold	= 100
Window	= 1000,OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.404814E-05
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= LMI44-10
Detector Serial Number	= PR121036
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.8 volts

Detector Setup Checklist                      GENERATED: 9/13/2013 10:49:55 AM  
Model 2350-1 Serial Number: 152361  
Detector Setup Number: 3

The following list is stored as detector setup D3 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     ✓                    

Comments:

User ID	=
High Voltage	= 656 volts
Threshold	= 642
Window	= 40,ON
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 0.000000E+00
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= CS137/PK
Detector Serial Number	= 662KEV
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.8 volts



Designer and Manufacturer  
of  
Scientific and Industrial  
Instruments

# CERTIFICATE OF CALIBRATION

**LUDLUM MEASUREMENTS, INC.**

501 Oak Street

325-235-5494

Sweetwater, TX 79556 U.S.A.

10744 Dutchtown Road

865-392-4601

Knoxville, TN 37932 U.S.A.

CUSTOMER **TETRA TECH MFG, INC.**

ORDER NO. **20235349/399955**

Mfg. **Ludlum Measurements, Inc.**

Model

**2350-1**

Serial No.

**129438**

Cal. Date **10-Dec-13**

Cal Due Date

**10-Dec-14**

Cal. Interval

**1 Year**

Meterface

**N/A**

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec.

T.

**72 °F**

RH

**20 %**

Alt

**709.8 mm Hg**

☐ New Instrument

☐ Instrument Received

☒ Within Toler.  $\pm 10\%$

☐ 10-20%

☐ Out of Tol.

☐ Requiring Repair

☐ Other-See comments

☒ Input Sens. Linearity

☒ Mechanical check

☒ F/S Resp. check

☒ Audio check

☒ Ratemeter Linearity check

☒ Data Log check

☒ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89.

☒ Reset check

☒ Alarm Setting check

☒ Integrated Dose check

☒ Overload check

☒ Window Operation

☒ Battery check (Min. Volt)

**4.4 VDC**

☒ Recycle Mode check

☒ Scaler Readout check

Threshold

Dial Ratio

**100**

**=**

**10**

**mV**

☒ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☒ HV Readout (2 points)

Ref./Inst.

**500**

/

**500**

V

Ref./Inst.

**2000**

/

**2000**

V

**COMMENTS:** Firmware: 37122N21

I/O Firmware: 37123N05 Calibrated with 39" cable.

Resolution for Cs137  $\approx 10.72\%$

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity $\pm 10\%$ *
Detector # 1	LMI44-10	PR121033	1150	100	4 / 2	1.669126E-05	5.397478E+10	<input checked="" type="checkbox"/>
Detector # 2	LMI44-10	PR121033	1150	100	7 / 1	1.669126E-05	1.000000E+00	
Detector # 3	CS137/PK	662KEV	809	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 -- rad, 1 -- Gray, 2 -- rem, 3 -- Sv, 4 -- R, 5 -- C/Kg, 6 -- Disintegrations, -- Counts, 8 -- Ci/cm sq., 9 -- Bq/cm sq.

Time Base: 0 -- Seconds, 1 -- Minutes, 2 -- Hours

\* See attached detector documentation, if applica

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400cpm	410054	410054	400cpm	410054	410054
	40kcpm	4001	4001	40kcpm	4001	4001
	4kcpm	400	400			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.

The calibration system conforms to the requirements of ANSI/NCSS Z540-1-1994 and ANSI N323-1978.

State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 280 ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 5105 ☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ M565 ☐ S-394 ☐ S-1054 ☐ T879 ☐ T10081 ☐ T10082 Neutron Am-241 Be S/N: ☐ T-304 Ra-226 S/N: ☐ Y982

☐ Alpha S/N

☐ Beta S/N

☐ Other

☒ m 500 S/N

**289158**

☐ Ra-226 S/N Y982

☒ Multimeter S/N

**93870637**

Calibrated By:

*Jeremy Thompson*

Date

**10-Dec-13**

Reviewed By:

*R. Paul*

Date

**11-Dec-13**



Designer and Manufacturer  
of  
Scientific and Industrial  
Instruments

# LUDLUM MEASUREMENTS, INC.

501 Oak Street

325-235-5494

Sweetwater, TX 79556, U.S.A.

☐ 10744 Dutchtown Road

865-392-4601

Knoxville, TN 37932, U.S.A.

## Model 2350 Bench Test Data

Customer TETRA TECH MFG, INC. Date 10-Dec-13 Order # 20235349/399955

Model 2350-1 Serial No. 129438 Detector 44-10 Serial No. PR121033

Source CS(37)-1.9mc:

High Voltage 1150 V As Found 1150 V. Input 10.00 mV As Found 10 mV.

Cal. Constant 5.397478E+10 as found 5.397478E+10

Dead Time 1.669126E-05 as found 1.669126E-05

Alarm Setting: Ratemeter 1000000000.000000 as found 1.0E+09

Scaler 1000000.000000 as found 1.0E+06

Integrated dose 1000000000.0000 as found 1.0E+09

Overload ☐ On ☒ Off as found ☐ On ☒ Off Window 1000 as found 1000

Detector Received: ☒ Within Toler. +/-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

Reference Point	"As Found" Readings: Meter Reading	After Adjustment Readings: Meter Reading
<u>2000 mR/hr</u>	<u>1.96 mR/hr</u>	<u>1.96 mR/hr</u>
<u>1500</u>	<u>1.48</u>	<u>1.48</u>
<u>1000</u>	<u>0.99</u>	<u>0.99</u>
<u>500</u>	<u>496 mR/hr</u>	<u>496 mR/hr</u>
<u>200</u>	<u>200</u>	<u>200</u>
<u>150</u>	<u>147</u>	<u>147</u>
<u>100</u>	<u>97.2</u>	<u>97.2</u>

Other \_\_\_\_\_

Signature [Signature] Date 10-Dec-13



Detector Setup Barcodes

GENERATED: 12/10/2013 2:58:03 PM

Model 2350-1 Serial Number: 129438

Detector Setup Number: 1



\*H1150\$K\*

Set High Voltage: 1150



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F6\$H\*

Set Scaler Count Time: 6



\*SB2\$.\*

Set Readout Time Base: hours



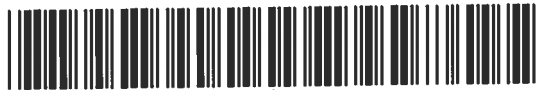
\*SL1.669126E-05\$\$\*

Set Dead Time: 1.669126E-05



\*SC5.397478E+10\$0\*

Set Calibration Constant: 5.397478E+10



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR121033\$ \*

Set High Detector Serial #: PR121033



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP1\$7\*



Save Parameters as: D1



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$O\$FF\$6\*

Set Overload: 40.0,OFF



\*SU4\$F\*

Set Readout Units: R



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D1\$A\*

Set Active Detector Setup: 1

Detector Setup Barcodes

GENERATED: 12/10/2013 2:58:03 PM

Model 2350-1 Serial Number: 129438

Detector Setup Number: 2



\*H1150\$K\*

Set High Voltage: 1150



\*W1000\$W0FF\$P\*

Set Window: 1000,OFF



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL1.669126E-05\$\$\*

Set Dead Time: 1.669126E-05



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR121033\$ \*

Set High Detector Serial #: PR121033



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP2\$8\*

Save Parameters as: D2



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$O0FF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D2\$B\*

Set Active Detector Setup: 2

Detector Setup Barcodes

GENERATED: 12/10/2013 2:58:04 PM

Model 2350-1 Serial Number: 129438

Detector Setup Number: 3



\*H809\$U\*

Set High Voltage: 809



\*W40\$WON\$L\*

Set Window: 40,ON



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL0.000000E+00\$8\*

Set Dead Time: 0.000000E+00



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MCS137/PK\$P\*

Set High Detector Model: CS137/PK



\*N662KEV\$C\*

Set High Detector Serial #: 662KEV



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP3\$9\*

Save Parameters as: D3



\*T642\$.\*

Set Threshold: 642



\*O40.0\$O0FF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D3\$C\*

Set Active Detector Setup: 3

Detector Setup Checklist                      GENERATED: 12/10/2013 2:58:07 PM  
Model 2350-1 Serial Number: 129438  
Detector Setup Number: 1

The following list is stored as detector setup D1 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     ✓                    

Comments:

User ID	=
High Voltage	= 1150 volts
Threshold	= 100
Window	= 1000, OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= R
Readout Time Base	= hours
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.669126E-05
Detector Calibration Constant	= 5.397478E+10
Detector Model Number	= LMI44-10
Detector Serial Number	= PR121033
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.3 volts

Detector Setup Checklist                      GENERATED: 12/10/2013 2:58:07 PM  
Model 2350-1 Serial Number: 129438  
Detector Setup Number: 2

The following list is stored as detector setup D2 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     JY                    

Comments:

User ID	=
High Voltage	= 1150 volts
Threshold	= 100
Window	= 1000,OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.669126E-05
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= LMI44-10
Detector Serial Number	= PR121033
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.3 volts

Detector Setup Checklist                      GENERATED: 12/10/2013 2:58:07 PM  
Model 2350-1 Serial Number: 129438  
Detector Setup Number: 3

The following list is stored as detector setup D3 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     JS                    

Comments:

User ID	=
High Voltage	= 809 volts
Threshold	= 642
Window	= 40,ON
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 0.000000E+00
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= CS137/PK
Detector Serial Number	= 662KEV
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.3 volts





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# CERTIFICATE OF CALIBRATION

MFG 9

## LUDLUM MEASUREMENTS, INC.

501 Oak Street  
325-235-5494  
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865-392-4601  
Knoxville, TN 37932, U.S.A.

CUSTOMER TETRA TECH MFG, INC

ORDER NO. 20224032/392860

Mfg. Ludlum Measurements, Inc Model 2350-1 Serial No. 129403

Cal. Date 7-Jun-13 Cal Due Date 7-Jun-14 Cal. Interval 1 Year Meterface N/A

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T 75 °F RH 43 % Alt 702.8 mm Hg

☐ New Instrument Instrument Received ☒ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☒ Mechanical check

☒ Input Sens. Linearity

☒ F/S Resp. check

☒ Reset check

☒ Window Operation

☒ Audio check

☒ Alarm Setting check

☒ Battery check (Min. Volt) 4.4 VDC

☒ Ratemeter Linearity check

☒ Integrated Dose check

☒ Recycle Mode check

Threshold  
Dial Ratio 100 = 10 mV

☒ Data Log check

☒ Overload check

☒ Scaler Readout check

☒ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89.

☒ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☒ HV Readout (2 points) Ref./Inst. 500 / 501 V Ref./Inst. 2000 / 2002 V

COMMENTS: Firmware: 37122N21

Resolution for Cs137 is ~10.578 I/O Firmware: 37123N05

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR135858	1150	100	4 / 2	1.580945E-05	5.841502E+10	J
Detector # 2	LMI44-10	PR135858	1150	100	7 / 1	1.580945E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	846	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 -- rad, 1 -- Gray, 2 -- rem, 3 -- Sv, 4 -- R, 5 -- C/Kg, 6 -- Disintegrations, 7 -- Counts, 8 -- C/cm sq, 9 -- Bq/cm sq.

Time Base: 0 -- Seconds, 1 -- Minutes, 2 -- Hours

\* See attached detector documentation, if applicable

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400kcpm	40011	40011	400kcpm	400	400
	40kcpm	4001	4001	40kcpm	40	40
	4kcpm	400	400			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.

State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: ☐ 059 ☐ 280 ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 5105 ☐ 5717CO ☐ 5719CO

☐ 60646 ☐ 70897 ☐ 73410 ☐ E551 ☐ E552 ☐ G112 ☐ M565 ☐ S-394 ☐ S-1054 ☐ T-304 ☐ T879 ☐ T10081 ☐ T10082 ☐ Y982

☐ Alpha S/N ☐ Beta S/N ☐ Other

☒ m 500 S/N 63893 ☐ Ra-226 S/N Y982 ☒ Multimeter S/N 93870637

Calibrated By: [Signature] Date: 7-Jun-13

Reviewed By: [Signature] Date: 7-Jun-13



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Knoxville, TN 37932, U.S.A.

## Model 2350 Bench Test Data

Customer TETRA TECH MFG, INC. Date 7-Jun-13 Order #. 20224032/392860

Model 2350-1 Serial No. 129403 Detector 44-10 Serial No. PR135858

Source Cs-137 - 1.9 mCi

High Voltage 1150 V As Found 1150 V. Input 10.00 mV As Found 10 mV.

Cal. Constant 5.841502E+10 as found 5.841502E+10

Dead Time 1.580945E-05 as found 1.580945E-05

Alarm Setting: Ratemeter 1000000000.000000 as found 1.0E+09

Scaler 1000000.000000 as found 1.0E+06

Integrated dose 1000000000.0000 as found 1.0E+09

Overload ☐ On ☒ Off as found ☐ On ☒ Off Window 1000 as found 1000

Detector Received: ☒ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

Reference Point	"As Found" Readings Meter Reading	After Adjustment Readings Meter Reading
<u>2000 mR/hr</u>	<u>2.08 mR/hr</u>	<u>2.08 mR/hr</u>
<u>1500</u>	<u>1.57</u>	<u>1.57</u>
<u>1000</u>	<u>1.03</u>	<u>1.03</u>
<u>500</u>	<u>502 mR/hr</u>	<u>502 mR/hr</u>
<u>200</u>	<u>207</u>	<u>207</u>
<u>150</u>	<u>151</u>	<u>151</u>
<u>100</u>	<u>103</u>	<u>103</u>

Other \_\_\_\_\_

Signature [Signature] Date 7-Jun-13

### Bench Test Data For Detector

Detector 44-10 Serial No. PR135858

Customer TETRA TECH MFG, INC.

Order #. 20224032/392860

Counter 2350-1 Serial No. 129403

Counter Input Sensitivity 10.00 mV

Count Time 6 seconds

Distance Source to Detector Surface

Other Cal Constant = 1.000000E+00 Dead Time = 1.580945E-05

High Voltage \_\_\_\_\_ Isotope Am-241 Isotope \_\_\_\_\_ Isotope \_\_\_\_\_ Isotope \_\_\_\_\_  
Background \_\_\_\_\_ Size 30.11mm Size \_\_\_\_\_ Size \_\_\_\_\_ Size \_\_\_\_\_

[illegible]

Signature Jeremy Thompson

Date 7.2.13

Detector Setup Checklist                      GENERATED: 6/7/2013 3:22:57 PM  
Model 2350-1 Serial Number: 129403  
Detector Setup Number: 1

The following list is stored as detector setup D1 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table: JS

Comments:

User ID	=
High Voltage	= 1150 volts
Threshold	= 100
Window	= 1000,OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 10 seconds
Readout Units	= R
Readout Time Base	= hours
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.580945E-05
Detector Calibration Constant	= 5.841502E+10
Detector Model Number	= LMI44-10
Detector Serial Number	= PR135858
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.5 volts

Detector Setup Checklist                      GENERATED: 6/7/2013 3:22:57 PM  
Model 2350-1 Serial Number: 129403  
Detector Setup Number: 2

The following list is stored as detector setup D2 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     SS                    

Comments:

User ID	=
High Voltage	= 1150 volts
Threshold	= 100
Window	= 1000,OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.580945E-05
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= LMI44-10
Detector Serial Number	= PR135858
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.5 volts

Detector Setup Checklist                      GENERATED: 6/7/2013 3:22:58 PM  
Model 2350-1 Serial Number: 129403  
Detector Setup Number: 3

The following list is stored as detector setup D3 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table: JS

Comments:

User ID	=
High Voltage	= 846 volts
Threshold	= 642
Window	= 40,ON
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 0.000000E+00
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= CS137PK
Detector Serial Number	= 662KEV
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 5.5 volts

Detector Setup Barcodes

GENERATED: 6/7/2013 3:22:56 PM

Model 2350-1 Serial Number: 129403

Detector Setup Number: 1



\*H1150\$K\*

Set High Voltage: 1150



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F10\$C\*

Set Scaler Count Time: 10



\*SB2\$.\*

Set Readout Time Base: hours



\*SL1.580945E-05\$/\*

Set Dead Time: 1.580945E-05



\*SC5.841502E+10\$P\*

Set Calibration Constant: 5.841502E+10



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR135858\$F\*

Set High Detector Serial #: PR135858



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP1\$7\*



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$O\$FF\$6\*

Set Overload: 40.0,OFF



\*SU4\$F\*

Set Readout Units: R



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameter



\*SVD2\$R\*

Set Display Mode: Detector



\*D1\$A\*

Set Active Detector Setup: 1



Detector Setup Barcodes

GENERATED: 6/7/2013 3:22:56 PM

Model 2350-1 Serial Number: 129403

Detector Setup Number: 2



\*H1150\$K\*

Set High Voltage: 1150



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL1.580945E-05\$/\*

Set Dead Time: 1.580945E-05



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR135858\$F\*

Set High Detector Serial #: PR135858



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP2\$8\*



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$OOFF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D2\$B\*

Set Active Detector Setup: 2

Detector Setup Barcodes

GENERATED: 6/7/2013 3:22:56 PM

Model 2350-1 Serial Number: 129403

Detector Setup Number: 3



\*H846\$V\*

Set High Voltage: 846



\*W40\$WON\$L\*

Set Window: 40,ON



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL0.000000E+00\$8\*

Set Dead Time: 0.000000E+00



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MCS137PK\$S\*

Set High Detector Model: CS137PK



\*N662KEV\$C\*

Set High Detector Serial #: 662KEV



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP3\$9\*

Save Parameters as: D3



\*T642\$.\*

Set Threshold: 642



\*O40.0\$O0FF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D3\$C\*

Set Active Detector Setup: 3



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# CERTIFICATE OF CALIBRATION

## LUDLUM MEASUREMENTS, INC.

501 Oak Street  
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Sweetwater, TX 79556, U.S.A.  
10744 Dutchtown Road  
865-392-4601  
Knoxville, TN 37932, U.S.A.

CUSTOMER TETRA TECH MFG, INC.

ORDER NO. 20235349/399955

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 134764

Cal. Date 10-Dec-13 Cal Due Date 10-Dec-14 Cal. Interval 1 Year Meterface N/A

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 20 % Alt 709.8 mm Hg

☐ New Instrument ☐ Instrument Received ☒ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☒ Mechanical check ☒ F/S Resp. check ☒ Audio check ☒ Ratemeter Linearity check ☒ Data Log check ☒ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89.

☒ Reset check ☒ Alarm Setting check ☒ Integrated Dose check ☒ Overload check

☒ Window Operation ☒ Battery check (Min. Volt) 4.4 VDC ☒ Recycle Mode check ☒ Scaler Readout check ☒ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Threshold Dial Ratio 100 = 10 mV

☒ HV Readout (2 points) Ref./Inst. 500 / 50 V Ref./Inst. 2000 / 1996 V

### COMMENTS: Firmware: 37122N21

I/O Firmware: 37123N05 Calibrated with 39" cable.

Resolution for Cs137 = 9.51  
Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR139484	900	100	4 / 2	1.382029E-05	5.535037E+10	
Detector # 2	LMI44-10	PR139484	900	100	7 / 1	1.382029E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	598	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 -- rad, 1 -- Gray, 2 -- rem, 3 -- Sv, 4 -- R, 5 -- C/Kg, 6 -- Disintegrations, -- Counts, 8 -- Ci/cm sq, 9 -- Bq/cm sq

Time Base: 0 -- Seconds, 1 -- Minutes, 2 -- Hours

\* See attached detector documentation, if applicable

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400kcpm	40013 101	40013 101	400cpm	40 101	40 101
	40kcpm	4001	4001	40cpm	4	4
	4kcpm	400	400			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.

The calibration system conforms to the requirements of ANSI/NCSS Z540-1-1994 and ANSI N323-1978.

State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 280 ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 5105 ☐ 5717CO ☐ 5719CO  
☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ M565 ☐ S-394 ☐ S-1054 ☐ T879 ☐ T10081 ☐ T10082 Neutron Am-241 Be S/N: ☐ T-304 Ra-226 S/N: ☐ Y982

☐ Alpha S/N ☐ Beta S/N ☐ Other

☒ m 500 S/N 289158 ☐ Ra-226 S/N Y982 ☒ Multimeter S/N 93870637

Calibrated By: Jeremy Thompson Date 10-Dec-13  
Reviewed By: Paul H. Date 11-Dec-13



Designer and Manufacturer  
of  
Scientific and Industrial  
Instruments

# LUDLUM MEASUREMENTS, INC.

501 Oak Street

325-235-5494

Sweetwater, TX 79556, U.S.A.

☐ 10744 Dutchtown Road

865-392-4601

Knoxville, TN 37932, U.S.A.

## Model 2350 Bench Test Data

Customer TETRA TECH MFG, INC. Date 10-Dec-13 Order # 20235349/399955

Model 2350-1 Serial No. 134764 Detector 44-10 Serial No. PR139484

Source CS15731.9 mCi

High Voltage 900 V As Found 900 V. Input 10.00 mV As Found 10 mV.

Cal. Constant 5.535037E+10 as found 5.535037E+10

Dead Time 1.382029E-05 as found 1.382029E-05

Alarm Setting: Ratemeter 1000000000.000000 as found 1.0 E+09

Scaler 1000000.000000 as found 1.0 E+06

Integrated dose 1000000000.0000 as found 1.0 E+09

Overload ☐ On ☒ Off as found ☐ On ☐ Off Window 1000 as found 1000

Detector Received: ☒ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

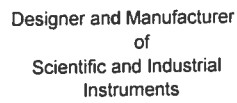
Reference Point	"As Found" Readings: Meter Reading	After Adjustment Readings: Meter Reading
<u>2000 mR/hr</u>	<u>1.94 mR/hr</u>	<u>1.94 mR/hr</u>
<u>1500</u>	<u>1.51</u>	<u>1.51</u>
<u>1000</u>	<u>1.01</u>	<u>1.01</u>
<u>500</u>	<u>506 mR/hr</u>	<u>506 mR/hr</u>
<u>200</u>	<u>205</u>	<u>205</u>
<u>150</u>	<u>153</u>	<u>153</u>
<u>100</u>	<u>99.9</u>	<u>99.9</u>

Other

Signature

Jeremy Thompson

Date 10-Dec-13



☐ 10744 Dutchtown Road  
865-392-4601  
A. Knoxville, TN 37932, U.S.A.

Detector Setup Barcodes GENERATED: 12/10/2013 1:25:22 PM  
Model 2350-1 Serial Number: 134764  
Detector Setup Number: 1



\*H900\$M\*

Set High Voltage: 900



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F6\$H\*

Set Scaler Count Time: 6



\*SB2\$.\*

Set Readout Time Base: hours



\*SL1.382029E-05\$X\*

Set Dead Time: 1.382029E-05



\*SC5.535037E+10\$S\*

Set Calibration Constant: 5.535037E+10



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR139484\$E\*

Set High Detector Serial #: PR139484



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP1\$7\*



Save Parameters as: D1



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$OFF\$6\*

Set Overload: 40.0,OFF



\*SU4\$F\*

Set Readout Units: R



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D1\$A\*

Set Active Detector Setup: 1

Detector Setup Barcodes

GENERATED: 12/10/2013 1:25:22 PM

Model 2350-1 Serial Number: 134764

Detector Setup Number: 2



\*H900\$M\*

Set High Voltage: 900



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL1.382029E-05\$X\*

Set Dead Time: 1.382029E-05



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR139484\$E\*

Set High Detector Serial #: PR139484



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP2\$8\*

Save Parameters as: D2



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$OFF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D2\$B\*

Set Active Detector Setup: 2

Detector Setup Barcodes GENERATED: 12/10/2013 1:25:22 PM  
Model 2350-1 Serial Number: 134764  
Detector Setup Number: 3



\*H598\$Z\*

Set High Voltage: 598



\*W40\$WON\$L\*

Set Window: 40,ON



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL0.000000E+00\$8\*

Set Dead Time: 0.000000E+00



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MCS137PK\$S\*

Set High Detector Model: CS137PK



\*N662KEV\$C\*

Set High Detector Serial #: 662KEV



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP3\$9\*

Save Parameters as: D3



\*T642\$.\*

Set Threshold: 642



\*O40.0\$OFF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D3\$C\*

Set Active Detector Setup: 3

Detector Setup Checklist                      GENERATED: 12/10/2013 1:25:26 PM  
Model 2350-1 Serial Number: 134764  
Detector Setup Number: 1

The following list is stored as detector setup D1 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     27                    

Comments:

User ID	=
High Voltage	= 900 volts
Threshold	= 100
Window	= 1000,OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= R
Readout Time Base	= hours
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.382029E-05
Detector Calibration Constant	= 5.535037E+10
Detector Model Number	= LMI44-10
Detector Serial Number	= PR139484
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 6.1 volts

Detector Setup Checklist                      GENERATED: 12/10/2013 1:25:26 PM  
Model 2350-1 Serial Number: 134764  
Detector Setup Number: 2

The following list is stored as detector setup D2 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     25                    

Comments:

User ID	=
High Voltage	= 900 volts
Threshold	= 100
Window	= 1000, OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.382029E-05
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= LMI44-10
Detector Serial Number	= PR139484
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 6.1 volts

Detector Setup Checklist                      GENERATED: 12/10/2013 1:25:26 PM  
Model 2350-1 Serial Number: 134764  
Detector Setup Number: 3

The following list is stored as detector setup D3 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     ST                    

Comments:

User ID	=
High Voltage	= 598 volts
Threshold	= 642
Window	= 40,ON
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 0.000000E+00
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= CS137PK
Detector Serial Number	= 662KEV
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 6.1 volts





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# CERTIFICATE OF CALIBRATION

**LUDLUM MEASUREMENTS, INC.**

501 Oak Street  
325-235-5494  
Sweetwater, TX 79556, U.S.A.  
10744 Dutchtown Road  
865-392-4601  
Knoxville, TN 37932 U.S.A.

CUSTOMER **TETRA TECH MFG, INC.**

ORDER NO. **20235349/399955**

Mfg. **Ludlum Measurements, Inc.** Model **2350-1** Serial No. **129434**

Cal. Date **11-Dec-13** Cal Due Date **11-Dec-14** Cal. Interval **1 Year** Meterface **N/A**

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. **72** °F RH **20** % Alt **706.8** mm Hg

☐ New Instrument ☐ Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☒ Other-See comments

☒ Mechanical check

☒ F/S Resp. check

☒ Audio check

☒ Ratemeter Linearity check

☒ Data Log check

☒ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89.

☒ Reset check

☒ Alarm Setting check

☒ Integrated Dose check

☒ Overload check

☒ Window Operation

☒ Battery check (Min. Volt) **4.4** VDC

☒ Recycle Mode check

☒ Scaler Readout check

☒ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☒ Input Sens. Linearity

Threshold  
Dial Ratio **100** = **10** mV

☒ HV Readout (2 points) Ref./Inst. **500** / **500** V Ref./Inst. **2000** / **2000** V

## COMMENTS: Firmware: 37122N21

I/O Firmware: 37123N05 Calibrated with 39" cable.

Resolution for Cs137 ~10.57% No as found readings due to 2350-1 memory loss.  
Gamma Calibration: GM detectors positioned perpendicular to source except for M44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR135854	1000	100	4 / 2	1.614994E-05	5.519918E+10	
Detector # 2	LMI44-10	PR135854	1000	100	7 / 1	1.614993E-05	1.000000E+00	
Detector # 3	CS137	662KEV	721	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 -- rad, 1 -- Gray, 2 -- rem, 3 -- Sv, 4 -- R, 5 -- C/Kg, 6 -- Disintegrations, -- Counts, 8 -- Ci/cm sq, 9 -- Bq/cm sq

Time Base: 0 -- Seconds, 1 -- Minutes, 2 -- Hours

\* See attached detector documentation, if applicable

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400cpm	NA	40068 (0)	400cpm	NA	40 (0)
	40kcpm		4002 ( )	40cpm		4 ( )
	4kcpm		400 ( )			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.

The calibration system conforms to the requirements of ANSI/NCSS Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N ☐ 059 ☐ 280 ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 5105 ☐ 5717CO ☐ 5719CO  
☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ M565 ☐ S-394 ☐ S-1054 ☐ T879 ☐ T10081 ☐ T10082 Neutron Am-241 Be S/N: ☐ T-304 Ra-226 S/N: ☐ Y982

☐ Alpha S/N ☐ Beta S/N ☐ Other

☒ m 500 S/N **289158** ☐ Ra-226 S/N Y982 ☒ Multimeter S/N **93870637**

Calibrated By: Jeremy Thompson Date **11 Dec 13**  
Reviewed By: Phyllis H Date **11 Dec 13**



Designer and Manufacturer  
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# • LUDLUM MEASUREMENTS, INC. •

501 Oak Street 10744 Dutchtown Road  
325-235-5494 865-392-4601  
Sweetwater, TX 79556, U.S.A. Knoxville, TN 37932, U.S.A.

## Model 2350 Bench Test Data

Customer TETRA TECH MFG, INC. Date 11-Dec-13 Order # 20235349/399955  
Model 2350-1 Serial No. 129434 Detector 44-10 Serial No. PR135854

Source CS 137 = 1.4 mCi

High Voltage 1000 V As Found NA V. Input 10.00 mV As Found NA mV.

Cal. Constant 5.519918E+10 as found NA

Dead Time 1.614994E-05 as found NA

Alarm Setting: Ratemeter 1000000000.000000 as found NA

Scaler 1000000.000000 as found NA

Integrated dose 1000000000.0000 as found NA

Overload ☐ On ☒ Off as found ☐ On ☐ Off Window 1000 as found NA

Detector Received: ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☒ Other-See comments

Reference Point	"As Found" Readings: Meter Reading	After Adjustment Readings: Meter Reading
<u>2000 <math>\mu</math>R/hr</u>	<u>NA</u>	<u>1.96 mR/hr</u>
<u>1500</u>	<u>NA</u>	<u>1.49</u>
<u>1000</u>	<u>NA</u>	<u>1.02</u>
<u>500</u>	<u>NA</u>	<u>499 <math>\mu</math>R/hr</u>
<u>200</u>	<u>NA</u>	<u>202</u>
<u>150</u>	<u>NA</u>	<u>151</u>
<u>100</u>	<u>NA</u>	<u>100</u>

Other No as found readings due to memory loss.

Signature Jeremy Thompson Date 11 Dec 13

### Bench Test Data For Detector

Detector 44-10 Serial No. PR135854

Customer TETRA TECH MFG, INC.

Order #. 20235349/399955

Counter 2350-1 Serial No. 129434

Counter Input Sensitivity 10.00 mV

Count Time 6 seconds

Distance Source to Detector Surface

Other Cal Constant = 1.000000E+00 Dead Time = 1.614993E-05

High  
Voltage

## Background

Isotope Am241  
Size 20.7746

Isotope Size

Isotope  
SizeIsotope  
Size[illegible]

Signature

Jeremy Thompson

Date 11. Dec. 13

Detector Setup Barcodes GENERATED: 12/11/2013 8:39:37 AM  
Model 2350-1 Serial Number: 129434  
Detector Setup Number: 1



\*H1000\$E\*

Set High Voltage: 1000



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F10\$C\*

Set Scaler Count Time: 10



\*SB2\$.\*

Set Readout Time Base: hours



\*SL1.614994E-05\$%\*

Set Dead Time: 1.614994E-05



\*SC5.519918E+10\$ \*

Set Calibration Constant: 5.519918E+10



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR135854\$B\*

Set High Detector Serial #: PR135854



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP1\$7\*

Save Parameters as: D1



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$OOFF\$6\*

Set Overload: 40.0,OFF



\*SU4\$F\*

Set Readout Units: R



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D1\$A\*

Set Active Detector Setup: 1

Detector Setup Barcodes GENERATED: 12/11/2013 8:39:37 AM  
Model 2350-1 Serial Number: 129434  
Detector Setup Number: 2



\*H1000\$E\*

Set High Voltage: 1000



\*W1000\$WOFF\$P\*

Set Window: 1000,OFF



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL1.614993E-05\$+\*

Set Dead Time: 1.614993E-05



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MLMI44-10\$ \*

Set High Detector Model: LMI44-10



\*NPR135854\$B\*

Set High Detector Serial #: PR135854



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP2\$8\*

Save Parameters as: D2



\*T100\$Q\*

Set Threshold: 100



\*O40.0\$O\$FF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D2\$B\*

Set Active Detector Setup: 2

Detector Setup Barcodes

GENERATED: 12/11/2013 8:39:37 AM

Model 2350-1 Serial Number: 129434

Detector Setup Number: 3



\*H721\$N\*

Set High Voltage: 721



\*W40\$WON\$L\*

Set Window: 40,ON



\*F6\$H\*

Set Scaler Count Time: 6



\*SB1\$-\*

Set Readout Time Base: minutes



\*SL0.000000E+00\$8\*

Set Dead Time: 0.000000E+00



\*SC1.000000E+00\$0\*

Set Calibration Constant: 1.000000E+00



\*MCS137\$Q\*

Set High Detector Model: CS137



\*N662KEV\$C\*

Set High Detector Serial #: 662KEV



\*J1.000000E+09\$V\*

Set High Ratemeter Alarm: 1.000000E+09



\*K1000000\$H\*

Set High Scaler Alarm: 1000000



\*P1.000000E+09\$.\*

Set High Dose Alarm: 1.000000E+09



\*SP3\$9\*



Save Parameters as: D3



\*T642\$.\*

Set Threshold: 642



\*O40.0\$OOFF\$6\*

Set Overload: 40.0,OFF



\*SU7\$I\*

Set Readout Units: c



\*SM0\$3\*

Set Readout Range Multiplier: Auto



\*SVD0\$P\*

Set Display Mode: Normal



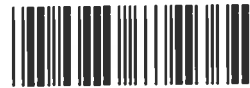
\*SVD1\$Q\*

Set Display Mode: Parameters



\*SVD2\$R\*

Set Display Mode: Detector



\*D3\$C\*

Set Active Detector Setup: 3

Detector Setup Checklist                      GENERATED: 12/11/2013 8:39:40 AM  
Model 2350-1 Serial Number: 129434  
Detector Setup Number: 1

The following list is stored as detector setup D1 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table: DT

Comments:

User ID	=
High Voltage	= 1000 volts
Threshold	= 100
Window	= 1000,OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 10 seconds
Readout Units	= R
Readout Time Base	= hours
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.614994E-05
Detector Calibration Constant	= 5.519918E+10
Detector Model Number	= LMI44-10
Detector Serial Number	= PR135854
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 6.0 volts

Detector Setup Checklist                      GENERATED: 12/11/2013 8:39:40 AM  
Model 2350-1 Serial Number: 129434  
Detector Setup Number: 2

The following list is stored as detector setup D2 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     JY                    

Comments:

User ID	=
High Voltage	= 1000 volts
Threshold	= 100
Window	= 1000, OFF
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 1.614993E-05
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= LMI44-10
Detector Serial Number	= PR135854
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 6.0 volts

Detector Setup Checklist                      GENERATED: 12/11/2013 8:39:41 AM  
Model 2350-1 Serial Number: 129434  
Detector Setup Number: 3

The following list is stored as detector setup D3 in the Model 2350.

I have verified the list below has no discrepancies with the  
detector settings table:                     JY                    

Comments:

User ID	=
High Voltage	= 721 volts
Threshold	= 642
Window	= 40,ON
Overload Current	= 40.0 micro amperes
Scaler Count Time	= 6 seconds
Readout Units	= C
Readout Time Base	= minutes
Readout Range Multiplier	= Auto
Detector Dead Time	= 0.000000E+00
Detector Calibration Constant	= 1.000000E+00
Detector Model Number	= CS137
Detector Serial Number	= 662KEV
Ratemeter Alarm Setting	= 1.000000E+09
Scaler Alarm Setting	= 1000000
Integrated Dose Alarm Setting	= 1.000000E+09
Low Count Alarm Setting	= 0.000000E+00
Operating Batter Voltage	= 6.0 volts



Designer and Manufacturer  
of  
Scientific and Industrial  
Instruments

Work Order: 20235349

LUDLUM MEASUREMENTS, INC

POST OFFICE BOX 810 PH: 325-235-5494

TAG #: 399955

501 OAK STREET

FAX: 325-235-4672

SWEETWATER, TEXAS 79556, U.S.A.

Date Received: 12/9/2013 Received Via: EXPRESS SAVER Condition Received: FIAR/ NO HANDLE, CABLES

SHIP TO: TETRA TECH MFG, INC. BILL TO: TETRA TECH MFG, INC. CUSTOMER #: 04935

STE 100  
3801 AUTOMATION WAY  
FT COLLINS CO 80525  
USA

STE 100  
3801 AUTOMATION WAY  
FT COLLINS CO 80525  
USA

Reason for Return: Calibration Cal Interval \ Special Instructions: 1 YR

Comments: Cal'd Items 1, 5, 3, 7 modification done. ST  
3116011

ITEM	QTY	PART #	DESCRIPTION	PRICE	COST	ITEM	QTY	PART #	DESCRIPTION	PRICE	COST
01*	1.00 EA	2350-1	M 2350-1 FOR REPAIR/CAL *129426			1.57	3	2371-088	Retainer	N/C	
02*	1.00 EA	44-10	M 44-10 FOR REPAIR/CAL *PR135855			1.2, 5.7	16	21-9313	D Battery (installed)	N/C	
03*	1.00 EA	2350-1	M 2350-1 FOR REPAIR/CAL *129434								
04*	1.00 EA	44-10	M 44-10 FOR REPAIR/CAL PR135854								
05*	1.00 EA	2350-1	M 2350-1 FOR REPAIR/CAL *129438								
06*	1.00 EA	44-10	M 44-10 FOR REPAIR/CAL *PR121033								
07*	1.00 EA	2350-1	M 2350-1 FOR REPAIR/CAL *134764								
08*	1.00 EA	44-10	M 44-10 FOR REPAIR/CAL *PR139484								
09	1. ea	Red cooler									

Instrument Calibrated: at

Total Parts Cost:

Sub Total Calibration, Parts, and Labor: 440.00

Secondary Detectors: 8 at \$15

Total Calibration Charge: 440

Shipping Charges:

Extended Calibration: 4 at \$80

Total Labor:

Sales Tax:

Labor: hour(s) at \$ per hour

Total Charges:

Signed: Jeremy Thompson

Date: 11 Dec 13

QC Released: Phil H

Date: 11 Dec 13

DO NOT PAY!  
INVOICE TO FOLLOW

Date: Dec 11 2013

Contacted: AARON ORECHWA

By:

PO Number: 180000-12-9-2013

Return Ship:

Phone #:

(970) 223-9600

# LUDLUM MEASUREMENTS, INC.



501 OAK STREET, SWEETWATER, TEXAS 79556  
ATTN: REPAIR AND CALIBRATION  
1.800.622.0828 325.235.5497 fax: 325.235.4672  
www.ludlums.com



## ► INSTRUMENT RETURN FORM ◀

Date: \_\_\_\_\_ Item(s) returned for: ☐ Calibration ☐ Repair ☐ Other \_\_\_\_\_

Company Name: \_\_\_\_\_

Contact Person: \_\_\_\_\_ Phone: (     ) \_\_\_\_\_  
(End-User)

Bill to Address: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Ship to Address: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Ship Via: ☐ UPS ☐ FedEx ☐ Other \_\_\_\_\_

Instrument/Probe Model Number	Serial Number	Instrument/Probe Model Number	Serial Number

Purchase Order # \_\_\_\_\_

Call for PO# ☐ Call with Est. ☐ Call for CC# ☐

Credit Card # \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_

Expiration: \_\_\_\_\_ / \_\_\_\_\_

Extended Warranty Contract # \_\_\_\_\_

Calibration Contract # \_\_\_\_\_

Contact Person: \_\_\_\_\_  
(Purchasing)

Phone: (     ) \_\_\_\_\_

Fax: (     ) \_\_\_\_\_

E-mail: \_\_\_\_\_

Malfunctioning Symptoms, Special Instructions, etc: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Reuter-Stokes**

## Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique\*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type: 100 R/Hr

Serial Number: 07J00KM1

Calibration Date: 9/10/2013

Sensitivity: 10.03 mV/ $\mu$ R/h

A handwritten signature in black ink, appearing to read 'Paul Brown'.

Authorized Signature

\*Calibration Procedure: RS-SOP 238.1



Reuter-Stokes

## Calibration Data

Sensor Type: 100 R/Hr Source (CS-137): BB-400  
 Serial Number: 07J00KM1 Date of Certification: 12/1/1994  
 Calibration Date: 9/10/2013 Exposure Rate at 1 meter: 4.226 mR/h  
 Customer Name: ENVIRONMENTAL RESTORATION GRP  
 Sensitivity (Ra-226): 10.03 mV/ $\mu$ R/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
feet	cm	$\mu$ R/h	V	V	V	mV/ $\mu$ R/h
12	366	200.999	2.599	0.558	2.041	10.15
14	427	147.062	1.984	0.489	1.494	10.16
16	488	112.128	1.576	0.440	1.136	10.13
18	549	88.229	1.299	0.406	0.893	10.12

$$k(\text{CS-137}) = 10.14 \text{ mV}/\mu\text{R/h}$$

$$\bar{k} = 10.14 \text{ mV}/\mu\text{R/h}$$

$$k(\text{Ra-226}) = 0.9892 k(\text{CS-137})$$

$$\sigma = .019 \text{ mV}/\mu\text{R/h}$$

$$k(\text{Ra-226}) = 10.03 \text{ mV}/\mu\text{R/h}$$

$$V = \frac{\sigma}{\bar{k}} = 0.183\%$$

By:

Date:

9-12-13



**Reuter-Stokes****RSS-131 FIRMWARE PARAMETERS**

S/N 07J00KM1

RAC	2.171E-08
ZLN	0.000E+00
ZMN	4.324E-01
ZHN	-2.127E-03
ZLD	0.000E+00
ZMD	-2.414E-04
ZHD	-6.174E-07
RLN	4.619E+11
RMN	2.231E+09
RHN	1.001E+07
RLV	-1.524E+08
RMV	2.094E+04
RHV	-1.548E+02

By:

  
Level 2 Nuclear / Electrical Inspector

Date:

9-12-13

Reviewed By:

  
Product Engineer