



facility 149017

project 10243

## Gross Alpha/Beta Case Narrative

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**COGCC**

**PW NORM 2017 – 10048**

Work Order Number: 1705158

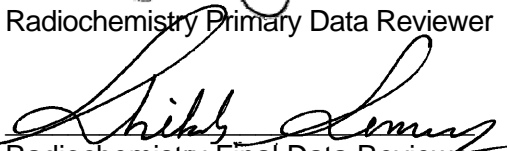
1. This report consists of the analytical results and supporting documentation for one water sample received by ALS on 05/08/2017.
2. This sample was prepared according to the current revision of SOP 702.
3. The sample was analyzed for gross alpha and beta activity by gas flow proportional counting according to the current revision of SOP 724. The analyses were completed on 05/11/2017. Gross alpha results are referenced to  $^{230}\text{Th}$ . Gross beta results are referenced to  $^{137}\text{Cs}$ .
4. The analysis results for this sample are reported in units of pCi/L. The sample was not filtered prior to analysis.
5. Sample volume was insufficient to allow preparation of a duplicate. A laboratory control sample duplicate (LCSD) was prepared in lieu of a client sample duplicate in batch GA170509-1.
6. The requested MDC for gross beta for samples 1705158-1 and -1D was not achieved. The reported activity exceeds the achieved MDC. The results are flagged with an "M3" qualifier on the final reports. Results are submitted without further qualification.
7. No further anomalous situations were encountered during the preparation or analysis of this sample. All remaining quality control criteria were met.



The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

  
Pik Yee Yuen  
Radiochemistry Primary Data Reviewer

5/18/17  
Date

  
Radiochemistry Final Data Reviewer

5/18/17  
Date

## Section 1

# CHAIN OF CUSTODY

# ALS -- Fort Collins

## Sample Number(s) Cross-Reference Table

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**OrderNum:** 1705158

**Client Name:** COGCC

**Client Project Name:** PW NORM 2017

**Client Project Number:** 10048

**Client PO Number:** CT 2017-3066

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Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
149017 Wellington Rapid Infiltrati	1705158-1		WATER	08-May-17	10:40
149017 Wellington Rapid Infiltrati	1705158-2		WATER	08-May-17	10:40

## Chain-of-Custody

**Turnaround time for samples received after 2 p.m. will be calculated beginning from the next business day.**

**Turnaround time for samples received Saturday will be calculated beginning from the next business day.**

[illegible]

Time Zone (Circle):	MST	Matrix:	O = oil	S = soil	NS = non-soil solid	W = water	L = liquid	E = extract	F = filter
						Form 2029			
NOTES						SIGNATURE	PRINTED NAME	DATE	TIME
GAB prepped (coprecip) and counted within 4 days of sampling 224Ra prepped and counted within 4 days of sampling Uso U only if 6020 "total" U > 3µg/l Th only if 6020 "total" Th > 3µg/l						RELINQUISHED BY	RALPH	5/8/17	11:00
						RECEIVED BY	C Trumble	5-8-17	1110
						RELINQUISHED BY			
						RECEIVED BY			
						RELINQUISHED BY			
PRESERVATION KEY	1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaOHzAcetate 6-HaHSO4 7-4°C 8-Other								



TE: (800) 443-1511 PH: (970) 490-1511 FX: (970) 490-1522

## Chain-of-Custody

1705158

[illegible]



ALS Environmental - Fort Collins  
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: COGCC

Workorder No: 1705158

Project Manager: SS

Initials: es Date: 5-8-17

1. Does this project require any special handling in addition to standard ALS procedures?		YES	<u>NO</u>
2. Are custody seals on shipping containers intact?	<u>NONE</u>	YES	NO
3. Are Custody seals on sample containers intact?	<u>NONE</u>	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?		<u>YES</u>	NO
5. Are the COC and bottle labels complete and legible?		<u>YES</u>	NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)		<u>YES</u>	NO
7. Were airbills / shipping documents present and/or removable?	<u>DROP OFF</u>	YES	NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	N/A	<u>YES</u>	NO
9. Are all aqueous non-preserved samples pH 4-9?	N/A	<u>YES</u>	NO
10. Is there sufficient sample for the requested analyses?		<u>YES</u>	NO
11. Were all samples placed in the proper containers for the requested analyses?		<u>YES</u>	NO
12. Are all samples within holding times for the requested analyses?		<u>YES</u>	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)		<u>YES</u>	NO
14. Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: ____ < green pea ____ > green pea	N/A	<u>YES</u>	NO
15. Do any water samples contain sediment? Amount Amount of sediment: ____ dusting ____ moderate ____ heavy	N/A	YES	<u>NO</u>
16. Were the samples shipped on ice?		<u>YES</u>	NO
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: <u>#2</u> #4 RAD ONLY		<u>YES</u>	NO
Cooler #: <u>1</u>			
Temperature (°C): <u>4.6</u>			
No. of custody seals on cooler: <u>0</u>			
External µR/hr reading: <u>NA</u>			
Background µR/hr reading: <u>NA</u>			
Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES / NO <u>NA</u> (If no, see Form 008.)			

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 AND #16.

If applicable, was the client contacted? YES / NO / NA Contact: Shiloh Lemay Date/Time: \_\_\_\_\_

Project Manager Signature / Date: Shiloh Lemay

## Section 2



# **SAMPLE RESULTS SUMMARY**

Gross Alpha(Co-Precipitation) Analysis by GFPC Sample Results Summary

Client Name: COGCC

Client Project Name: PW NORM 2017

Client Project Number: 10048

Laboratory Name: ALS -- Fort Collins

PAI Work Order: 1705158

Page: 1 of 1

Reported on: Thursday, May 18, 2017

8:57:53 AM

Lab Sample ID	Client Sample ID	Sample Type	Nuclide	Result +/- 2 s TPU	MDC	DL	Units	Matrix	Prep Batch	Date Analyze	Flags
1705158-1	149017 Wellington Rapid Infiltration Basin	Sample	GROSS ALPHA	1.02E+01 +/- 2.9E+00	3E+00	NA	pCi/l	WATER	GA170509-1	5/11/2017	

Comments:

Data Package ID: GA1705158-1

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

LT - Result is less than Requested MDC, greater than sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

M - The requested MDC was not met.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

Gross Beta by GFPC Sample Results Summary

Client Name: COGCC  
Client Project Name: PW NORM 2017  
Client Project Number: 10048  
Laboratory Name: ALS -- Fort Collins  
PAI Work Order: 1705158

Page: 1 of 1  
Reported on: Thursday, May 18, 2017  
9:01:48 AM

Lab Sample ID	Client Sample ID	Sample Type	Nuclide	Result +/- 2 s TPU	MDC	DL	Units	Matrix	Prep Batch	Date Analyze	Flags
1705158-1	149017 Wellington Rapid Infiltration Basin	Sample	GROSS BETA	9.3E+00 +/- 3.2E+00	4.5E+00	NA	pCi/l	WATER	AB170509-2	5/10/2017	M3

Comments:

Data Package ID: AB1705158-1

Qualifiers/Flags:

- U - Result is less than the sample specific MDC.
- LT - Result is less than Requested MDC, greater than sample specific MDC.
- Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 - Chemical Yield outside default limits.
- M - The requested MDC was not met.
- M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

Abbreviations:

- TPU - Total Propagated Uncertainty
- MDC - Sample specific Minimum Detectable Concentration
- BDL - Below Detection Limit

## Section 3

# QC RESULTS SUMMARY

3

# Gross Alpha(Co-Precipitation) Analysis by GFPC

PAI 724 Rev 12

## Method Blank Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: GA170509-1MB

Sample Matrix: WATER

Prep SOP: PAI 786 Rev 7

Date Collected: 09-May-17

Date Prepared: 09-May-17

Date Analyzed: 11-May-17

Prep Batch: GA170509-1

QCBatchID: GA170509-1-1

Run ID: GA170509-1A

Count Time: 1000 minutes

Final Aliquot: 500 ml

Result Units: pCi/l

File Name: abc0511d

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
12587-46-1	GROSS ALPHA	2.2E-01 +/- 2.2E-01	3.6E-01	3E+00	NA	U

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

#### Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

M - Requested MDC not met.

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

DL - Decision Level

Data Package ID: GA1705158-1

# Gross Beta by GFPC

PAI 724 Rev 12

## Method Blank Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: AB170509-2MB

Sample Matrix: WATER

Prep SOP: PAI 702 Rev 20

Date Collected: 09-May-17

Date Prepared: 09-May-17

Date Analyzed: 10-May-17

Prep Batch: AB170509-2

QCBatchID: AB170509-2-1

Run ID: AB170509-2B

Count Time: 1000 minutes

Final Aliquot: 200 ml

Result Units: pCi/l

File Name: abc0510g

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
12587-47-2	GROSS BETA	-1.9E-01 +/- 6.6E-01	1.1E+00	4E+00	NA	U

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

#### Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

M - Requested MDC not met.

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

DL - Decision Level

Data Package ID: AB1705158-1

# Gross Alpha(Co-Precipitation) Analysis by GFPC

PAI 724 Rev 12

## Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: GA170509-1LCS

Sample Matrix: WATER

Prep SOP: PAI 786 Rev 7

Date Collected: 09-May-17

Date Prepared: 09-May-17

Date Analyzed: 11-May-17

Prep Batch: GA170509-1

QCBatchID: GA170509-1-1

Run ID: GA170509-1A

Count Time: 30 minutes

Final Aliquot: 500 ml

Result Units: pCi/l

File Name: aba0511

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
12587-46-1	GROSS ALPHA	9.8E+01 +/- 1.8E+01	2E+00	8.920E+01	109	75 - 125	P

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC.

LT - Result is less than Requested MDC, greater than sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS Recovery within control limits.

M - The requested MDC was not met.

M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

#### Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Minimum Detectable Concentration

Data Package ID: GA1705158-1

Date Printed: Thursday, May 18, 2017

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LIMS Version: 6.841

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# Gross Beta by GFPC

PAI 724 Rev 12

## Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: AB170509-2LCS

Sample Matrix: WATER

Prep SOP: PAI 702 Rev 20

Date Collected: 09-May-17

Date Prepared: 09-May-17

Date Analyzed: 10-May-17

Prep Batch: AB170509-2

QCBatchID: AB170509-2-1

Run ID: AB170509-2B

Count Time: 30 minutes

Final Aliquot: 200 ml

Result Units: pCi/l

File Name: abc0510b

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
12587-47-2	GROSS BETA	2.1E+02 +/- 3.6E+01	1.2E+01	2.270E+02	92.4	75 - 125	P,M3

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC.

LT - Result is less than Requested MDC, greater than sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS Recovery within control limits.

M - The requested MDC was not met.

M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

#### Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Minimum Detectable Concentration

Data Package ID: AB1705158-1

# Gross Alpha(Co-Precipitation) Analysis by GFPC

PAI 724 Rev 12

## Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: GA170509-1LCSD

Sample Matrix: WATER

Prep SOP: PAI 786 Rev 7

Date Collected: 09-May-17

Date Prepared: 09-May-17

Date Analyzed: 11-May-17

Prep Batch: GA170509-1

QCBatchID: GA170509-1-1

Run ID: GA170509-1A

Count Time: 30 minutes

Final Aliquot: 500 ml

Result Units: pCi/l

File Name: aba0511

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
12587-46-1	GROSS ALPHA	9.8E+01 +/- 1.8E+01	2E+00	8.920E+01	109	75 - 125	P

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC.

LT - Result is less than Requested MDC, greater than sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS Recovery within control limits.

M - The requested MDC was not met.

M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

#### Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Minimum Detectable Concentration

Data Package ID: GA1705158-1

Date Printed: Thursday, May 18, 2017

ALS -- Fort Collins

LIMS Version: 6.841

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# Gross Alpha(Co-Precipitation) Analysis by GFPC

PAI 724 Rev 12

## Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID:   
Lab ID: GA170509-1LCSD

Sample Matrix: WATER

Prep SOP: PAI 786 Rev 7

Date Collected: 09-May-17

Date Prepared: 09-May-17

Date Analyzed: 11-May-17

Prep Batch: GA170509-1

QCBatchID: GA170509-1-1

Run ID: GA170509-1A

Count Time: 30 minutes

Final Aliquot: 500 ml

Prep Basis: Unfiltered

Moisture(%): NA

Result Units: pCi/l

File Name: aba0511

CASNO	Analyte	Sample				Duplicate				DER	DER Lim
		Result +/-	2 s TPU	MDC	Flags	Result +/-	2 s TPU	MDC	Flags		
12587-46-1	GROSS ALPHA	9.8E+01 +/- 1.8E+01		2E+00	P	9.8E+01 +/- 1.8E+01		2E+00	P	0.000876	2

### Comments:

#### Duplicate Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.

Y2 - Chemical Yield outside default limits.

W - DER is greater than Warning Limit of 1.42

D - DER is greater than Control Limit of 2

LT - Result is less than Request MDC, greater than sample specific MDC

M - Requested MDC not met.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS, Matrix Spike Recovery within control limits.

N - Matrix Spike Recovery outside control limits

#### Abbreviations:

TPU - Total Propagated Uncertainty

DER - Duplicate Error Ratio

BDL - Below Detection Limit

NR - Not Reported

Data Package ID: GA1705158-1

# Gross Beta by GFPC

## PAI 724 Rev 12

### Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins  
Work Order Number: 1705158  
Client Name: COGCC  
ClientProject ID: PW NORM 2017 10048

Field ID:	149017 Wellington Rapid In
Lab ID:	1705158-1DUP

Sample Matrix: WATER  
Prep SOP: PAI 702 Rev 20  
Date Collected: 08-May-17  
Date Prepared: 09-May-17  
Date Analyzed: 10-May-17

Prep Batch: AB170509-2  
QCBatchID: AB170509-2-1  
Run ID: AB170509-2B  
Count Time: 1000 minutes  
Report Basis: Unfiltered

Final Aliquot: 60.0 ml  
Prep Basis: Unfiltered  
Moisture(%): NA  
Result Units: pCi/l  
File Name: abc0510g

CASNO	Analyte	Sample				Duplicate				DER	DER Lim
		Result +/-	2 s TPU	MDC	Flags	Result +/-	2 s TPU	MDC	Flags		
12587-47-2	GROSS BETA	9.3E+00 +/-	3.2E+00	4.5E+00	M3	1.29E+01 +/-	3.7E+00	4.7E+00	M3	0.749	2

#### Comments:

##### Duplicate Qualifiers/Flags:

U - Result is less than the sample specific MDC.  
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.  
Y2 - Chemical Yield outside default limits.  
W - DER is greater than Warning Limit of 1.42  
D - DER is greater than Control Limit of 2  
LT - Result is less than Request MDC, greater than sample specific MDC  
M - Requested MDC not met.  
M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.  
L - LCS Recovery below lower control limit.  
H - LCS Recovery above upper control limit.  
P - LCS, Matrix Spike Recovery within control limits.  
N - Matrix Spike Recovery outside control limits

##### Abbreviations:

TPU - Total Propagated Uncertainty  
DER - Duplicate Error Ratio  
BDL - Below Detection Limit  
NR - Not Reported

Data Package ID: AB1705158-1

## Section 4

# INDIVIDUAL SAMPLE RESULTS

4

# Gross Alpha(Co-Precipitation) Analysis by GFPC

PAI 724 Rev 12

## Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 149017 Wellington Rapid In  
Lab ID: 1705158-1

Sample Matrix: WATER

Prep SOP: PAI 786 Rev 7

Date Collected: 08-May-17

Date Prepared: 09-May-17

Date Analyzed: 11-May-17

Prep Batch: GA170509-1

QCBatchID: GA170509-1-1

Run ID: GA170509-1A

Count Time: 1000 minutes

Report Basis: Unfiltered

Final Aliquot: 50.0 ml

Prep Basis: Unfiltered

Moisture(%): NA

Result Units: pCi/l

File Name: abc0511d

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
12587-46-1	GROSS ALPHA	1.02E+01 +/- 2.9E+00	3E+00	3E+00	NA	

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

#### Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

Data Package ID: GA1705158-1

# Gross Beta by GFPC

PAI 724 Rev 12

## Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 149017 Wellington Rapid In  
Lab ID: 1705158-1

Sample Matrix: WATER

Prep SOP: PAI 702 Rev 20

Date Collected: 08-May-17

Date Prepared: 09-May-17

Date Analyzed: 10-May-17

Prep Batch: AB170509-2

QCBatchID: AB170509-2-1

Run ID: AB170509-2B

Count Time: 1000 minutes

Report Basis: Unfiltered

Final Aliquot: 60.0 ml

Prep Basis: Unfiltered

Moisture(%): NA

Result Units: pCi/l

File Name: abc0510g

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
12587-47-2	GROSS BETA	9.3E+00 +/- 3.2E+00	4.5E+00	4E+00	NA	M3

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

#### Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

Data Package ID: AB1705158-1

# Gross Beta by GFPC

PAI 724 Rev 12

## Sample Duplicate Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 149017 Wellington Rapid In  
Lab ID: 1705158-1DUP

Sample Matrix: WATER

Prep SOP: PAI 702 Rev 20

Date Collected: 08-May-17

Date Prepared: 09-May-17

Date Analyzed: 10-May-17

Prep Batch: AB170509-2

QCBatchID: AB170509-2-1

Run ID: AB170509-2B

Count Time: 1000 minutes

Report Basis: Unfiltered

Final Aliquot: 60.0 ml

Prep Basis: Unfiltered

Moisture(%): NA

Result Units: pCi/l

File Name: abc0510g

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
12587-47-2	GROSS BETA	1.29E+01 +/- 3.7E+00	4.7E+00	4E+00	NA	M3

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M - The requested MDC was not met.

M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

W - DER is greater than Warning Limit of 1.42

D - DER is greater than Control Limit of 2

#### Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

Data Package ID: AB1705158-1

Date Printed:

Thursday, May 18, 2017

ALS -- Fort Collins

LIMS Version: 6.841

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## Section 5

# RAW DATA

5

# Gross Alpha(Co-Precipitation) Analysis by GFPC Raw Data Report

Laboratory Name: ALS -- Fort Collins

Prep SOP: PAI 786

Reported on: Thursday, May 18, 2017

PAI Work Order: 1705158

Analytical SOP: PAI 724

8:56:36 AM

Sample ID QC Type	Nuclide Type	Sample Date/Time	Prep Batch QC Batch ID	Ingrowth Date /Time	Decay Date/Time	Matrix %Moist.	Samp Aliq Analy Aliq	Inst ID Det ID	AnRunID File Name	Count Date/Time	GrossCPM BkgCPM	BaseEff ProgEff	CntDur(min) Yield	Activity +/- 2 s TPU	MDC DeclEv	ReportUnits ReportBasis	DER RPD	%Spk. Recov Flags
1705158-1	GROSS ALPHA	5/8/2017	GA170509-1	NA	NA	WATER	50 ml	LB4100-c	GA170509-1A	5/11/2017	0.249	23.45%	1000	1.02E+01	3E+00	pCi/l	NA	
SMP	Trg. Analyte	10:40:00 AM	GA170509-1-1	NA	NA	NA	50 ml	A1	abc0511d	2:33 PM	0.090	NA	NA	2.9E+00		Unfiltered	NA	
GA170509-1	GROSS ALPHA	5/9/2017	GA170509-1	NA	NA	WATER	500 ml	LB4100-c	GA170509-1A	5/11/2017	0.157	22.79%	1000	2.2E-01	3.8E-01	pCi/l	NA	
MB	Trg. Analyte	1:56:31 PM	GA170509-1-1	NA	NA	NA	500 ml	C4	abc0511d	2:33 PM	0.123	NA	NA	2.2E-01		Unfiltered	NA	U
GA170509-1	GROSS ALPHA	5/9/2017	GA170509-1	NA	NA	WATER	500 ml	LB4100-a	GA170509-1A	5/11/2017	16.833	23.77%	30	9.8E+01	2E+00	pCi/l	NA	109
LCS	Trg. Analyte	1:56:31 PM	GA170509-1-1	NA	NA	NA	500 ml	B1	aba0511	8:52 AM	0.106	NA	NA	1.8E+01		Unfiltered	NA	P
GA170509-1	GROSS ALPHA	5/9/2017	GA170509-1	NA	NA	WATER	500 ml	LB4100-a	GA170509-1A	5/11/2017	16.633	23.20%	30	9.8E+01	2E+00	pCi/l	0.00	109
LCSD	Trg. Analyte	1:56:31 PM	GA170509-1-1	NA	NA	NA	500 ml	B3	aba0511	8:52 AM	0.129	NA	NA	1.8E+01		Unfiltered	NA	P

Comments:

Data Package ID: GA1705158-1

Qualifiers/Flags:

U - Result is less than the sample specific MDC.  
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.  
Y2 - Chemical Yield outside default limits.  
W - DER is greater than Warning Limit of 1.42  
D - DER is greater than Control Limit of 2  
+ - Duplicate RPD not within limits.  
LT - Result is less than Request MDC, greater than sample specific MDC  
\* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'  
# - Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'

M - Requested MDC not met.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS, Matrix Spike Recovery within control limits.

N - Matrix Spike Recovery outside control limits

NC - Not Calculated for duplicate results less than 5 times MDC

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Notes:

1) The Tracer results are not yield corrected (i.e. activity measured not activity added).  
2) Where sample time is not available, 12:00 PM (Mountain) is used for decay correction.

Abbreviations:

TR- Tracer TA - Target Analyte

TPU - Total Propagated Uncertainty

MDC - Minimum Detectable Concentration

DER - Duplicate Error Ratio

BDL - Below Detection Limit

Date Printed: Thursday, May 18, 2017

ALS -- Fort Collins

LIMS Version: 6.841

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# Gross Beta by GFPC Raw Data Report

Laboratory Name: ALS -- Fort Collins  
PAI Work Order: 1705158

Prep SOP: PAI 702  
Analytical SOP: PAI 724

Reported on: Thursday, May 11, 2017  
3:27:36 PM

Sample ID QC Type	Nuclide Type	Sample Date/Time	Prep Batch QC Batch ID	Ingrowth Date /Time	Decay Date/Time	Matrix %Moist.	Samp Aliq Analy Aliq	Inst ID Det ID	AnRunID File Name	Count Date/Time	GrossCPM BkgCPM	BaseEff ProgEff	CntDur(min) Yield	Activity +/- 2 s TPU	MDC DeclEv	ReportUnits ReportBasis	DER RPD	%Spk. Recov Flags
1705158-1	GROSS BETA	5/8/2017	AB170509-2	NA	NA	WATER	60 ml	LB4100-c	AB170509-2B	5/10/2017	2,028	40.49%	1000	9.3E+00	4.5E+00	pCi/l	NA	
SMP	Trg. Analyte	10:40:00 AM	AB170509-2-1	NA	NA	NA	60 ml	B1	abc0510g	1:20 PM	1,589	NA	NA	3.2E+00		Unfiltered	NA	M3
1705158-1	GROSS BETA	5/8/2017	AB170509-2	NA	NA	WATER	60 ml	LB4100-c	AB170509-2B	5/10/2017	2,242	40.74%	1000	1.29E+01	4.7E+00	pCi/l	0.75	
DUP	Trg. Analyte	10:40:00 AM	AB170509-2-1	NA	NA	NA	60 ml	B2	abc0510g	1:20 PM	1,646	NA	NA	3.7E+00		Unfiltered	NA	M3
AB170509-2	GROSS BETA	5/9/2017	AB170509-2	NA	NA	WATER	200 ml	LB4100-c	AB170509-2B	5/10/2017	1,648	41.79%	1000	-1.9E-01	1.1E+00	pCi/l	NA	
MB	Trg. Analyte	12:58:25 PM	AB170509-2-1	NA	NA	NA	200 ml	D2	abc0510g	1:20 PM	1,682	NA	NA	6.6E-01		Unfiltered	NA	U
AB170509-2	GROSS BETA	5/9/2017	AB170509-2	NA	NA	WATER	200 ml	LB4100-c	AB170509-2B	5/10/2017	41,233	40.88%	30	2.1E+02	1.2E+01	pCi/l	NA	92.4
LCS	Trg. Analyte	12:58:25 PM	AB170509-2-1	NA	NA	NA	200 ml	A4	abc0510b	10:05 AM	1,495	NA	NA	3.6E+01		Unfiltered	NA	P, M3

Comments:

Data Package ID: AB1705158-1

Qualifiers/Flags:

U - Result is less than the sample specific MDC.  
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.  
Y2 - Chemical Yield outside default limits.  
W - DER is greater than Warning Limit of 1.42  
D - DER is greater than Control Limit of 2  
+ - Duplicate RPD not within limits.  
LT - Result is less than Request MDC, greater than sample specific MDC  
\* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'  
# - Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'

Notes:

M - Requested MDC not met.  
M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.  
L - LCS Recovery below lower control limit.  
H - LCS Recovery above upper control limit.  
P - LCS, Matrix Spike Recovery within control limits.  
N - Matrix Spike Recovery outside control limits  
NC - Not Calculated for duplicate results less than 5 times MDC  
B - Analyte concentration greater than MDC.  
B3 - Analyte concentration greater than MDC but less than Requested MDC.

Abbreviations:

TR- Tracer TA - Target Analyte  
TPU - Total Propagated Uncertainty  
MDC - Minimum Detectable Concentration  
DER - Duplicate Error Ratio  
BDL - Below Detection Limit

Date Printed: Thursday, May 18, 2017

ALS -- Fort Collins

LIMS Version: 6.841

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Alpha Attenuation Calibration	Beta Attenuation Calibration
$y = b \cdot m^{-1} \cdot (e^{(m \cdot a - x_0)})$	$y = b \cdot m^{-1} \cdot (e^{(m \cdot a - x_0)})$
Alpha b= m= a= x0=	Beta b= m= a= x0=
Alpha to Beta X-talk $y = b \cdot m^{-1} \cdot m_{\text{mass}}$	Beta to Alpha X-talk $y = b \cdot m^{-1} \cdot m$
a -> b xtalk b= a -> b xtalk m=	b -> a xtalk b= b -> a xtalk m=

Background logfile: BKGABW  
Date of Bkg. Cal: 5/10/2017  
Alpha efficiency logfile: TH230-06/15  
Alpha attenuation calibration: ATH0609\_0610Alpha prog. attenuation: n/a  
Beta efficiency logfile: Cs-137-06/15  
Beta attenuation calibration: ACS0609\_0608ABeta prog. attenuation: n/a

Unit Type: LB4100 -C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision:  
Rev.12/01/08 JCP  
Data file name: ABC05108  
Batch ID: AB170509-2  
Count Preset (m): 30  
Batch Ended: 5/10/2017 10:32

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity			
					Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Eff	Gross CPM	Bkg. CPM	a>b xtlk CPM	Base Eff
A4	AB170509-2LCS	5/10/2017 10:32	30.00	29.2	13.667	0.092	0.016	0.2370	0.632	n/a	n/a	0.4088
									41.233	1.495	3.8056	0.944
												n/a

TS 5/12/17  
JCS 5/11/17

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100 -C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev.12/01/08 JCP

Data file name: ABC0510G  
Batch ID: AB170509-2  
Count Preset (m): 1000  
Batch Ended: 5/11/2017 6:01

2

Background log file: BKGABW  
Date of Bkg. Cal: 5/10/2017  
Alpha efficiency log file: TH230-06/15  
Alpha attenuation calibration: ATH0609\_0610A  
Beta efficiency log file: Cs-137-06/15  
Beta attenuation calibration: ACS0608\_0608A

Alpha prog. log file: n/a  
Alpha prog. attenuation: n/a  
Beta prog. log file: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration	Beta Attenuation Calibration
$y = b'm^2(e^{(mass \cdot x)})$	$y = b'm^2(e^{(mass \cdot x)})$
Alpha b= 0.81480	Beta b= 0.9784
m= 0.9620	m= 0.9988
a= 0.8822	a= 0.9758
x0= 0.0000	x0= 0.0000
Alpha to Beta X-talk	Beta to Alpha X-talk
$y = b'm^2 \cdot mass$	$y = b'm^2 \cdot mass$
a -> b xtalk b= 0.2652	b -> a xtalk b= -1.07E-07
a -> b xtalk m= 0.9981	b -> a xtalk m= 0.0004

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity					Beta Activity				
					Gross CPM	Bkg. CPM	b-a xtlk CPM	Base Eff	Progeny Cor.Fact.	Gross CPM	Bkg. CPM	a-b xtlk CPM	Base Eff	Progeny Cor.Fact.
B1	1705158-1	5/11/2017 6:00	1000.00	191.8	0.224	0.095	0.000	0.2254	0.154	2.028	1.589	0.0493	0.4049	n/a
B2	1705158-1D	5/11/2017 6:00	1000.00	207.2	0.247	0.097	0.000	0.2196	0.135	2.242	1.646	0.0590	0.4074	n/a
B3	1705177-1	5/11/2017 6:00	1000.00	173.8	0.527	0.110	0.000	0.2269	0.180	2.806	1.589	0.1539	0.3987	n/a
B4	1705177-2	5/11/2017 6:00	1000.00	172.9	0.581	0.116	0.000	0.2192	0.181	2.854	1.621	0.1713	0.4100	n/a
D1	1705177-3	5/11/2017 6:01	1000.00	189.1	0.747	0.094	0.001	0.2303	0.158	3.569	1.687	0.2481	0.4069	n/a
D2	AB170509-2MB	5/11/2017 6:01	1000.00	26.9	0.085	0.093	0.000	0.2281	0.645	1.648	1.682	0.0000	0.4179	n/a

MS/SL  
5/11/17

Date 5/10/17SOP 724r. 12

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	TP	P			*				P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK00509W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	1900	Dr A	10
		Dr B	
Tank 2	2100	Dr C	
		Dr D	

Comments: \*Not necessary to run daily background checks following a long background calibration.  
 TP 5/10/17

Date 5/10/17SOP 724r 12

ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Darb Bksett.			30	7:35	JP	EFCOSIO	JCB
5	1705181-1	AB170509-3	$\alpha\beta$	240	907	JCB	ABLOSIO	JCB
6	↓ -10	↓	↓	↓	↓	↓	↓	↓
2	↓ -3	↓	↓	↓	↓	↓	↓	↓
8	AB170509-3LUS	↓	↓	30	909	↓	AB10510A	JCB
4	AB170509-2LUS	AB170509-2	↓	↓	1002	↓	ABLOSIOB	↓
1	1717004-1	RA170503-1	RA228	90	1039	↓	RACOSIO	↓
2	↓ 2	↓	↓	↓	↓	↓	↓	↓
3	↓ 3	↓	↓	↓	↓	↓	↓	↓
4	↓ 4	↓	↓	↓	↓	↓	↓	↓
13	↓ 5	↓	↓	↓	↓	↓	↓	↓
14	RA170511-11AMB	↓	↓	↓	↓	↓	↓	↓
15	↓ AMB	↓	↓	↓	↓	↓	↓	↓
16	↓ CMB	↓	↓	↓	↓	↓	↓	↓
8	1705153-19	AB170510-12	$\alpha\beta$	30	1131	↓	ABLOSIOC	↓
7	↓ 22	↓	↓	↓	↓	↓	↓	↓
10	↓ 23	↓	↓	↓	↓	↓	↓	↓
11	1705174-1	↓	↓	↓	↓	↓	↓	↓
9	AB170509-2 MB	↓	↓	↓	1219	↓	ABLOSIOD	JCB
10	1705174-1	↓	↓	↓	↓	↓	↓	↓
1	1705181-2	AB170509-3	↓	1000	1230	↓	ABLOSIOE	↓
2	AB170509-3 MB	↓	↓	↓	↓	↓	↓	↓
3	1704584-1	AB170503-1	↓	↓	1232	↓	ABLOSIOF	↓
4	↓ -10	↓	↓	↓	↓	↓	↓	↓
9	1704281-4	TR170424-1	RA226	1000	1256	↓	RDCOSIG	↓
10	↓ -4MB	↓	↓	↓	↓	↓	↓	↓
11	TR170424-1 MB	↓	↓	↓	↓	↓	↓	↓
5	1705158-1	AB170509-2	$\alpha\beta$	1000	1316	↓	ABLOSIOG	↓
6	↓ -10	↓	↓	↓	1316	↓	↓	↓
7	1705177-1	↓	↓	↓	↓	↓	↓	↓
8	↓ 2	↓	↓	↓	↓	↓	↓	↓
13	↓ 3	↓	↓	↓	↓	↓	↓	↓
14	AB170509-2 MB	↓	↓	↓	↓	↓	↓	↓
15	AB170509-3LUS	AB170509-3	$\alpha\beta$	30	1331	↓	ABLOSIOH	↓
15	1705154-3	AB170508-1	$\alpha\beta$	120	1525	JCB	ABLOSIOI	↓
16	1705072-2	↓	↓	↓	↓	↓	↓	↓

Comments:

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(cont. from page NA **B**)

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Reviewed By / Date

JP 5/11/17

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# PAI - Gas Flow Proportional Sample Analysis LB4100-A

Unit Type: LB4100-A/W  
 Counting Unit ID: Orange  
 High Voltage Mode: Simultaneous  
 Application Revision: C  
 Application Version: PA  
 Rev.05/09/13 JP

Data file name: ABA0511  
 Batch ID: GA170509-1  
 Count Preset (m): 30  
 Batch Ended: 5/11/17 9:20

Background logfile: BKGABW  
 Date of Bkg. Cal: 5/10/17  
 Alpha efficiency logfile: Th-230-12/16  
 Alpha attenuation calibration: ACP0415  
 Beta efficiency logfile: C5137-12/16  
 Beta attenuation calibration: ACS1207

Alpha prog. logfile: n/a  
 Alpha prog. attenuation: n/a  
 Beta prog. logfile: n/a  
 Beta prog. attenuation: n/a

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^a \cdot (e^{(mass-x)})$		$y = b \cdot m^a \cdot (e^{(mass-x)})$	
Alpha b=	0.98100	Beta b=	0.9455
m=	0.98690	m=	0.9886
a=	0.8971	a=	1.0026
x0=	0.0000	x0=	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b \cdot m^a \cdot x$		$y = b \cdot m^a \cdot x$	
a->b xtalk b=	0.2339	b->a xtalk b=	1.618E-06
a->b xtalk m=	0.9968	b->a xtalk m=	0.0037

Det. ID	Sample ID	Count		Resid. Mass (mg)	Alpha Activity										Beta Activity																			
		End Date & Time	Dur. (min)		Gross					b>a xtlk					Gross					a>b xtlk					Base					Progeny				
					CPM	CPM	CPM	CPM	Eff	Cor.Fact.	CPM	CPM	CPM	CPM	Eff	Cor.Fact.	CPM	CPM	CPM	CPM	CPM	CPM	Eff	Cor.Fact.	CPM	CPM	CPM	CPM	Eff	Cor.Fact.	CPM	CPM	CPM	CPM
B1	GA170509-1LCS	5/11/17 9:20	30.00	34.8	16.833	0.108	0.017	0.2377	0.650	n/a	n/a	6.533	2.033	4.3742	0.4271	0.900	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
B3	GA170509-1LCS	5/11/17 9:20	30.00	33.9	16.633	0.129	0.017	0.2320	0.657	n/a	n/a	6.533	2.000	4.3034	0.4171	0.902	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

5/16/17  
 GABW

Date 5/11/17SOP 724r 12

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	✓	P			✓	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16	✓	✓			✓	✓			✓

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK0509W			
Dr B				
Dr C				
Dr D	✓			

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	1600	Dr A	10
		Dr B	
Tank 2	2050	Dr C	
		Dr D	✓

Comments:

Date 5/11/17SOP 724r 12

## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Daily Eff	—	—	30	7:09	JP	EFC0511	JP
1-16	Daily Bkg	—	—	60	7:17	JP	BKC0511	JCS
1	1704356-16	RA170430-1	Ra224	90	8:29	JCS	RAC0511	JCS
2	17							
3	18							
4	19							
5	20							
6	21							
7	22							
8	23							
9	1704497-21							
10	22							
11	1704502-21							
13	22							
14	23							
15	24							
16	1704512-1							
1	<del>170504</del> 1704504-1	AB170506-1	AB	150	10:07	JCS	ABC0511	
2	2							
3	3							
4	1705074-1							
5	1705072-1			75	10:09		ABC0511A	
6	1705087-6							
7	1705087-6							
8	1705087-6							
13	1705067-1 MS			30	10:11		ABC0511B	
14	1705072-1 MS							
15	1705072-1 MS							
16	AB170508-1 MS				14:25			
5	1704604-1	AB170503-1		1000	12:05		ABC0511C	JCS
6	10							
7	2							
8	3							
9	4							
10	5							
11	6							
13	1705052-1	AB170508-1						
14	1705067-1							
15	1705087-1							
16	AB170508-1 MB				14:33			
1	1705156-1	GA170509-1	2		12:41		ABC0511D	
2	1705177-1							
3	2							
4	3							
12	GA170509-1 MB							
JCS 5/12/17								

Comments:

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Reviewed By / Date JCS 5/12/17

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PAI - Gas Flow Proportional Sample Analysis LB4100-C

Alpha Attenuation Calibration	Beta Attenuation Calibration
$y = b \cdot m^x \cdot (e^{(mass-x)})$	$y = b \cdot m^x \cdot (e^{(mass-x)})$
Alpha b= 0.81480	Beta b= 0.9764
m= 0.99020	m= 0.9988
e= 0.8822	e= 0.9758
x0= 0.0000	x0= 0.0000
Alpha to Beta X-talk	Beta to Alpha X-talk
$y = b \cdot m^x \cdot mass$	$y = b \cdot m^x \cdot mass$
a -> b xtalk b= 0.2952	b -> a xtalk b= -1.07E-07
e -> b xtalk m= 0.9981	b -> a xtalk m= 0.0004

Background logfile: BKGABW  
Date of Bkg. Cal: 5/10/2017  
Alpha efficiency logfile: Th230-06/15  
Alpha attenuation calibration: AT-H0609, 0610A  
Alpha prog. logfile: n/a  
Beta efficiency logfile: Cs-137-06/15  
Beta attenuation calibration: ACS0608, 0608A  
Beta prog. logfile: n/a  
Beta attenuation calibration: ACS0608, 0608A  
Beta prog. attenuation: n/a

Unit Type: LB4100 -C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: 2  
Rev.12/01/08 JCP  
Data file name: ABC0511D  
Batch ID: GA170509-1  
Count Preset (m): 1000  
Batch Ended: 5/12/2017 7:19

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity			
					Gross CPM	Bkg. CPM	b-a xtlk CPM	Base Eff	Progeny Cor.Fact.	Gross CPM	Bkg. CPM	a-b xtlk CPM
A1	1705158-1	5/12/2017 7:18	1000.00	35.1	0.249	0.090	0.000	0.2345	0.601	1.845	1.446	0.0451
A2	1705177-1	5/12/2017 7:18	1000.00	46.4	9.687	0.113	0.004	0.2280	0.544	10.725	1.433	2.7733
A3	1705177-2	5/12/2017 7:18	1000.00	52.5	9.751	0.096	0.004	0.2309	0.516	10.836	1.581	2.8294
A4	1705177-3	5/12/2017 7:18	1000.00	41.1	6.328	0.092	0.003	0.2370	0.570	8.634	1.495	1.7882
C4	GA170509-1MB	5/12/2017 7:19	1000.00	34.7	0.157	0.123	0.000	0.2279	0.603	3.064	3.340	0.0096
							Base Eff		Progeny Cor.Fact.			Progeny Cor.Fact.
							0.4119		0.937			n/a
							0.4183		0.925			n/a
							0.4102		0.918			n/a
							0.4088		0.930			n/a
							0.4060		0.937			n/a

TS 5/16/17  
703 5/16/17

Date 5/11/17SOP 724r 12

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100CA**

JP 5/11/17

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									OL
7									P
8									
9									
10									OL
11									P
12									OL
13	OL				OL				
14									
15									
16									

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKA0509W			
Dr B				
Dr C				
Dr D	OL			

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	1600	Dr A	10
		Dr B	
Tank 2	2050	Dr C	
		Dr D	

Comments:

Date 5/11/17SOP 724r 12

ALS  
Low Background Gas Flow Proportional Counter Log  
Instrument: LB4100A

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-12	Daily Eff	—	—	30	7:03	JK	EFA0511	JP
1-12	Daily BKG	—	—	60	7:16	JK	BKA0511	JKB
1	1704559-1	RA170430-1	Reuse	90	8:36	JKB	RAA0511	JKB
2	1704560-1	↓	↓	↓	↓	↓	↓	↓
3	1704563-1	↓	↓	↓	↓	↓	↓	↓
4	RA1704301MB	↓	↓	↓	↓	↓	↓	↓
9	LS	↓	↓	↓	↓	↓	↓	↓
11	LSD	↓	↓	↓	↓	↓	↓	↓
5	GA1705091LS	GA170509-1	2	30	8:49	JKB	ABA0511	↓
7	LS	↓	↓	↓	↓	↓	↓	↓
8	AB1705101LS	AB170510-1	2/B	↓	8:51	↓	ABA0511A	↓
5	170524-2	↓	↓	240	11:51	↓	ABA0511B	↓
7	-3	↓	↓	↓	↓	↓	↓	↓
8	-4	↓	↓	↓	↓	↓	↓	↓
9	-5	↓	↓	↓	↓	↓	↓	↓
11	-6	↓	↓	↓	↓	↓	↓	↓
1	-1	↓	↓	400	15:54	↓	ABA0511C	↓
2	-10	↓	↓	↓	↓	↓	↓	↓
3	AB170524-4MB	↓	↓	↓	↓	↓	↓	↓
JKB 5/12/17								

Comments:

Page No.: 472218 **B**  
(cont. from page NA **B**)

Form 780r8.doc (6/23/06)

Reviewed By / Date JKB 5/12/17

35 of 348

## Section 6

# QUALITY ASSURANCE SUMMARY REPORTS

**6**

**No *NON-CONFORMANCE REPORTS* or *QUALITY ASSURANCE SUMMARY SHEETS* are included in this data package.**

## Section 7

# LABORATORY BENCH SHEETS



# Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: GA170509-1

Prep Procedure: GR\_ALPH\_CO 1000nm

Analytical QASS / NCR? Y / ☒ NA

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes
1	1705158-1	SMP	50	50	ml	pCi/l	35.1	AB0511D	1	JIK							
1	1705177-1	SMP	50	50	ml	pCi/l	46.4		2								
1	1705177-2	SMP	50	50	ml	pCi/l	52.5		3								
1	1705177-3	SMP	50	50	ml	pCi/l	41.1		4								
1	GA170509-1	MB	500	500	ml	pCi/l	34.7		12								
1	GA170509-1	LCS	500	500	ml	pCi/l	34.8	ABA0511	5	JCS							
1	GA170509-1	LCSD	500	500	ml	pCi/l	33.9		7								

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Th-230	760.4243.03	7/23/18	98.994	DPM/ml	05/09/17	1	ml	RS-033

## Sample Barcodes

1705158-1 GA170509-1PS1		1705177-1 GA170509-1PS2		1705177-2 GA170509-1PS3	
1705177-3 GA170509-1PS4		GA170509-1MB GA170509-1PS5		GA170509-1LCS GA170509-1PS6	
GA170509-1LCSD GA170509-1PS7					

## Reporting Units

LabID	TstGrpName	RptUnits
1705177-1	GrossA_96h_COGCC Co-pre	pCi/l
1705158-1	GrossA_96h_COGCC Co-pre	pCi/l
1705177-2	GrossA_96h_COGCC Co-pre	pCi/l
1705177-3	GrossA_96h_COGCC Co-pre	pCi/l

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: GA170509-1

Prep Procedure: GR\_ALPHA\_CO

Reviewed By: rlm

Review Date: 5/10/2017

Prep QASS / NCR? Y / MD

Batch: MD

Re-Prep? Y / N

Prep Analyst: Rebecca L. Merola  
Prep Date: 5/9/2017  
Prep Dept: RS

Prep SOP: PAI 786 Rev: 7  
Prep SOP: NONE  
Matrix Class: liquid

Balance: 13  
Balance: NA

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1705158-1	SMP		50	50	Unfiltered		
2	1	1705177-1	SMP		50	50	Unfiltered		
3	1	1705177-2	SMP		50	50	Filtered		
4	1	1705177-3	SMP		50	50	Unfiltered		
5	1	GA170509-1	MB		500	500	Unfiltered		
6	1	GA170509-1	LCS		500	500	Unfiltered	S1	
7	1	GA170509-1	LCSD		500	500	Unfiltered	S1	

Comments

COGCC

Spiked By: Rebecca L. Merola Date: 5/10/2017

Witnessed By: Macey S. Hall Date: 5/10/2017

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Th-230	760.4243.03	4/23/17	98.994	DPM/ml	05/09/17	1	ml	RS-033

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: GA170509-1

Prep Procedure: GR\_ALPH\_CO

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch: Re-Prep? Y / N Batch: Prep QASS / NCR? Y / N

Prep SOP: PAI 786 Rev: 7

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 5/9/2017

Prep Dept: RS

Balance: 13

Balance: NA

Sampl Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1705158-1	SMP	50	500	500	Filtered		
2	1	1705177-1	SMP	50	500	500	Filtered		
3	1	1705177-2	SMP	50	500	500	Filtered		
4	1	1705177-3	SMP	50	500	500	Filtered		
5	1	GA170509-1	MB	500	500	500	Filtered		
6	1	GA170509-1	LCS	500	500	500	Filtered	S1	
7	1	GA170509-1	LCSD	500	500	500	Filtered	S1	

Comments

Spiked By: PC Date: 5/10/17  
 Witnessed By: MSH Date: 5/10/17

Spike Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
S1	Th-230	760.4243.03	4/23/18	98.994	DPW/ml	RS-033

# Radiochemistry Gravimetric Worksheet

ALS -- Fort Collins

Prep Batch: GA170509-1

Prep Procedure: GR\_ALPHA\_CO

Reviewed By: rlmf

Review Date: 5/10/2017

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Gross Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1705158-1	SMP	0	9.4236	0.0000	0	0	50	50	9.4587	35.1	0	
1	2	1705177-1	SMP	0	9.3951	0.0000	0	0	50	50	9.4415	46.4	0	
1	3	1705177-2	SMP	0	9.3555	0.0000	0	0	50	50	9.4080	52.5	0	
1	4	1705177-3	SMP	0	9.2970	0.0000	0	0	50	50	9.3381	41.1	0	
1	5	GA170509-1	MB	0	9.3945	0.0000	0	0	500	500	9.4292	34.7	0	
1	6	GA170509-1	LCS	0	9.3233	0.0000	0	0	500	500	9.3581	34.8	0	
1	7	GA170509-1	LCS	0	9.4347	0.0000	0	0	500	500	9.4686	33.9	0	



# Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: AB170509-2

Prep Procedure: GROSS\_BETA

1000 min

Analytical QASS / NCR? Y *NA*

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes
1	1705158-1	SMP	60	60	ml	pCi/l	191.8	AB05106 5 JP									
1	1705158-1	DUP	60	60	ml	pCi/l	207.2										
1	1705177-1	SMP	5	5	ml	pCi/l	173.8	6									
1	1705177-2	SMP	5	5	ml	pCi/l	172.9	7									
1	1705177-3	SMP	10	10	ml	pCi/l	189.1	8									
1	AB170509-2	MB	40	20	40.00 ml	pCi/l	26.9	13									
1	AB170509-2	LCS	40	40	ml	pCi/l	29.2	14									
								AB05106 4 765									

Spike Solution Information									
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1013.4095.77	12/29/17	100.839	DPM/ml	05/09/17	1	ml	RS-033
S2	Th-230	760.4243.03	4/23/18	98.994	DPM/ml	05/09/17	1	ml	RS-033

## Sample Barcodes

1705158-1 AB170509-2PS1		1705158-1DUP AB170509-2PS2		1705177-1 AB170509-2PS3	
1705177-2 AB170509-2PS4		1705177-3 AB170509-2PS5		AB170509-2MB AB170509-2PS6	
AB170509-2LCS AB170509-2PS7					

## Reporting Units

LabID	TstGrpName	RptUnits
1705177-1	GrossB_96h_COGCC Co-pre	pCi/l
1705158-1	GrossB_96h_COGCC Co-pre	pCi/l
1705177-2	GrossB_96h_COGCC Co-pre	pCi/l
1705177-3	GrossB_96h_COGCC Co-pre	pCi/l

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: AB170509-2

Prep Procedure: GROSS\_BETA

Reviewed By: rlm

Review Date: 5/10/2017

Non-Routine Pre-Treatment? Y ☒ Batch: NA Re-Prep? Y ☒ Batch: NA Prep QASS / NCR? Y ☒ NA

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 5/9/2017

Prep Dept: RS

Balance: 13

Balance: na

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1705158-1	SMP		60	60	Unfiltered		
2	1	1705158-1	DUP		60	60	Unfiltered		
3	1	1705177-1	SMP		5	5	Unfiltered		
4	1	1705177-2	SMP		5	5	Unfiltered		
5	1	1705177-3	SMP		10	10	Unfiltered		
6	1	AB170509-2	MB		100	100	Unfiltered		
7	1	AB170509-2	LCS		10	10	Unfiltered	S1, S2	
Comments									
COGCC									

Spiked By: Rebecca L. Merola Date: 5/9/2017

Witnessed By: Hunter C. Jordan Date: 5/9/2017

Spike Solution Information									
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1013.4095.77	12/29/17	100.839	DPM/ml	05/09/17	1	ml	RS-033
S2	Th-230	760.4243.03	4/23/18	98.994	DPM/ml	05/09/17	1	ml	RS-033

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: AB170509-2

Prep Procedure: GROSS\_BETA

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch: Re-Prep? Y / N Batch: Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 5/9/2017

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1705158-1	SMP		200	200			
2	1	1705158-1	DUP		200	200	As Received		
3	1	1705177-1	SMP		200	200			
4	1	1705177-2	SMP		200	200			
5	1	1705177-3	SMP		200	200			
6	1	AB170509-2	MB		200	200			
7	1	AB170509-2	LCS		200	200		S1,S2	

Comments

COGCC

Spiked By: h Date: 5/9/17

Witnessed By: HCS Date: 5-9-17

Spike Solution Information									
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1013.4095.77	<del>12-29-17</del>	100.839	DFM/ml	05/09/17	1	ml	RS-033
S2	Th-230	760.4243.03	<del>4-23-18</del>	98.994	DFM/ml	05/09/17	1	ml	RS-033

# Radiochemistry Gravimetric Worksheet

ALS -- Fort Collins

Prep Batch: AB170509-2

Prep Procedure: GROSS\_BETA

Reviewed By: rlm

Review Date: 5/10/2017

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Gross Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1705158-1	SMP	10	9.4475	9.4845	37	20	200	60	9.6393	191.8	0	
1	2	1705158-1	DUP	10	9.4187	9.4551	36.4	21	200	60	9.6259	207.2	0	
1	3	1705177-1	SMP	10	9.3642	9.7177	353.5	2	200	5	9.5380	173.8	0	
1	4	1705177-2	SMP	10	9.3460	9.7506	404.6	2	200	5	9.5189	172.9	0	
1	5	1705177-3	SMP	10	9.4462	9.6299	183.7	4	200	10	9.6353	189.1	0	
1	6	AB170509-2	MB	0	9.3862	9.3863	0.1	0	200	10	9.4131	26.9	0.5	
1	7	AB170509-2	LCS	0	9.3492	9.3493	0.1	0	200	10	9.3784	29.2	0.5	

## Sample Condition Form (Liquid)

Analyst: R

Analysis Date: 5/9/17	Method: Prep
-----------------------	--------------

Method: Prep

	Sample Condition (Visual Appearance of Analysis Aliquot at Time of Prep)
--	--

Work Order	Sample ID	pH	Color	Remarks
1705158	1	62.0	clear	sulfur smell
1705177	1		mucky	
↓	2	↓	↓	sediment
	3	↓	black	↓
<div style="position: absolute; top: 50%; left: 50%; transform: translate(-50%, -50%); opacity: 0.5;">             R-5110117           </div>				

## Section 8

# STANDARDS TRACEABILITY DOCUMENTS



Prepare a working dilution of 1013.4095.76

1. Density of 4% HCl, lot # 0000094396  
Mass of 100mL vol. flask: 68.5652g  
Mass of flask & 100mL acid: 169.0154g  
Net Mass: 100.4502g  
Density: 1.0045g/mL

Balance # 12  
Balance# 12

2. Mass of 1013.4095.76 transferred:  
Mass of empty nalgene: 74.1532g  
Mass of nalgene & standard 75.4532g  
Net mass of standard transferred: 1.3000g

Balance# 12  
Balance# 12

3. Dilute to final volume:

Mass of nalgene, standard, & diluent: 1069.7g  
Mass of empty nalgene: 74.1532g  
Net mass of new dilution: 995.5468g

Balance# 26  
Balance# 12

4. Final activity calculation:

$$100,443.61 \text{ dpm/g} (1.0045 \text{ g/mL}) \left( \frac{1.3000 \text{ g}}{995.5468 \text{ g}} \right) = 131.75 \text{ dpm/mL}$$

Std ID: 1013.4095.77

Description: Cs-137  
Expiration: 1/20/2016  
Activity: 131.75 dpm/mL

2s Uncertainty: 0.92 dpm/mL

Ref. Date: 9/30/2005

Ref Time: N/A

Prep Date: 1/16/2015 Prep by: TE

Matrix/Comp. 4% HCl

Half Life (y): 3.01E+01

Reverification Log		
Analysis Date	Initials	Expiration Date
12/29/16	JP	12/29/2017

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Signed

Date

Read and Understood by

Signed

Date

12/16/15  
Prepare an intermediate dilution of RSO# 1013

1. Density of 4% HCl, lot # 0000094396

Mass of 100mL vol. flask:

68.5652g

Balance # 12

Mass of flask & 100mL acid:

169.0154g

Balance # 12

Net Mass:

100.4502g

Density:

1.0045 g/mL

2. Mass of RSO# 1013 transferred:

Mass of open empty bottle:

398.34g

Balance # 26

Mass of bottle and standard:

403.33g

Balance # 26

Net mass of standard transferred:

4.99g

3. Dilute to final volume:

Mass of open empty bottle:

398.34g

Balance # 26

Mass of bottle, standard, & diluent:

1288.4g

Balance # 26

Net mass of new dilution:

890.06g

4. Final activity calculation:

298.6 kBq/g  $\left( \frac{1000 \text{ Bq}}{1 \text{ kBq}} \right) \left( \frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left( \frac{4.99 \text{ g}}{890.06 \text{ g}} \right) = 100,443.61 \text{ dpm/g}$

Continued on Page

1/16/15  
Signed

1/16/15  
Date

Read and Understood By

[Signature]  
Signed

1-16-15  
Date



# National Institute of Standards & Technology Certificate

## Standard Reference Material 4233E Cesium-137 Radioactivity Standard

This Standard Reference Material (SRM) consists of radioactive cesium-137 chloride, non-radioactive cesium chloride, and hydrochloric acid dissolved in 5 mL of distilled water. The solution is contained in a flame-sealed NIST borosilicate-glass ampoule. The SRM is intended for the calibration of ionization chambers and solid-state gamma-ray spectrometry systems.

**Radiological Hazard:** The SRM ampoule contains cesium-137 with a total activity of approximately 1.5MBq. Cesium-137 decays by beta-particle emission to barium-137m, which decays by internal conversion. During the decay process X-rays and gamma rays with energies from approximately 3 keV to 662 keV are emitted. Most of these photons escape from the SRM ampoule and can represent a radiation hazard. Approximate unshielded dose rates at several distances (as of the reference time) are given in note [a]\*. Appropriate shielding and/or distance should be used to minimize personnel exposure. The SRM should be used only by persons qualified to handle radioactive material.

**Chemical Hazard:** The SRM ampoule contains hydrochloric acid with a concentration of 1 mole per liter of water. The solution is corrosive and represents a health hazard if it comes in contact with eyes or skin. If the ampoule is to be opened to transfer the solution, the recommended procedure is given on page 2. The ampoule should be opened only by persons qualified to handle both radioactive material and strong acid solution.

**Storage and Handling:** The SRM should be stored and used at a temperature between 5 and 65 °C. The solution in an unopened ampoule should remain stable and homogeneous until at least September 2015. The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material. If the ampoule is transported, it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The solution in the ampoule is a dangerous good (hazardous material) because of both the radioactivity and the strong acid.

**Preparation:** This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, M.P. Unterweger, Acting Group Leader. The overall technical direction and physical measurements leading to certification were provided by L.L. Lucas, R. Collé and L. Laureano-Pérez of the Radioactivity Group. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program.

Lisa R. Karam, Deputy Chief  
Ionizing Radiation Division

Gaithersburg, Maryland 20899  
October 2005

Robert L. Watters, Jr., Chief  
Measurement Services Division

### **Recommended Procedure for Opening the SRM Ampoule**

- 1) If the SRM solution is to be diluted, it is recommended that the diluting solution have a composition comparable to that of the SRM solution.
- 2) Wear eye protection, gloves, and protective clothing and work over a tray with absorbent paper in it. Work in a fume hood. In addition to the radioactive material, the solution contains strong acid and is corrosive.
- 3) Shake the ampoule to wet all of the inside surface of the ampoule. Return the ampoule to the upright position.
- 4) Check that all of the liquid has drained out of the neck of the ampoule. If necessary, gently tap the neck to speed the process.
- 5) Holding the ampoule upright, score the narrowest part of the neck with a scribe or diamond pencil.
- 6) Lightly wet the scored line. This reduces the crack propagation velocity and makes for a cleaner break.
- 7) Hold the ampoule upright with a paper towel, a wiper, or a support jig. Position the scored line away from you. Using a paper towel or wiper to avoid contamination, snap off the top of the ampoule by pressing the narrowest part of the neck away from you while pulling the tip of the ampoule towards you.
- 8) Transfer the solution from the ampoule using a pycnometer or a pipet with dispenser handle. NEVER PIPETTE BY MOUTH.
- 9) Seal any unused SRM solution in a flame-sealed glass ampoule, if possible, to minimize the evaporation loss.

See also reference [4]\*.

PROPERTIES OF SRM 4233E

Certified values

Radionuclide	Cesium-137
Reference time	1200 EST, 30 September 2005
Massic activity of the solution [c]*	298.6 kBq·g <sup>-1</sup>
Relative expanded uncertainty (k=2)	0.70% [d] [e]
Solution mass	(5.0668 ± 0.0009) g [b]
Solution density	(1.015 ± 0.002) g·mL <sup>-1</sup> at 20 °C [b]

Uncertified values

Physical Properties:			
Source description	Liquid in flame-sealed NIST borosilicate-glass ampoule		
Ampoule specifications	Body outside diameter	(16.5 ± 0.5) mm	
	Wall thickness	(0.60 ± 0.04) mm	
	Barium content	Less than 2.5%	
	Lead-oxide content	Less than 0.02%	
	Other heavy elements	Trace quantities	
Chemical Properties:			
Solution composition	Chemical Formula	Concentration (mol·L <sup>-1</sup> )	Mass Fraction (g·g <sup>-1</sup> )
	H <sub>2</sub> O	54	0.96
	HCl	1.0	0.04
	CsCl	1.6 × 10 <sup>-4</sup>	2.7 × 10 <sup>-5</sup>
	<sup>137</sup> CsCl	6.9 × 10 <sup>-7</sup>	1.2 × 10 <sup>-7</sup>
Radiological Properties:			
Photon-emitting impurities	None detected [f]		
Half lives used	Cesium-137: (10983 ± 11) d [g] [5] Radium-226: (1600 ± 7) a [g] [5]		
Calibration method and measuring instrument(s)	Pressurized "4π"γ ionization chamber A calibrated using an cesium-137 solution whose activity was determined by the 4π(e+X)-γ-coincidence efficiency-extrapolation technique.		

EVALUATION OF THE UNCERTAINTY OF THE MASSIC ACTIVITY [d]\*

Input Quantity $x_i$ , the source of uncertainty  (and individual uncertainty components where appropriate)	Method Used To Evaluate $u(x_i)$ , the standard uncertainty of $x_i$ (A) denotes evaluation by statistical methods (B) denotes evaluation by other methods	Relative Uncertainty Of Input Quantity, $u(x_i)/x_i$ , (%) [h]	Relative Sensitivity Factor, $ \partial y/\partial x_i  \cdot$ $(x_i/y)$ [i]	Relative Uncertainty Of Output Quantity, $u(y)/y$ , (%) [j]
PIC A net response per gram of SRM 4233E, measured relative to RRS20 [k]	Standard deviation of the mean (within-measurement precision ) for 20 to 100 repeated measurements (A)	0.02	1.0	0.02
	Standard deviation (between- measurement precision) for 4 sets of measurement (A)	0.13	1.0	0.13
PIC A net response per Bq of cesium-137 in solution, measured relative to RRS20.	Standard deviation of the mean (for both between- and within- measurement precision) for >100 repeated measurements (A)	0.01	1.0	0.01
Activity used to calibrate PIC A net response per Bq of cesium-137 in solution	Standard uncertainty of the activity determined by the $4\pi(e+X)$ - $\gamma$ -coincidence efficiency-extrapolation technique. (B)	0.31	1.0	0.31
Half life of cesium-137 Half life of radium-226	Standard uncertainty of the half life (A)	0.10 [m] 0.44 [m]	0.0001 [n] 0.010 [n]	0.00001 0.004
Gravimetric measurements	Estimated (B)	0.03	1.0	0.03
PIC A charge collection	Estimated (B)	0.05	1.0	0.05
Charge collection measurement time [p]	Estimated (B)	0.05	1.0	0.05
Long-term RRS positioning	Estimated (B)	0.05	1.0	0.05
Photon-emitting impurities	Limit of detection (B) [q]	100.	0.0001	0.01
Relative Combined Standard Uncertainty of the Output Quantity, $u_c(y)/y$ , (%)				0.35
Coverage Factor, $k$				<u>x 2</u>
Relative Expanded Uncertainty of the Output Quantity, $U/y$ , (%)				0.70

## NOTES

- [a] The Sievert is the SI unit for dose equivalent. See reference [1]. One  $\mu\text{Sv}$  is equal to 0.1 mrem.  
 Distance from Ampoule (cm):           1       30       100  
 Approximate Dose Rate ( $\mu\text{Sv/h}$ ):   300       4       0.3
- [b] The stated uncertainty is two times the standard uncertainty.
- [c] **Massic activity** is the preferred name for the quantity activity divided by the total mass of the sample. See reference [1].
- [d] The reported value,  $y$ , of massic activity (activity per unit mass) at the reference time was not measured directly but was derived from measurements and calculations of other quantities. This can be expressed as  $y = f(x_1, x_2, x_3, \dots, x_n)$ , where  $f$  is a mathematical function derived from the assumed model of the measurement process. The value,  $x_i$ , used for each input quantity  $i$  has a **standard uncertainty**,  $u(x_i)$ , that generates a corresponding uncertainty in  $y$ ,  $u_i(y) \equiv |\partial y / \partial x_i| \cdot u(x_i)$ , called a **component of combined standard uncertainty** of  $y$ . The **combined standard uncertainty** of  $y$ ,  $u_c(y)$ , is the positive square root of the sum of the squares of the components of combined standard uncertainty. The combined standard uncertainty is multiplied by a **coverage factor** of  $k = 2$  to obtain  $U$ , the **expanded uncertainty** of  $y$ .
- Since it can be assumed that the possible estimated values of the massic activity are approximately normally distributed with approximate standard deviation  $u_c(y)$ , the unknown value of the massic activity is believed to lie in the interval  $y \pm U$  with a level of confidence of approximately 95 percent.
- For further information on the expression of uncertainties, see references [2] and [3].
- [e] The value of each component of combined standard uncertainty, and hence the value of the expanded uncertainty itself, is a best estimate based upon all available information, but is only approximately known. That is to say, the "uncertainty of the uncertainty" is large and not well known. This is true for uncertainties evaluated by statistical methods (e.g., the relative standard deviation of the standard deviation of the mean for the massic response is approximately 50%) and for uncertainties evaluated by other methods (which could easily be over estimated or under estimated by substantial amounts). The unknown value of the expanded uncertainty is believed to lie in the interval  $U/2$  to  $2U$  (i.e., within a factor of 2 of the estimated value).
- [f] Estimated limits of detection for photon-emitting impurities, as of 3 October 2005 (3 days after the reference time), expressed as massic photon emission rates, are:  
 $< 40 \gamma \cdot \text{s}^{-1} \cdot \text{g}^{-1}$  for energies between 40 keV and 1350 keV, and  
 $< 4 \gamma \cdot \text{s}^{-1} \cdot \text{g}^{-1}$  for energies between 1350 keV and 3600 keV,
- [g] The stated uncertainty is the standard uncertainty.
- [h] Relative standard uncertainty of the input quantity  $x_i$ .
- [i] The relative change in the output quantity  $y$  divided by the relative change in the input quantity  $x_i$ . If  $|\partial y / \partial x_i| \cdot (x_i / y) = 1.0$ , then a 1% change in  $x_i$  results in a 1% change in  $y$ . If  $|\partial y / \partial x_i| \cdot (x_i / y) = 0.05$ , then a 1% change in  $x_i$  results in a 0.05% change in  $y$ .

- [j] Relative component of combined standard uncertainty of output quantity  $y$ , rounded to two significant figures or less. The relative component of combined standard uncertainty of  $y$  is given by  $u_i(y)/y \approx |\partial y/\partial x_i| \cdot u(x_i)/y = |\partial y/\partial x_i| \cdot (x_i/y) \cdot u(x_i)/x_i$ . The numerical values of  $u(x_i)/x_i$ ,  $|\partial y/\partial x_i| \cdot (x_i/y)$ , and  $u_i(y)/y$ , all dimensionless quantities, are listed in columns 3, 4, and 5, respectively. Thus, the value in column 5 is equal to the value in column 4 multiplied by the value in column 3. The input quantities are independent, or very nearly so. Hence the covariances are zero or negligible.
- [k] The response of pressurized ionization chamber A (PIC A) is determined from measurement of the time required to collect a given amount of charge on a stable fixed capacitor. All of the response measurements in the NIST pressurized ionization chambers are made relative to the response of one or more artifact standards. These artifact standards consist of microgram quantities of aged radium-226 in small welded stainless-steel capsules. These capsules are encapsulated in plastic rods whose dimensions are similar to those of the standard NIST ampoule. The artifact standards are called **Radium Reference Sources** and are designated as RRSx, where x is the nominal mass (in micrograms) of radium-226 in the capsule.
- [m] The relative standard uncertainty of  $\lambda \cdot t$  is determined by the relative standard uncertainty of  $\lambda$  (i.e., of the half life). The relative standard uncertainty of  $t$  is negligible.
- [n]  $|\partial y/\partial x_i| \cdot (x_i/y) = |\lambda \cdot t|$
- [p] The charge collection measurement time is determined by counting the pulses from a gated crystal-controlled oscillator.
- [q] The standard uncertainty for each undetected impurity that might reasonably be expected to be present is estimated to be equal to the estimated limit of detection for that impurity, i.e.  $u(x_i)/x_i = 100\%$ .  $|\partial y/\partial x_i| \cdot (x_i/y) = \{(\text{response per Bq of impurity})/(\text{response per Bq of cesium-137})\} \cdot \{(\text{Bq of impurity})/(\text{Bq of cesium-137})\}$ . Thus  $u_i(y)/y$  is the relative change in  $y$  if the impurity were present with a massic activity equal to the estimated limit of detection.

## REFERENCES

- [1] International Organization for Standardization (ISO), *ISO Standards Handbook - Quantities and Units*, 1993. Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
- [2] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993 (corrected and reprinted, 1995). Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
- [3] B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407, U.S.A.
- [4] National Council on Radiation Protection and Measurements Report No. 58, *A Handbook of Radioactivity Measurements Procedures*, Second Edition, 1985. Available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Bethesda, MD 20814 U.S.A.
- [5] Evaluated Nuclear Structure Data File (ENSDF), September 2005.

Prepare a working dilution of 760.3020.08

1. Density of 0.5 M HNO<sub>3</sub> lot # 0000127617  
Mass of 100mL vol. flask: 68.2961 g Balance # 12  
Mass of flask & 100mL acid: 169.4362 g Balance # 12  
Net Mass: 101.1401 g  
Density: 1.0114 g/mL

2. Mass of 760.3020.08 transferred:  
Mass of open empty nalgene: 74.6548 g Balance # 12  
Mass of nalgene & standard: 77.6893 g Balance # 12  
Net mass of standard transferred: 3.0345 g

3. Dilute to final volume:  
Mass of nalgene, standard, & diluent: 897.2 g Balance # 26  
Mass of empty nalgene (from above): 74.6548 g Balance # 12  
Net mass of new dilution: 822.5452 g

4. Final activity calculation:  
$$26,534.43 \text{ dpm/g} \times 1.0114 \text{ g/mL} \times \frac{3.0345 \text{ g}}{822.5452 \text{ g}} = 99.01 \text{ dpm/mL}$$

Std ID: 760.4243.03

Description: Th-230  
Expiration: 5/5/2017  
Activity: 99.01 dpm/ml

2s Uncertainty: 3.27 dpm/ml

Ref. Date: 7/13/2004

Ref Time: N/A

Prep Date: 4/7/2016 Prep by: TE

Matrix/Comp. 0.5 M HNO<sub>3</sub>

Half Life (y): 7.54E+04

Reverification Log		
Analysis Date	Initials	Expiration Date
04/23/17	JP	04/23/2018

Signed

Date

Signed

Date

Continued on Page \_\_\_\_\_

Prepare a primary dilution of R50 #760 (Analytical # 68750-307) in 0.5 M  $\text{HNO}_3$  to a concentration of approx 30,000 dpm/mL.

1) Prepare 0.5 M  $\text{HNO}_3$  by diluting 31 mL of conc. (16M)  $\text{HNO}_3$  (EMD lot # 44287) to a final volume of 1000 mL.

2) Determine density of 0.5 M  $\text{HNO}_3$

Mass of 100 mL volumetric flask = 66.4289 g (Bal 12)

Mass of flask + 0.5 M  $\text{HNO}_3$  = 167.5792 g

Net mass of solution = 101.1503 g <sup>11/24/06</sup>

$\div 100 \text{ mL} = \text{density} = 1.0115 \text{ g/mL}$

3) Transfer # 760 to a 40 mL VOA vial.

Mass of bottle w/out lid = 21.5801 g (Bal 12)

Mass of std + bottle

26.5278 g

Net mass of std transferred

4.9477 g

4) Dilute to volume w/ 0.5 M  $\text{HNO}_3$

Mass of bottle + std + soln = 61.8912 g (Bal 12)

Mass of bottle (from above)

21.5801 g

Net mass of std.

40.3111 g

5) Final activity calc.

$$\frac{(1.832 \times 10^4 \text{ d/sec}) \left( \frac{1600 \text{ sec}}{1 \text{ min}} \right) (4.9477 \text{ g}) (1.0115 \text{ g/mL})}{(5.08447) (40.3111 \text{ g})} = 26,534.43 \text{ d/g}$$

Continued on Page

Read and Understood By

Deborah Baker

Signed

1/24/06

Date

[Signature]

Signed

1/27/06

Date



ANALYTICS

RSO# 760 Rec'd 7/14/04 JCB

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318 - U.S.A.

Phone (404) 352-8577  
Fax (404) 352-2837

## CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

68750-307

Th-230 5 mL Liquid in Flame Sealed Vial

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

ISOTOPE:	Th-230
ACTIVITY (dps):	1.832 Bq
HALF-LIFE:	7.538 Bq years
CALIBRATION DATE:	July 13, 2004 12:00 EST
RELATIVE EXPANDED UNCERTAINTY (k=2):	3.3%

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%

5.08447 grams 0.5M HNO<sub>3</sub> solution.

P O NUMBER 70635, Item 1

SOURCE PREPARED BY:

M. D. Currie  
M. D. Currie, Radiochemist

Q A APPROVED:

A. Currie 7/13/04

## Section 9

# **ADDITIONAL SUPPORTING DOCUMENTATION**

**Gas Proportional Counter**

**Instrument Calibration**

**Background Calibration**

**LB4100-A Long Background Instrument Calibration  
Background Determinations**

Detector ID	Alpha			Beta			Flag	Detector ID
	CPM	LCL	UCL	CPM	LCL	UCL		
A1 (01)	0.121	0.0808	0.1920	2.064	1.833	2.488	PASS	A1 (01)
A2 (02)	0.115	0.0778	0.2056	1.931	1.814	2.358	PASS	A2 (02)
A3 (03)	0.121	0.0423	0.1841	2.330	1.882	2.627	PASS	A3 (03)
A4 (04)	0.109	0.0660	0.1534	2.234	1.910	2.350	PASS	A4 (04)
B1 (05)	0.106	0.0565	0.1769	2.033	1.625	2.614	PASS	B1 (05)
B2 (06)	0.128	0.0530	0.1824	1.824	1.673	2.157	PASS	B2 (06)
B3 (07)	0.129	0.0777	0.2003	2.000	1.540	2.483	PASS	B3 (07)
B4 (08)	0.173	0.1055	0.2263	1.911	1.613	2.011	PASS	B4 (08)
C1 (09)	0.128	0.0158	0.2074	1.991	1.267	2.743	PASS	C1 (09)
C2 (10)	0.159	0.1259	0.2317	1.851	1.612	1.987	PASS	C2 (10)
C3 (11)	0.103	0.0310	0.1808	1.794	1.289	2.177	PASS	C3 (11)
C4 (12)	0.136	0.1023	0.2329	1.995	1.719	2.289	PASS	C4 (12)
D1 (13)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D1 (13)
D2 (14)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D2 (14)
D3 (15)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D3 (15)
D4 (16)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D4 (16)

Reviewed by: \_\_\_\_\_

Date: \_\_\_\_\_

*JP* *5/10/17*

Historical Control Limits set to AVE 10 POINTS +- 3 Std Dev JP 04/10/2017

**LB4100-C**  
**Long Instrument Background Calibration**  
**Background Determination**

Detector ID	Alpha				Beta				Detector ID
	CPM	LCL	UCL	Flag	CPM	LCL	UCL	Flag	
A1 (01)	0.090	0.0012	0.2468	PASS	1.446	1.075	2.150	PASS	A1 (01)
A2 (02)	0.113	0.0016	0.3124	PASS	1.433	1.211	2.423	PASS	A2 (02)
A3 (03)	0.096	0.0011	0.2229	PASS	1.581	1.123	2.246	PASS	A3 (03)
A4 (04)	0.092	0.0011	0.2189	PASS	1.495	1.157	2.313	PASS	A4 (04)
B1 (05)	0.095	0.0011	0.2269	PASS	1.589	1.217	2.433	PASS	B1 (05)
B2 (06)	0.097	0.0012	0.2428	PASS	1.646	1.202	2.405	PASS	B2 (06)
B3 (07)	0.110	0.0013	0.2667	PASS	1.589	1.236	2.472	PASS	B3 (07)
B4 (08)	0.116	0.0015	0.2886	PASS	1.621	1.220	2.441	PASS	B4 (08)
C1 (09)	0.121	0.0010	0.2030	PASS	1.590	1.136	2.273	PASS	C1 (09)
C2 (10)	0.124	0.0011	0.2229	PASS	1.701	1.160	2.319	PASS	C2 (10)
C3 (11)	0.103	0.0011	0.2149	PASS	1.722	1.234	2.468	PASS	C3 (11)
C4 (12)	0.123	0.0012	0.2368	PASS	3.340	1.395	4.184	PASS	C4 (12)
D1 (13)	0.094	0.0010	0.1930	PASS	1.687	1.247	2.495	PASS	D1 (13)
D2 (14)	0.093	0.0009	0.1851	PASS	1.682	1.178	2.357	PASS	D2 (14)
D3 (15)	0.104	0.0009	0.1791	PASS	1.801	1.173	2.346	PASS	D3 (15)
D4 (16)	0.089	0.0009	0.1731	PASS	1.716	1.210	2.420	PASS	D4 (16)

Reviewed by: \_\_\_\_\_

Date: 5/10/17

Historical limits for alpha/beta set to be +/- 3 Std Deviations  
JP 09/30/2016

**Gas Proportional Counter**

**Quality Control Data**

**Daily Instrument Performance Checks**

LB4100-A Daily Instrument Performance Check  
Efficiency Determinations

Detector ID	Alpha				Beta				Detector ID
	Eff.	LCL	UCL	Flag	Eff.	LCL	UCL	Flag	
A1 (01)	0.2135	0.1979	0.2300	PASS	0.2255	0.2088	0.2426	PASS	A1 (01)
A2 (02)	0.2050	0.1918	0.2229	PASS	0.2269	0.2077	0.2414	PASS	A2 (02)
A3 (03)	0.2234	0.2064	0.2399	PASS	0.2317	0.2145	0.2492	PASS	A3 (03)
A4 (04)	0.2219	0.2084	0.2421	PASS	0.2295	0.2166	0.2518	PASS	A4 (04)
B1 (05)	0.2215	0.2064	0.2399	PASS	0.2438	0.2220	0.2580	PASS	B1 (05)
B2 (06)	0.2298	0.2124	0.2468	PASS	0.2532	0.2291	0.2663	PASS	B2 (06)
B3 (07)	0.2281	0.1937	0.2352	PASS	0.2303	0.2051	0.2387	PASS	B3 (07)
B4 (08)	0.2169	0.2003	0.2328	PASS	0.2133	0.1998	0.2322	PASS	B4 (08)
C1 (09)	0.2145	0.1911	0.2221	PASS	0.2394	0.2198	0.2554	PASS	C1 (09)
C2 (10)	0.2143	0.1997	0.2320	PASS	0.2443	0.2225	0.2586	PASS	C2 (10)
C3 (11)	0.2186	0.2004	0.2329	PASS	0.2328	0.2144	0.2492	PASS	C3 (11)
C4 (12)	0.2079	0.1908	0.2217	PASS	0.2678	0.2325	0.2702	PASS	C4 (12)
D1 (13)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D1 (13)
D2 (14)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D2 (14)
D3 (15)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D3 (15)
D4 (16)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D4 (16)

Reviewed by: \_\_\_\_\_

Date: \_\_\_\_\_

*JP* *5/11/17*

Historical Control Limits -- +/-7.5% of Average of 30 Data Points. JP 02/10/17

**LB4100-A Daily Instrument Calibration and Check  
Background Determinations**

Detector ID	Alpha			Flag	Beta			Flag	Detector ID
	CPM	LCL	UCL		CPM	LCL	UCL		
A1 (01)	0.183	-0.0137	0.2557	PASS	2.167	1.508	2.620	PASS	A1 (01)
A2 (02)	0.167	-0.0163	0.2463	PASS	2.433	1.393	2.469	PASS	A2 (02)
A3 (03)	0.033	-0.0137	0.2557	PASS	2.483	1.739	2.921	PASS	A3 (03)
A4 (04)	0.067	-0.0189	0.2369	PASS	1.967	1.655	2.813	PASS	A4 (04)
B1 (05)	0.100	-0.0201	0.2321	PASS	1.983	1.481	2.585	PASS	B1 (05)
B2 (06)	0.167	-0.0106	0.2666	PASS	1.917	1.301	2.347	PASS	B2 (06)
B3 (07)	0.183	-0.0101	0.2681	PASS	2.483	1.452	2.548	PASS	B3 (07)
B4 (08)	0.117	0.0119	0.3341	PASS	1.967	1.376	2.446	PASS	B4 (08)
C1 (09)	0.150	-0.0106	0.2666	PASS	2.117	1.445	2.537	PASS	C1 (09)
C2 (10)	0.200	0.0046	0.3134	PASS	1.783	1.324	2.378	PASS	C2 (10)
C3 (11)	0.050	-0.0213	0.2273	PASS	1.917	1.275	2.313	PASS	C3 (11)
C4 (12)	0.200	-0.0068	0.2788	PASS	1.883	1.448	2.542	PASS	C4 (12)
D1 (13)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D1 (13)
D2 (14)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D2 (14)
D3 (15)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D3 (15)
D4 (16)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D4 (16)

Reviewed by: JCB

Date: 5/11/17

Control Limits established from previous weekly background determinations

Weekly Bkg File: BKA0509W Date: 5/9/17 Analyst: JP  
0 1/0/00 0

LB4100-A Daily Instrument Performance Check  
Efficiency Determinations

Detector ID		Alpha			Beta			Detector ID	
	Eff.	LCL	UCL	Flag	Eff.	LCL	UCL	Flag	
A1 (01)	0.2186	0.1979	0.2300	PASS	0.2283	0.2088	0.2426	PASS	A1 (01)
A2 (02)	0.2093	0.1918	0.2229	PASS	0.2275	0.2077	0.2414	PASS	A2 (02)
A3 (03)	0.2227	0.2064	0.2399	PASS	0.2323	0.2145	0.2492	PASS	A3 (03)
A4 (04)	0.2234	0.2084	0.2421	PASS	0.2272	0.2166	0.2518	PASS	A4 (04)
B1 (05)	0.2241	0.2064	0.2399	PASS	0.2415	0.2220	0.2580	PASS	B1 (05)
B2 (06)	0.2260	0.2124	0.2468	PASS	0.2442	0.2291	0.2663	PASS	B2 (06)
B3 (07)	0.2386	0.1937	0.2352	FLAG-HIGH	0.2362	0.2051	0.2387	PASS	B3 (07)
B4 (08)	0.2273	0.2003	0.2328	PASS	0.2161	0.1998	0.2322	PASS	B4 (08)
C1 (09)	0.2150	0.1911	0.2221	PASS	0.2423	0.2198	0.2554	PASS	C1 (09)
C2 (10)	0.2189	0.1997	0.2320	PASS	0.2416	0.2225	0.2586	PASS	C2 (10)
C3 (11)	0.2243	0.2004	0.2329	PASS	0.2313	0.2144	0.2492	PASS	C3 (11)
C4 (12)	0.2052	0.1908	0.2217	PASS	0.2625	0.2325	0.2702	PASS	C4 (12)
D1 (13)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D1 (13)
D2 (14)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D2 (14)
D3 (15)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D3 (15)
D4 (16)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D4 (16)

recounted in  
EFA0512 A

Reviewed by: JCB

Date: 5/12/17

Historical Control Limits -- +/- 7.5% of Average of 30 Data Points. JP 02/10/17

LB4100-A Daily Instrument Performance Check  
Efficiency Determinations

Detector ID	Alpha				Beta				Detector ID
	Eff.	LCL	UCL	Flag	Eff.	LCL	UCL	Flag	
A1 (01)	#VALUE!	0.1979	0.2300	#VALUE!	#VALUE!	0.2088	0.2426	#VALUE!	A1 (01)
A2 (02)	#VALUE!	0.1918	0.2229	#VALUE!	#VALUE!	0.2077	0.2414	#VALUE!	A2 (02)
A3 (03)	#VALUE!	0.2064	0.2399	#VALUE!	#VALUE!	0.2145	0.2492	#VALUE!	A3 (03)
A4 (04)	#VALUE!	0.2084	0.2421	#VALUE!	#VALUE!	0.2166	0.2518	#VALUE!	A4 (04)
B1 (05)	#VALUE!	0.2064	0.2399	#VALUE!	#VALUE!	0.2220	0.2580	#VALUE!	B1 (05)
B2 (06)	#VALUE!	0.2124	0.2468	#VALUE!	#VALUE!	0.2291	0.2663	#VALUE!	B2 (06)
B3 (07)	0.2297	0.1937	0.2352	PASS	0.2309	0.2051	0.2387	PASS	B3 (07)
B4 (08)	#VALUE!	0.2003	0.2328	#VALUE!	#VALUE!	0.1998	0.2322	#VALUE!	B4 (08)
C1 (09)	#VALUE!	0.1911	0.2221	#VALUE!	#VALUE!	0.2198	0.2554	#VALUE!	C1 (09)
C2 (10)	#VALUE!	0.1997	0.2320	#VALUE!	#VALUE!	0.2225	0.2586	#VALUE!	C2 (10)
C3 (11)	#VALUE!	0.2004	0.2329	#VALUE!	#VALUE!	0.2144	0.2492	#VALUE!	C3 (11)
C4 (12)	#VALUE!	0.1908	0.2217	#VALUE!	#VALUE!	0.2325	0.2702	#VALUE!	C4 (12)
D1 (13)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D1 (13)
D2 (14)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D2 (14)
D3 (15)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D3 (15)
D4 (16)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	D4 (16)

Reviewed by: 765

Date: 5/12/17

Historical Control Limits -- +/-7.5% of Average of 30 Data Points. JP 02/10/17

LB4100-A Daily Instrument Calibration and Check  
Background Determinations

Detector ID	Alpha				Beta				Detector ID
	CPM	LCL	UCL	Flag	CPM	LCL	UCL	Flag	
A1 (01)	0.167	-0.0137	0.2557	PASS	2.267	1.508	2.620	PASS	A1 (01)
A2 (02)	0.133	-0.0163	0.2463	PASS	2.183	1.393	2.469	PASS	A2 (02)
A3 (03)	0.117	-0.0137	0.2557	PASS	2.100	1.739	2.921	PASS	A3 (03)
A4 (04)	0.133	-0.0189	0.2369	PASS	2.400	1.655	2.813	PASS	A4 (04)
B1 (05)	0.067	-0.0201	0.2321	PASS	1.750	1.481	2.585	PASS	B1 (05)
B2 (06)	0.217	-0.0106	0.2666	PASS	1.633	1.301	2.347	PASS	B2 (06)
B3 (07)	0.267	-0.0101	0.2681	PASS	2.200	1.452	2.548	PASS	B3 (07)
B4 (08)	0.217	0.0119	0.3341	PASS	1.600	1.376	2.446	PASS	B4 (08)
C1 (09)	0.133	-0.0106	0.2666	PASS	1.933	1.445	2.537	PASS	C1 (09)
C2 (10)	0.150	0.0046	0.3134	PASS	2.100	1.324	2.378	PASS	C2 (10)
C3 (11)	0.083	-0.0213	0.2273	PASS	1.700	1.275	2.313	PASS	C3 (11)
C4 (12)	0.200	-0.0068	0.2788	PASS	1.733	1.448	2.542	PASS	C4 (12)
D1 (13)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D1 (13)
D2 (14)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D2 (14)
D3 (15)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D3 (15)
D4 (16)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	D4 (16)

Reviewed by: JCS Date: 5/12/17

Control Limits established from previous weekly background determinations

Weekly Bkg File: BKA0509W Date: 5/9/17 Analyst: JP  
0 1/0/00 0

**LB4100-C**  
**Daily Instrument Performance Check-Efficiency Determination**

Detector ID	Alpha				Beta				Detector ID
	Eff.	LCL	UCL	Flag	Eff.	LCL	UCL	Flag	
A1 (01)	0.2034	0.1859	0.2160	PASS	0.3934	0.3641	0.4232	PASS	A1 (01)
A2 (02)	0.2025	0.1952	0.2268	PASS	0.3863	0.3753	0.4362	PASS	A2 (02)
A3 (03)	0.2117	0.2000	0.2324	PASS	0.3968	0.3769	0.4381	PASS	A3 (03)
A4 (04)	0.2068	0.1960	0.2278	PASS	0.3940	0.3791	0.4406	PASS	A4 (04)
B1 (05)	0.2306	0.2151	0.2500	PASS	0.4170	0.3905	0.4538	PASS	B1 (05)
B2 (06)	0.1965	0.1877	0.2182	PASS	0.3723	0.3547	0.4122	PASS	B2 (06)
B3 (07)	0.2189	0.2045	0.2376	PASS	0.4025	0.3736	0.4341	PASS	B3 (07)
B4 (08)	0.2159	0.2022	0.2349	PASS	0.3934	0.3756	0.4365	PASS	B4 (08)
C1 (09)	0.2100	0.1945	0.2261	PASS	0.4019	0.3758	0.4367	PASS	C1 (09)
C2 (10)	0.2166	0.2041	0.2372	PASS	0.4143	0.3833	0.4454	PASS	C2 (10)
C3 (11)	0.2122	0.1952	0.2269	PASS	0.4030	0.3726	0.4330	PASS	C3 (11)
C4 (12)	0.2190	0.2057	0.2390	PASS	0.4165	0.3878	0.4507	PASS	C4 (12)
D1 (13)	0.2125	0.1992	0.2316	PASS	0.3958	0.3737	0.4342	PASS	D1 (13)
D2 (14)	0.2090	0.1979	0.2300	PASS	0.4043	0.3729	0.4333	PASS	D2 (14)
D3 (15)	0.2101	0.2015	0.2342	PASS	0.4162	0.3809	0.4427	PASS	D3 (15)
D4 (16)	0.2146	0.2062	0.2396	PASS	0.4146	0.3833	0.4455	PASS	D4 (16)

Reviewed by: \_\_\_\_\_

JLB

Date: \_\_\_\_\_

5/10/17

Historical Control Limits -- +/-7.5% of average from last 30 data points  
 Established: 01/24/17 JP

# ALS Laboratory Group - Fort Collins

## QUALITY ASSURANCE SUMMARY SHEET

PAR W.O. # / BATCH GAS FLOW PROPORTIONAL  
 TEST GFPC / ALL COUNTER  
 METHOD GFPC  
 SOP/REV (PREP) -  
 SOP/REV (ANAL) 724

Briefly document any QA or other problems or deviations associated with the analysis of samples. Problems could result from: log-in, color, odor, dilution, consistency, scheduling, equipment, or instrumentation, or may include documentation of minor deviations necessary due to unique DQO's or sample characteristics.

Daily Background Checks are not necessary, and therefore not performed, the day following the Weekly Background Calibration. The results of the Weekly Background Calibration will be used as that day's Daily Background Check. If the Weekly Background Calibration is outside the established control limits for a detector, the Weekly Background Calibration will be performed a second time and will be considered as the second Daily Background Check for that day.

*[Handwritten signature across the form]*

*MC*  
*08/05/09*

TECHNICIAN/ANALYST

DATE 08-05-09

DEPARTMENT MANAGER

DATE 08/05/09

**376920**

FORM 302r6.doc (4/22/04)

**LB4100-C**  
Daily Instrument Performance Check-Efficiency Determination

Detector ID	Alpha				Beta				Detector ID
	Eff.	LCL	UCL	Flag	Eff.	LCL	UCL	Flag	
A1 (01)	0.1980	0.1859	0.2160	PASS	0.3887	0.3641	0.4232	PASS	A1 (01)
A2 (02)	0.2006	0.1952	0.2268	PASS	0.3959	0.3753	0.4362	PASS	A2 (02)
A3 (03)	0.2132	0.2000	0.2324	PASS	0.4018	0.3769	0.4381	PASS	A3 (03)
A4 (04)	0.2014	0.1960	0.2278	PASS	0.3945	0.3791	0.4406	PASS	A4 (04)
B1 (05)	0.2238	0.2151	0.2500	PASS	0.4167	0.3905	0.4538	PASS	B1 (05)
B2 (06)	0.1948	0.1877	0.2182	PASS	0.3680	0.3547	0.4122	PASS	B2 (06)
B3 (07)	0.2158	0.2045	0.2376	PASS	0.4075	0.3736	0.4341	PASS	B3 (07)
B4 (08)	0.2140	0.2022	0.2349	PASS	0.4006	0.3756	0.4365	PASS	B4 (08)
C1 (09)	0.2088	0.1945	0.2261	PASS	0.3970	0.3758	0.4367	PASS	C1 (09)
C2 (10)	0.2158	0.2041	0.2372	PASS	0.4149	0.3833	0.4454	PASS	C2 (10)
C3 (11)	0.2124	0.1952	0.2269	PASS	0.4091	0.3726	0.4330	PASS	C3 (11)
C4 (12)	0.2227	0.2057	0.2390	PASS	0.4198	0.3878	0.4507	PASS	C4 (12)
D1 (13)	0.2189	0.1992	0.2316	PASS	0.4024	0.3737	0.4342	PASS	D1 (13)
D2 (14)	0.2118	0.1979	0.2300	PASS	0.4047	0.3729	0.4333	PASS	D2 (14)
D3 (15)	0.2073	0.2015	0.2342	PASS	0.4096	0.3809	0.4427	PASS	D3 (15)
D4 (16)	0.2229	0.2062	0.2396	PASS	0.4152	0.3833	0.4455	PASS	D4 (16)

Reviewed by:  Date: 5/11/17

Historical Control Limits -- +/-7.5% of average from last 30 data points  
Established: 01/24/17 JP

## LB4100-C

Daily Instrument Performance Checks  
Background Checks

Detector ID	Alpha				Beta				Detector ID
	CPM	LCL	UCL	Flag	CPM	LCL	UCL	Flag	
A1 (01)	0.100	-0.026	0.206	PASS	1.467	0.980	1.912	PASS	A1 (01)
A2 (02)	0.183	-0.017	0.243	PASS	1.467	0.969	1.897	PASS	A2 (02)
A3 (03)	0.050	-0.024	0.216	PASS	1.617	1.094	2.068	PASS	A3 (03)
A4 (04)	0.150	-0.025	0.209	PASS	1.417	1.021	1.969	PASS	A4 (04)
B1 (05)	0.083	-0.024	0.214	PASS	1.417	1.101	2.077	PASS	B1 (05)
B2 (06)	0.100	-0.024	0.218	PASS	1.433	1.149	2.143	PASS	B2 (06)
B3 (07)	0.133	-0.018	0.238	PASS	1.517	1.101	2.077	PASS	B3 (07)
B4 (08)	0.067	-0.016	0.248	PASS	1.567	1.128	2.114	PASS	B4 (08)
C1 (09)	0.133	-0.014	0.256	PASS	1.467	1.102	2.078	PASS	C1 (09)
C2 (10)	0.133	-0.012	0.260	PASS	1.583	1.196	2.206	PASS	C2 (10)
C3 (11)	0.100	-0.021	0.227	PASS	1.683	1.214	2.230	PASS	C3 (11)
C4 (12)	0.150	-0.013	0.259	PASS	2.950	2.632	4.048	PASS	C4 (12)
D1 (13)	0.150	-0.025	0.213	PASS	1.767	1.184	2.190	PASS	D1 (13)
D2 (14)	0.100	-0.025	0.211	PASS	1.800	1.180	2.184	PASS	D2 (14)
D3 (15)	0.100	-0.021	0.229	PASS	1.567	1.281	2.321	PASS	D3 (15)
D4 (16)	0.067	-0.027	0.205	PASS	1.733	1.209	2.223	PASS	D4 (16)

Reviewed by: 365Date: 5/11/17

Control Limits established from previous weekly background determinations.

Weekly Background File: BKC0509W

Date: 5/9/2017

Analyst: JP

0

1/0/1900

0

0

1/0/1900

0

**LB4100-C**  
Daily Instrument Performance Check-Efficiency Determination

Detector ID	Alpha				Beta				Detector ID
	Eff.	LCL	UCL	Flag	Eff.	LCL	UCL	Flag	
A1 (01)	0.2015	0.1859	0.2160	PASS	0.3873	0.3641	0.4232	PASS	A1 (01)
A2 (02)	0.2040	0.1952	0.2268	PASS	0.3941	0.3753	0.4362	PASS	A2 (02)
A3 (03)	0.2144	0.2000	0.2324	PASS	0.3968	0.3769	0.4381	PASS	A3 (03)
A4 (04)	0.2085	0.1960	0.2278	PASS	0.3985	0.3791	0.4406	PASS	A4 (04)
B1 (05)	0.2267	0.2151	0.2500	PASS	0.4103	0.3905	0.4538	PASS	B1 (05)
B2 (06)	0.1984	0.1877	0.2182	PASS	0.3666	0.3547	0.4122	PASS	B2 (06)
B3 (07)	0.2155	0.2045	0.2376	PASS	0.4078	0.3736	0.4341	PASS	B3 (07)
B4 (08)	0.2103	0.2022	0.2349	PASS	0.4028	0.3756	0.4365	PASS	B4 (08)
C1 (09)	0.2095	0.1945	0.2261	PASS	0.4053	0.3758	0.4367	PASS	C1 (09)
C2 (10)	0.2235	0.2041	0.2372	PASS	0.4058	0.3833	0.4454	PASS	C2 (10)
C3 (11)	0.2109	0.1952	0.2269	PASS	0.3910	0.3726	0.4330	PASS	C3 (11)
C4 (12)	0.2280	0.2057	0.2390	PASS	0.4217	0.3878	0.4507	PASS	C4 (12)
D1 (13)	0.2074	0.1992	0.2316	PASS	0.3983	0.3737	0.4342	PASS	D1 (13)
D2 (14)	0.2131	0.1979	0.2300	PASS	0.4139	0.3729	0.4333	PASS	D2 (14)
D3 (15)	0.2101	0.2015	0.2342	PASS	0.4091	0.3809	0.4427	PASS	D3 (15)
D4 (16)	0.2159	0.2062	0.2396	PASS	0.4176	0.3833	0.4455	PASS	D4 (16)

Reviewed by: \_\_\_\_\_

JCB

Date: \_\_\_\_\_

5/12/17

Historical Control Limits --  $\pm 7.5\%$  of average from last 30 data points  
Established: 01/24/17 JP

**LB4100-C**

Reviewed by:

Date:

7/12/15

Control Limits established from previous weekly background determinations.  
Weekly Background File: BKC0509W Date: 5/9/2017 Analyst: JP

Weekly Background File: BKC0509W

Date: 5/9/2017

**Analyst: JP**

1/0/1900



1/0/1900

Q

**Gas Proportional Counter**

**Instrument Calibration**

**Initial Efficiency Calibration  
Standards Traceability**

Instrument: LB4100-A

Calibration: Gross Alpha (Th-230) -- ringed planchet  
Gross Beta (Cs-137) -- ringed planchet  
Drinking Water EPA Method 900.0 Compliant

Date of Calibration: Gross Alpha 12/07/16  
Gross Beta 12/07/16

Efficiency Log Files: **Th230-12/16**  
**Cs-137-12/16**

Efficiency Instrument Files: ETH1207A-C  
ECS1207A-C

Source ID's: (Th-230 853.3020.89)  
(Cs-137 1019.4095.83)

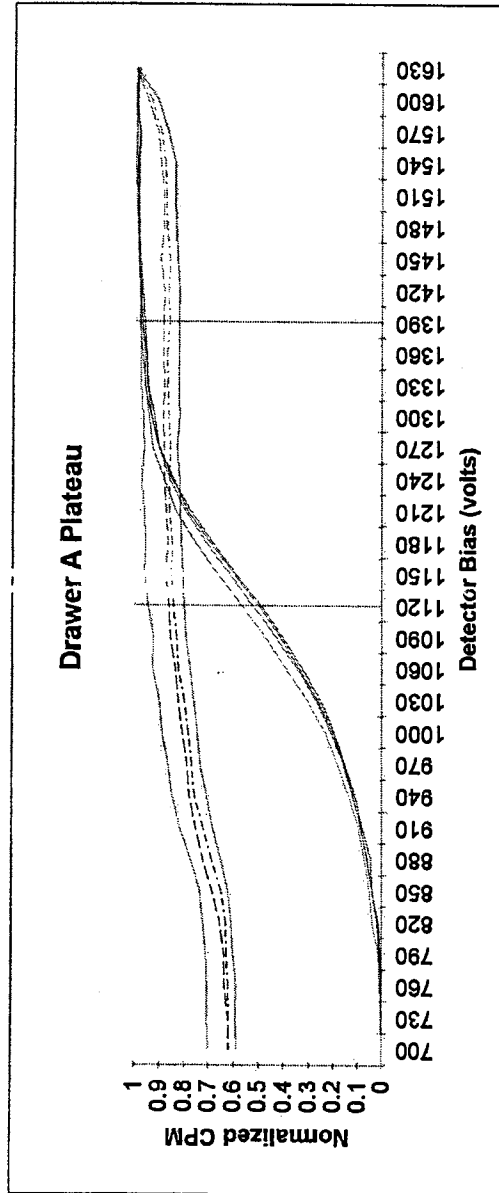
OK JP 2/15/2017

Expires 11/03/2017

# **Instrument Plateaus**

Unit Type: LB4100/W  
 Date Performed: 11/3/16 13:18  
 FileName: PTA1103  
 Batch ID: PLATEAU CHECK

Unit Id: Orange  
 Application Revision: B  
 Application Version: Standard



Optimum alpha beta simultaneous operating voltage: **1402.5**

Optimum alpha only operating voltage: **1120**

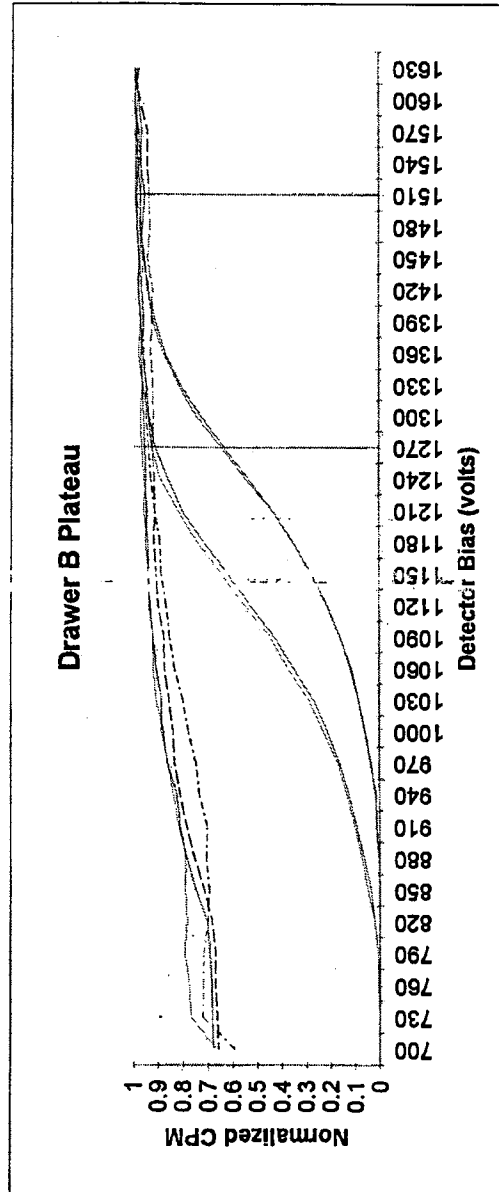
	A1	A2	A3	A4
Beta slope at beta voltage	2.48%	2.17%	3.46%	2.60%
Alpha slope at beta voltage	0.69%	1.09%	0.53%	-0.62%
Alpha slope at alpha voltage	3.21%	3.26%	3.49%	2.70%

*OK 11/7/16*

Printed 11/4/16 7:03 AM

Unit Type: LB4100W  
 Date Performed: 11/3/16 13:18  
 FileName: PTA1103  
 Batch ID: PLATEAU CHECK

Unit Id: Orange  
 Application Revision: B  
 Application Version: Standard



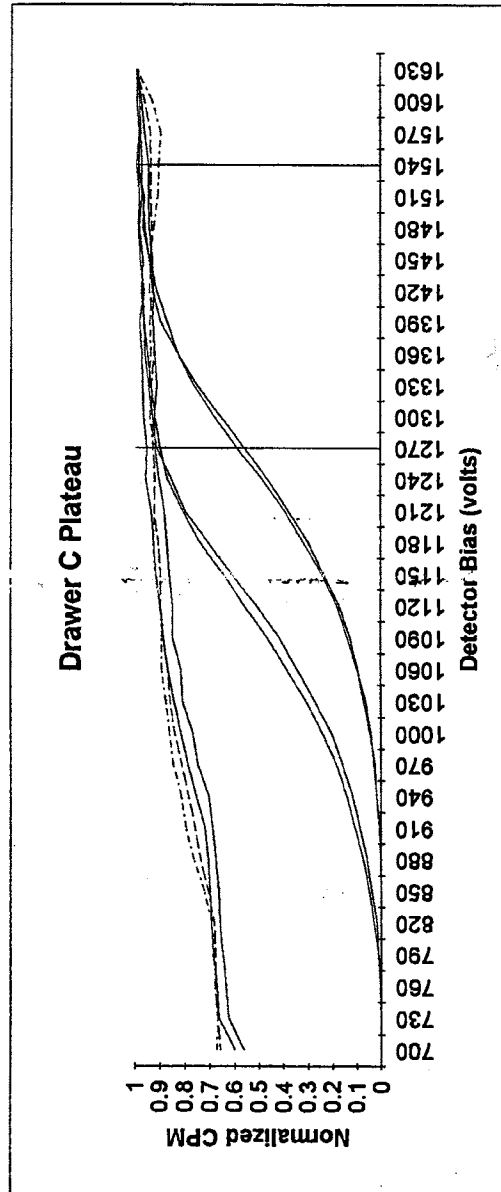
	B1	B2	B3	B4
Beta slope at beta voltage	1.06%	0.81%	1.70%	2.57%
Alpha slope at beta voltage	0.00%	0.72%	1.22%	1.58%
Alpha slope at alpha voltage	0.84%	0.83%	1.99%	3.07%

OK 11/7/16

Printed 11/4/16 7:03 AM

Unit Type: LB4100/W  
 Date Performed: 11/4/16 07:00  
 FileName: PTA1104C  
 Batch ID: DRAWER C PLATEAU

Unit Id: Orange  
 Application Revision: B  
 Application Version: Standard



Optimum alpha beta simultaneous operating voltage: **1530**

Optimum alpha only operating voltage: **1270**

	C1	C2	C3	C4
Beta slope at beta voltage	2.80%	0.60%	1.61%	0.38%
Alpha slope at beta voltage	2.88%	2.32%	-0.15%	-0.03%
Alpha slope at alpha voltage	2.92%	1.27%	2.92%	1.94%

OK 11/17/16

Printed 11/4/16 1:22 PM

11-4-15

Plateau checks performed for Drawers A-C

2 sources

Source	Detector	Count	Rate	PTA
410 Am-241	A1 B1 C1	406	51.90/4.90	PTA1104A
411 17800dpm	A2 B2 C2	407	29600dpm	B
412 2-16-95	A3 B3 C3	408	9-15-92	C
413	A4 B4 C4	409		

Parameters

Starting voltage 700	Ct. preset 40,000
Ending voltage 1650	weak check time 0.1
Volts/step 30	weak ct. limit 35
Ct. time/step 5	
Time between steps 0.1	

3-24-16

Power outage. Instrument was turned off. <sup>Turned</sup> ~~Restarted~~ back on when power was restored. Daily checks were performed.

All in control. Instrument on-line.

3-30-16

memory loss caused computer to crash and files to be lost. All instrument calibration files were restored from last back-up. As of 4-1-16 instrument was on-line and resumed as normal.

11-3-16 & 11-4-16

Plateau checks performed for Drawers A-C

2 sources Detectors 3 sources

Source	Detector	Count	Rate
410 Am-241	A1 B1 C1	406	51.90/4.90
411 17800dpm	A2 B2 C2	407	29600dpm
412 2-16-95	A3 B3 C3	408	9-15-92
413	A4 B4 C4	409	

Parameters

Starting voltage 700	Time between steps 0.1
Ending voltage 1650	Ct. preset 40,000
Volts/step 30	weak check time 0.1
Ct. time/step 5	weak ct. limit 35

Continued on Page \_\_\_\_\_

*M. J. In*

Signed

11-7-16

Date

Read and Understood By

*[Signature]*

Signed

11/7/16

Date

$$\underline{11/3/16} / 11/4/16$$

SOP 724r 11

# ALS

## Low Background Gas Flow Proportional Counter Log

**Instrument: LB4100A**

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-4	Alpha/Beta	Drynet Plat	Plat	5/Min/Stop	13:18	MH	PTA1103	JP
5-6	Beta/Alpha	B						
9-12	Alpha/Beta	C			0:55	JP	PTA11034C	
1-12	Daily Eff.	—	—	30	14:05	UW	EFA1104	UW
		—	—		14:20		A	
		—	—		14:31		B	
		—	—		14:44		C	
		—	—		14:54		D	
1-12	Weekly bkgd	—	—	1000	15:17	UW	EFA1104W	JP

JP 11/5/16

**Comments:**

Page No. 468536 B  
(cont. from page Mr B)

Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 11/5/16

# **Instrument ROIs**

# LB4100-AW Sample Counting Parameters for LIMS

Certainty requirement for MDA and flags	95%
Maximum count time (min)	120.00
Typical Residual Mass (mg)	80.00
Typical Sample Volume (l)	1.00

Action level for flags (pCi/l)	$1.000\text{E}+00$	$8.000\text{E}+00$
Activity Multiplier	$1.000\text{E}+00$	$1.000\text{E}+00$
Mass Error (%)	1.00%	
Volume Error (%)	1.00%	

	Alpha		Beta	
	eff.	bkg.	eff.	MDA (pCi/l)
A1	16.35%	0.142	34.64%	$6.404\text{E}-01$
A2	21.07%	0.125	37.63%	$5.775\text{E}-01$
A3	22.60%	0.1	36.33%	$6.140\text{E}-01$
A4	19.36%	0.141	35.10%	$6.206\text{E}-01$

Batch Specific:

Orange	Event	Recycle
	1	0

Drawer Specific:

	Date/Time	Official	Bias	Step
A	11/3/16 13:18	TRUE	1402.5	0
B	11/3/16 13:18	TRUE	1500	0
C	11/4/16 7:00	TRUE	1530	0
D	8/5/08 11:19	TRUE	1500	0

Detector Specific:

	Date/Time	Official	Threshold	bLL	bUL	aLL	aUL	Time
A1	11/4/16 0:00	TRUE	0.1	0	21.51	41.83	100	120
A2	11/4/16 0:00	TRUE	0.1	0	24.68	47.05	100	120
A3	11/4/16 0:00	TRUE	0.1	0	20.53	39.21	100	120
A4	11/4/16 0:00	TRUE	0.1	0	21.8	40.51	100	120
B1	11/4/16 0:00	TRUE	0.1	0	47.74	94.77	100	120
B2	11/4/16 0:00	TRUE	0.1	0	53.65	100	100	120
B3	11/4/16 0:00	TRUE	0.1	0	13.94	32.01	100	120
B4	11/4/16 0:00	TRUE	0.1	0	11.52	27.44	100	120
C1	11/4/16 0:00	TRUE	0.1	0	21.44	47.05	100	120
C2*	11/4/16 0:00	TRUE	0.1	0	67.57	100	100	120
C3	11/4/16 0:00	TRUE	0.1	0	23.27	50.98	100	120
C4	11/4/16 0:00	TRUE	0.1	0	88.44	100	100	120
D1	5/2/13 0:00	TRUE	0.1	0	60.52	100	100	120
D2	5/2/13 0:00	TRUE	0.1	0	60.52	100	100	120
D3	5/2/13 0:00	TRUE	0.1	0	60.52	100	100	120
D4	5/2/13 0:00	TRUE	0.1	0	60.52	100	100	120

# **Calibration Efficiencies**

SOURCES.XLS

628	Th-230	Alpha	28124250	5831.9	116.64	6-Nov-07	ALS	Th-230-12/16
629	Cs-137	Beta	10994	3937.1	70.87	9-Feb-15	ALS	Cs137-12/16

Th-230 Ringed Planchet Efficiency Calibration  
LB4100-A

Date: 12/7/2016

Source ID: 628

Det ID	A1	A2	A3	A4	B1	B2	B3	B4
File Name	ETH1207A	ETH1207A	ETH1207A	ETH1207A	ETH1207B	NA	ETH1207B	ETH1207B
Cnt Time	7.52	7.75	7.35	7.5	7.22	NA	7.39	7.64
Tot Cnts	10008	10009	10011	10011	10010	NA	10000	10001
Bkg CPM	0.122	0.156	0.124	0.095	0.105	NA	0.134	0.158
CPM	1330.7291	1291.3279	1361.9168	1334.705	1386.3216	NA	1353.046	1308.8734
Alpha EFF	0.2281997	0.221443	0.2335479	0.22888153	0.237733	NA	0.2320267	0.2244518
Beta EFF	0.0643288	0.0666528	0.0680612	0.06615498	0.0771242	NA	0.0679839	0.0654528
Efficiency	0.2282	0.2214	0.2335	0.2289	0.2377	NA	0.2320	0.2245

Det ID	C1	C3	C2	C4	D1	D2	D3	D4
File Name	ETH1207C	ETH1207C	NA	NA	NA	NA	NA	NA
Cnt Time	7.56	7.31	NA	NA	NA	NA	NA	NA
Tot Cnts	10005	10016	NA	NA	NA	NA	NA	NA
Bkg CPM	0.124	0.115	NA	NA	NA	NA	NA	NA
CPM	1323.2887	1370.0628	NA	NA	NA	NA	NA	NA
Alpha EFF	0.2269238	0.2349449	NA	NA	NA	NA	NA	NA
Beta EFF	0.071381	0.071137	NA	NA	NA	NA	NA	NA
Efficiency	0.2269	0.2349	NA	NA	NA	NA	NA	NA

	A1	A2	A3	A4	B1	B3	B4	C1	C3
		0	1	2	3	4	6	7	8
offset		0	1	2	3	0	1	2	0
NumRecs		1	1	1	1	1	1	1	1
total time	7.52	7.75	7.75	7.35	7.5	7.22	7.39	7.64	7.56
total counts	10008	10009	10011	10011	10011	10010	10000	10001	10005
reduced chi	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
chi-square	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CPM	1330.729	1291.328	1361.917	1334.705	1386.322	1353.046	1308.873	1323.289	1370.063
CPM var	354.0915	333.4363	370.8273	356.1425	384.2438	366.2193	342.6957	350.1968	375.1777
Efficiency	0.2282	0.221443	0.233548	0.228882	0.237733	0.232027	0.224452	0.226924	0.234945
archived ST	0.00559	0.005424	0.00572	0.005606	0.005823	0.005684	0.005498	0.005558	0.005754
predicted S	0.002281	0.002214	0.002334	0.002288	0.002376	0.00232	0.002245	0.002269	0.002348
actual STD	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
total counts	2837	3028	2934	2909	3261	2946	2930	3162	3045
reduced chi	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
chi-square	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CPM	375.1286	388.6807	396.8937	385.7777	449.744	396.4428	381.6829	416.253	414.8297
CPM var	64.40233	65.68159	70.24775	66.7617	82.95885	69.83822	64.90702	72.82024	74.33728
Efficiency	0.064329	0.066653	0.068061	0.066155	0.077124	0.067984	0.065453	0.071381	0.071137
archived ST	0.001884	0.001926	0.00198	0.001927	0.002195	0.001975	0.001903	0.002044	0.002052
predicted S	0.001211	0.001214	0.00126	0.00123	0.001353	0.001256	0.001212	0.001272	0.001292
actual STD	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Cs-137 Ringed Planchet Efficiency Calibration  
LB4100-A

Date: 12/7/2016

Source ID: 629

Det ID File Name	A1 ECS1207A	A2 ECS1207A	A3 ECS1207A	A4 ECS1207A	B1 ECS1207B	B2 NA	B3 ECS1207B	B4 ECS1207B
Cnt Time	6.72	6.67	6.56	6.75	6.2	NA	6.35	6.69
Tot Cnts	10015	10015	10019	10006	10008	NA	10011	10022
Bkg CPM	2.132	2.029	2.290	2.089	1.918	NA	2.204	1.825
CPM	1488.195381	1499.47025	1524.9966	1480.28137	1612.27555	NA	1574.33143	1496.2318
Alpha EFF	0.001071469	0.000832437	0.0005325	0.00056352	0.00155309	NA	0.00014488	0.0002741
Beta EFF	0.394236559	0.397223375	0.4039855	0.39214006	0.42710674	NA	0.41705499	0.3963657
<b>Efficiency</b>	<b>0.3942</b>	<b>0.3972</b>	<b>0.4040</b>	<b>0.3921</b>	<b>0.4271</b>	<b>NA</b>	<b>0.4171</b>	<b>0.3964</b>

Det ID File Name	C1 ECS1207C	C3 ECS1207C	C2 NA	C4 NA	D1 N.A.	D2 N.A.	D3 N.A.	D4 N.A.
Cnt Time	6.66	6.32	NA	NA	N.A.	N.A.	N.A.	N.A.
Tot Cnts	10003	10010	NA	NA	N.A.	N.A.	N.A.	N.A.
Bkg CPM	2.001	1.723	NA	NA	N.A.	N.A.	N.A.	N.A.
CPM	1499.950952	1582.137759	NA	NA	N.A.	N.A.	N.A.	N.A.
Alpha EFF	0.001200211	0.000682107	NA	NA	N.A.	N.A.	N.A.	N.A.
Beta EFF	0.397350495	0.419122519	NA	NA	N.A.	N.A.	N.A.	N.A.
<b>Efficiency</b>	<b>0.3974</b>	<b>0.4191</b>	<b>NA</b>	<b>NA</b>	<b>N.A.</b>	<b>N.A.</b>	<b>N.A.</b>	<b>N.A.</b>

	A1	A2	A3	A4	B1	B3	B4	C1	C3
		0	1	2	3	4	6	7	8
offset		0	1	2	3	0	1	2	0
NumRecs		1	1	1	1	1	1	1	1
total time	6.72	6.67	6.67	6.56	6.75	6.2	6.35	6.69	6.32
total counts	28	22	22	14	15	37	12	47	31
reduced chi	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!
chi-square	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!
CPM	4.044667	3.142351	2.010146	2.127222	5.862742	1.755764	6.867411	4.530655	2.574873
CPM var	0.621898	0.495749	0.325907	0.329807	0.966205	0.298092	1.05523	0.701188	0.426451
Efficiency	0.001071	0.000832	0.000533	0.000564	0.001553	0.000465	0.001819	0.0012	0.000682
archived ST	0.00021	0.000187	0.000152	0.000152	0.000262	0.000145	0.000274	0.000223	0.000173
predicted S	0.000206	0.000182	0.000147	0.000149	0.000258	0.000139	0.000268	0.000218	0.000169
actual STD	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!
total counts	10015	10015	10015	10019	10006	10008	10011	10022	10010
reduced chi	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!
chi-square	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!
CPM	1488.195	1499.47	1524.997	1480.281	1612.276	1574.331	1496.232	1499.951	1582.138
CPM var	443.8846	450.5644	466.0808	439.3547	520.9178	496.8219	448.344	451.1063	501.4741
Efficiency	0.394237	0.397223	0.403986	0.39214	0.427107	0.417055	0.396366	0.39735	0.419123
archived ST	0.009028	0.009096	0.009251	0.008981	0.009781	0.009551	0.009076	0.0091	0.009597
predicted S	0.003942	0.003972	0.004039	0.003923	0.004272	0.004171	0.003962	0.003976	0.004191
actual STD	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!	#DIV/O!

Date 12/2/16SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100A**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									OL
7									P
8									
9									
10									OL
11									P
12									OL
13	OL				OL				
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKAD201W			
Dr B				
Dr C				
Dr D	OL			

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	0	Dr A	10
		Dr B	
Tank 2	2050	Dr C	
		Dr D	

Comments:

Date 12/7/16

SOP 724r 11

# ALS

# Low Background Gas Flow Proportional Counter Log

**Instrument: LB4100A**

[illegible]

Comments:

Page No.: 468567 **B**  
(cont. from page 11 **B**)

Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 12/3/16

Date 12/8/16SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100A**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									α
7									P
8									
9									
10									α
11									P
12									OL
13	OL				OL				
14									
15									
16									

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib: File ID	Weekly Calib. Started	Status	File ID
Dr A	BKA7201W			
Dr B				
Dr C				
Dr D	OL			

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	0	Dr A	10
		Dr B	
Tank 2	1600	Dr C	
		Dr D	

Comments:

Continued from Page \_\_\_\_\_

8:01 12/16/16

Am 241 Mass Attn Curve

Filename: AAM1206

Benchsheet: AB121109-1

Source: 1223001-1-4, 714, 16-19

6, 8-14

JP 12/16/16

Def	8:23	8:52	9:20	9:50	10:21	10:51	11:26	11:57	12:26	12:55	13:23	13:49	14:15	14:39	14:57		
A1	1	19	18	17	16	14	13	12	11	10	9	8	7	4	3	2	
A2	2	1	19	18	17	16	14	13	12	11	10	9	8	7	6	4	3
A3	3	2	1	19	18	17	16	14	13	12	11	10	9	8	7	6	4
A4	4	3	2	1	19	18	17	16	14	13	12	11	10	9	8	7	6
B1	7	6	4	3	2	1	19	18	17	16	14	13	12	11	10	9	8
B3	8	7	6	4	3	2	1	19	18	17	16	14	13	12	11	10	9
B4	9	8	7	6	4	3	2	1	19	18	17	16	14	13	12	11	10
C1	10	9	8	7	6	4	3	2	1	19	18	17	16	14	13	12	11
C2	11	10	9	8	7	6	4	3	2	1	19	18	17	16	14	13	12
C3																	

JP 12/16/16

12/7/16

## Gross Alpha (Th-230) EFF Calibration

Benchsheet: AB150603-5 Source ID: 628

Logfile: Th-230-12/16

Sources	Detectors	Filename
1518003-1	A1 B1 C1	ETH1207A
-2	A2 B3 C3	B
-3	A3 B4	C
-4	A4	

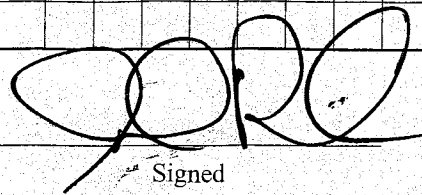
## Gross Beta (Cs-137) EFF Calibration

Benchsheet: AB150310-2 Source ID: 629

Logfile: Cs137-12/16

Sources	Detectors	Filename
1515003-1	A1 B1 C1	ECS1207A
-3	A2 B3 C3	B
-4	A3 B4	C
-5	A4	

Continued on Page

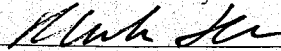


Signed

12/8/16

Date

Read and Understood By



Signed

12-12-16

96 of 348

Date

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-5

Prep Procedure: GROSS\_ALPHA

Base Efficiency

Analytical QASS / NCR? Y N

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes
1	1518003-1	SMP	200	200	ml	pCi/l											
1	1518003-2	SMP	200	200	ml	pCi/l											
1	1518003-3	SMP	200	200	ml	pCi/l											
1	1518003-4	SMP	200	200	ml	pCi/l											
1	1518003-5	SMP	200	200	ml	pCi/l											

See Maintenance Log #3974 pg 38

Mr Zlish

Other

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPM/ml	06/03/15	5	ml	RS-027

## Sample Barcodes

1518003-1 AB150603-SPS1		1518003-2 AB150603-SPS2		1518003-3 AB150603-SPS3	
1518003-4 AB150603-SPS4		1518003-5 AB150603-SPS5			

## Reporting Units

LabID:	TstGrpName:	RptUnits:
1518003-1	GrossAlpha_DW	pCi/l
1518003-2	GrossAlpha_DW	pCi/l
1518003-3	GrossAlpha_DW	pCi/l
1518003-4	GrossAlpha_DW	pCi/l
1518003-5	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Procedure: GROSS\_ALPHA

Prep Batch: AB150603-5

Reviewed By: jkb *3/6/15* Review Date: 6/8/2015

Non-Routine Pre-Treatment? Y *(N)* Batch: *NA* Prep QASS / NCR? Y *(N)* *NA*

Prep SOP: PAI 702 Rev: 20  
Prep SOP: NONE  
Matrix Class: liquid  
Prep Analyst: Jennie Kill-Bowden  
Prep Date: 6/3/2015  
Prep Dept: RS

Balance:  
Balance:

Prep Notes

Samp Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards
1	1518003-1	SMP	200	200	200	Unfiltered	S1
2	1518003-2	SMP	200	200	200	Unfiltered	S1
3	1518003-3	SMP	200	200	200	Unfiltered	S1
4	1518003-4	SMP	200	200	200	Unfiltered	S1
5	1518003-5	SMP	200	200	200	Unfiltered	S1

Comments

Zero Mass Efficiency for Th-230 USGS method

Spiked By: Jennie Kill-Bowden Date: 6/4/2015

Witnessed By: Dayna K. Lewis Date: 6/4/2015

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPM/ml	06/03/15	5	ml	RS-027

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-5

Prep Procedure: GROSS\_ALPHA

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch:

Re-Prep? Y / N Batch:

Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden *JKB*

Prep Date: 6/3/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1518003-1	SMP	200	200	200	Unfiltered	S1	
2	1	1518003-2	SMP	200	200	200	Unfiltered	S1	
3	1	1518003-3	SMP	200	200	200	Unfiltered	S1	
4	1	1518003-4	SMP	200	200	200	Unfiltered	S1	
5	1	1518003-5	SMP	200	200	200	Unfiltered	S1	

Comments

Zero Mass Efficiency for Th-230 USGS method

Spiked By: *JKB* Date: *6/4/15*

Witnessed By: *[Signature]* Date: *6/4/15*

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPM/ml	06/03/15
				5	ml
					RS-027

*ra/13/15*

# Radiochemistry Instrument Worksheet

Prep Batch: AB150603-5

ALS Environmental -- FC

Prep Procedure: GROSS\_ALPHA

Analytical QASS / NCR? Y *NA*

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Ins/Dat	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Ins/Dat	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Ins/Dat	Cnt 3 Pos Chk By	Notes
1	1518003-1	SMP	200	200	ml	pCi/l		AB00609									
1	1518003-2	SMP	200	200	ml	pCi/l		A									
1	1518003-3	SMP	200	200	ml	pCi/l		B									<i>pp 6/6/15</i>
1	1518003-4	SMP	200	200	ml	pCi/l		C									
1	1518003-5	SMP	200	200	ml	pCi/l		D									<i>Other</i>

Spike Solution Information					
Scan #	Nuclide	Soln ID	Prep Conc	Units	Pipet ID
51	Th-230	853.3020.89	1,166.300	DPW/ml	06/03/15
				5	ml
					RS-027

## Sample Barcodes

1518003-1  
AB150603-SPS1

1518003-2  
AB150603-SPS2

1518003-3  
AB150603-SPS3

1518003-4  
AB150603-SPS4

1518003-5  
AB150603-SPS5

## Reporting Units

LabID	TestName	RptUnits
1518003-1	GrossAlpha_DW	pCi/l
1518003-2	GrossAlpha_DW	pCi/l
1518003-3	GrossAlpha_DW	pCi/l
1518003-4	GrossAlpha_DW	pCi/l
1518003-5	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

Prep Batch: AB150603-5

ALS Environmental -- FC

Reviewed By: jkb 3/6/15 Review Date: 6/8/2015

Prep Procedure: GROSS\_ALPHA

Non-Routine Pre-Treatment? Y (N) Batch: NA Re-Prep? Y (N) Prep QASS / NCR? Y (N) NA

Prep SOP: PAI 702 Rev: 20  
Prep SOP: NONE  
Matrix Class: liquid

Prep Analyst: Jennie Kil-Bowden  
Prep Date: 6/3/2015  
Prep Dept: RS

Balance:  
Balance:

Sample Num	Prep Num	LabID	QC Type	Dish No.	Inu Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1518003-1	SMP		200	200	Unfiltered	S1	
2	1	1518003-2	SMP		200	200	Unfiltered	S1	
3	1	1518003-3	SMP		200	200	Unfiltered	S1	
4	1	1518003-4	SMP		200	200	Unfiltered	S1	
5	1	1518003-5	SMP		200	200	Unfiltered	S1	

Comments

Zero Mass Efficiency for Th-230 USGS method

Spiked By: Jennie Kil-Bowden Date: 6/4/2015

Witnessed By: Dayna K. Lewis Date: 6/4/2015

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date
S1	Th-230	853 3020.89	1,166,300	DPM/ml	06/03/15
				5 ml	RS-027

# Radiochemistry Prep Worksheet

Prep Batch: AB150603-5

ALS Environmental -- FC

Prep Procedure: GROSS\_ALPHA

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch: Re-Prep? Y / N Batch: Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden *JKB*

Prep Date: 6/3/2015

Prep Dept: RS

Balance:

Balance:

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1518003-1	SMP		200	200	Unfiltered	S1	
2	1	1518003-2	SMP		200	200	Unfiltered	S1	
3	1	1518003-3	SMP		200	200	Unfiltered	S1	
4	1	1518003-4	SMP		200	200	Unfiltered	S1	
5	1	1518003-5	SMP		200	200	Unfiltered	S1	

Comments

Zero Mass Efficiency for Th-230 USGS method

Spiked By: *JKB* Date: *6/4/15*

Witnessed By: *JKB* Date: *6/4/15*

Spike Solution Information					
Soln #	Isotope	SolnID	Prep Conc	Units	Prep Date
S1	Th-230	853.3020.89	1.166	300 DPM/ml	06/03/15
				5 ml	RS-027

*ra/13/15*

# PAJ - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
 Counting Unit ID: Magerita  
 High Voltage Mode: Simultaneous  
 Application Revision: Standard  
 Rev.120100a JCF

Background logfiles: BKCADW  
 Date of Bkg. Cal: 08/20/15  
 Alpha activity logfiles: TH230-06/15  
 Alpha activity calibration: AT18019, 06/20  
 Beta activity logfiles: Ca-137-03/15  
 Beta activity calibration: ACS3312

Alpha prog. logfiles: n/a  
 Alpha prog. attenuation: n/a  
 Beta prog. logfiles: n/a  
 Beta prog. attenuation: n/a

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity						Beta Activity								
					Gross			Bkg. a>b x10k			Base			Bkg. a>b x10k			Base		
					CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM
A1	1518003-1	6/9/2015 8:58	10.00	0.0	1379.300	0.124	1.223	0.2386	0.937	0.4155	0.0449	0.4155	0.0449	0.4155	0.0449	0.4155	0.0449		

JP 6/9/15

# PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev: 12/01/04 JCP  
Data file name: ASC0809A  
Batch ID: TH230 OUTLIER  
Count Preset Int: 10  
2  
Batch Ended: 6/5/2015 9:10

Background Logfile: BKGABW  
Data of Bkg. Cal: 6/5/2015  
Alpha efficiency logfile: TH230-06/13  
Alpha prop. logfile: n/a  
Alpha attenuation logfile: AT165-06/20  
Alpha prop. attenuation: n/a  
Beta efficiency logfile: C1-137-05/16  
Beta prop. attenuation: n/a  
Beta attenuation calibration: ACS0312

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^a$ (a: mass, b: eff)		$y = b \cdot m^a$ (a: mass, b: eff)	
Alpha B=	0.93740	Beta B=	0.9494
n=	0.99990	n=	0.9913
a=	0.5206	a=	1.0468
z=	0.0080	z=	0.0000
Alpha to Beta Ratio		Beta to Alpha Ratio	
$y = b \cdot m^a$ (a: mass, b: eff)		$y = b \cdot m^a$ (a: mass, b: eff)	
Alpha to Beta B=	0.2527	Beta to Alpha B=	0.3456
Alpha to Beta n=	0.9973	Beta to Alpha n=	0.9822

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity										Beta Activity									
					Gross CPM	Bkg. CPM	b <sub>2</sub> a xlik CPM	Base EN	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.	Gross CPM	Bkg. CPM	a <sub>2</sub> b xlik CPM	Base EN	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.						
A1	151803-2	6/5/2015 9:10	10.00	0.0	1319.700	0.124	1.210	0.2386	0.937	n/a	n/a	376.700	1.476	333.058	0.4155	0.949	n/a	n/a						

6/9/15  
JCP

Alphas Attenuation Calibration	Betas Attenuation Calibration
$y = b \cdot \ln^2(x/a)$	$y = b \cdot \ln^2(x/a + c)$
Alpha fit	Beta fit
$a = 0.92040$	$a = 0.9434$
$b = 0.8248$	$b = 0.9993$
$c = 0.0000$	$c = 0.0000$
$\sigma^2 = 0.0000$	$\sigma^2 = 0.0000$
Alpha to Beta Ratio	Beta to Alpha Ratio
$y = b \cdot \ln^2(x/a)$	$y = b \cdot \ln^2(x/a + c)$
$a \rightarrow b$ ratio	$b \rightarrow a$ ratio
$0.9277$	$-3.5628$
$0.9974$	$0.0032$

Background logfile: BKCA3W  
Date of Bkg. Cal: 15/2015  
Alpha efficiency logfile: 11230-0413  
Alpha attenuation calibration: ATTH015 0420  
Beta efficiency logfile: C3-157-0315  
Beta attenuation calibration: AC0302

Det. ID	Sample ID	Count End Date & Time	Dur. (min)	Resid. Mass (mg)	Alpha Activity										Beta Activity									
					Gross		Bkg.		b-a xlik		Base		Progeny		Gross		Bkg.		a+b xlik		Base		Progeny	
					CPM	Eff	CPM	Eff	CPM	Eff	CPM	Con.Fact.	Eff	Con.Fact.	CPM	Eff	CPM	Con.Fact.	Eff	Con.Fact.	CPM	Eff	CPM	Con.Fact.
A1	S80915-24	10.00	6.0	1213.000	0.124	1.242	0.2368	n/a	n/a	n/a	n/a	389.590	1.476	350.6774	0.4155	0.948	n/a	n/a	n/a	n/a	n/a			
A1	S158003-3	10.00	6.0	1213.000	0.124	1.242	0.2368	n/a	n/a	n/a	n/a	389.590	1.476	350.6774	0.4155	0.948	n/a	n/a	n/a	n/a	n/a			

May 19/15

# PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
 Counting Unit ID: Magenta  
 High Voltage Mode: Simultaneous  
 Application Revision: Standard  
 Rev: 1207188 ICP

Data file name: ABC0605C  
 Batch ID: TH230 OUTLIER  
 Count Preset (nt): 10  
 2 Batch Ended: 6/6/2015 9:47

Background log file: BKGARW  
 Date of Bkg. Cal: 6/6/2015  
 Alpha efficiency log file: TH230-06/13  
 Alpha attenuation calibration: A1H0619\_0630  
 Beta efficiency log file: Ca-137-03/15  
 Beta attenuation calibration: ACS06112

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot \ln(x) / (\ln(10) \cdot \ln(2))$		$y = b \cdot \ln(x) / (\ln(10) \cdot \ln(2))$	
Alpha b = 0.93740		Beta b = 0.9494	
m = 0.99500		m = 0.9983	
a = 0.9364		a = 1.0483	
x0 = 0.0080		x0 = 0.0003	
Alpha to Beta X-44k		Beta to Alpha X-44k	
$y = b \cdot \ln(x) / (\ln(10) \cdot \ln(2))$		$y = b \cdot \ln(x) / (\ln(10) \cdot \ln(2))$	
a -> b x44k m = 0.2557		b -> a x44k m = -1.58246	
a -> b x44k m = 0.9373		b -> a x44k m = 2.6032	

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity						Beta Activity					
					Gross CPM	Bkg. CPM	B>A x44k CPM	Base EH	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.	Gross CPM	Bkg. CPM	B>A x44k CPM	Base EH	Base Cor.Fact.
A1	1518003.4	6/6/2015 9:47	10.00	0.0	1348.500	0.124	1.276	0.2386	0.037	na	na	401.100	1.476	340.7348	0.4155	0.948
										na	na					na

TH230/15

# PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
Counting Unit ID: M-gentia  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev.12/01/04 JCP

Data file name: AEC0609D  
Batch ID: T1230 OUTLIER  
Count Preset (mg): 10  
Batch Endid: 0002015 10:01

Background logfiles: BKGADBW  
Date of Bkg. Cal: 08/20/15  
Alpha efficiency logfile: T1230-09/15  
Alpha attenuation calibration: ATH0019.DC20  
Alpha prog. logfiles: n/a  
Alpha prog. standard: n/a  
Beta efficiency logfile: C-137-02/15  
Beta attenuation calibration: ACS0012  
Beta prog. logfiles: n/a  
Beta prog. standard: n/a

Alpha Attenuation Calibration	Beta Attenuation Calibration
$y = b \cdot m^a$ (a: mass, b: cfi)	$y = b \cdot m^a$ (a: mass, b: cfi)
Alpha b= 0.31740	Beta b= 0.3434
m= 0.96090	m= 0.9933
a= 0.9208	a= 1.0164
sd= 0.0000	sd= 0.0000
Alpha to Beta Ratio	Beta to Alpha Ratio
$y = b \cdot m^a$ (a: mass, b: cfi)	$y = b \cdot m^a$ (a: mass, b: cfi)
g->b ratio b= 0.2537	b->g ratio b= -3.54E-06
g->b ratio m= 0.9878	b->g ratio m= 0.9832

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity						Beta Activity					
					Gross CPM	Bkg. CPM	p-a xlik CPM	Base Eff	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.	Gross CPM	Bkg. CPM	a-b xlik CPM	Base Eff	Base Cor.Fact.
A1	1818003-5	6/02/2015 10:01	10.00	0.0	1268.800	0.124	1.184	0.2366	0.837	n/a	n/a	374.580	1.476	320.1143	0.4155	0.849

MCP/9/15

Date 6/9/15

SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK00605W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

	P-10 Supply		P-10 Flow
Tank 1	1850	Dr A	0.1
		Dr B	
Tank 2	1200	Dr C	
		Dr D	

Comments:

Page No.: 455204 A

Form 780r8.doc (6/23/06)

Reviewed By / Date J 6/9/15

Date

6/9/15

SOP 724r/11

ALS

Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Daily EFP	==	==	30	7:13	JP	EFC0609	JP
1-16	Daily Bkg	==	==	60	7:22	JP	BK0609	JP
1	1518003-1	AB1506035	Th230	10	8:47	JP	AB0609	JP
	-2		Outlier		9:00	JP	A	
	-3				9:13	JP	B	
	-4				9:37	JP	C	
	-5				9:51	JP	D	
1-4	1067	AB1506035	Th230	30	10:15	JP	ETH0609	JP
5-8			Eff		10:23		B	
9-12			Cal		10:37		C	
13-16			Mass Ath		10:51		D	
1-16	1518004-1-16	AB1506036	Th230	30	11:01	JP	ATH0609	JP
1	1505092-1	SR1506051	SR90	180	16:03	JP	SR0609	JP
2	-3							
3	-30							
4	1505234-1							
5	-3							
6	-5							
7	-7							
8	-9							
9	-11							
10	-13							
11	-130							
12	1505235-1							
14	-3							
15	-30							
16	1505249-1							
1	-2	SR1506051	SR90	180	22:12	JP	SR0609	
2	1505344-1							
3	427-1							
4	-3							
5	SR1506051MB							
6	101							
7	1505379-8	AB1506051	917	120	22:13	JP	AB0609	
8	-80							
9	-10							
10	AB1506051CS							
11	1505341-1	AB1506052		480	22:15		AB0609	
12	-10							
14	1505448-1							
15	-4							

Comments:

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 (cont. from page 11 B)

Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 6/10/15

Date

6/10/15

SOP 724r

11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	P	P			P	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKC 010512			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

	P-10 Supply		P-10 Flow
Tank 1	1500	Dr A	0.1
		Dr B	
Tank 2	1200	Dr C	
		Dr D	

Comments:

Page No.: 455205

A

Form 780r8.doc (6/23/06)

Reviewed By / Date

JPC/w/15

Prepare an Intermediate dilution of Th-230 P50 # 853  
of approximately 1200 dpm/ml

1) Prepare 0.5M  $\text{HNO}_3$ , 31 ml  $\text{HNO}_3$  and 969 ml DI water,  
lot # 073602

2) Determine density of 0.5M  $\text{HNO}_3$

Mass of 100 ml vol. flask:

Cal. 12

68.2999g

Mass of flask + 100 ml 0.5M  $\text{HNO}_3$ :

107.4529g

Net mass of 0.5M  $\text{HNO}_3$ :

101.153g

$$\rho = 1.015 \text{ g/ml}$$

3) Transfer contents of vial to 1000 ml Nalgene

Cal. 14

Mass of full standard vial:

81.2827

Mass of empty standard vial:

3.2327

Net mass of standard transferred:

5.05g

4) Dilute with 0.5M  $\text{HNO}_3$

Mass of Nalgene w/ lid (empty):

73.66g

Mass of Nalgene with standard:

73.73g

Mass of Nalgene, standard, and diluent:

78.71g

Net mass of standard:

1085.2

1011.54g

5) Final activity calculation

$$(1.983 \times 10^4 \text{ Bq}) (5.1519 \text{ g}) = 3849.60 \text{ Bq/g} \times \left( \frac{60 \text{ s}}{1 \text{ min}} \right) = 230,976.755 \text{ dpm}$$

$$(3849.60 \text{ Bq/g}) \cdot \left( \frac{5.05 \text{ g}}{1011.54 \text{ g}} \right) \cdot (1.015 \text{ g/ml}) = 1166.38 \text{ dpm/ml}$$

Std ID: 853.3020.89

Description: Th-230

Expiration: 2/5/2009

Activity: 1166.38 dpm/mL

2s Uncertainty: 23.33 dpm/mL

Ref. Date: 11/6/2007

Ref Time: N/A

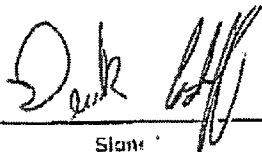
Prep Date: 12/12/2007 Prep by: DC

Matrix/Comp. 0.5 M  $\text{HNO}_3$

Half Life (y): 7.70E+04

Reverification Log		
Analysis Date	Initials	Expiration Date
5/5/09	RG	5/5/2010
11/19/10	RG	11/19/2011
12/13/14	JP	12/13/2015

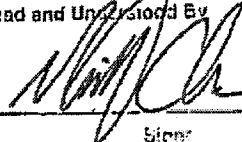
Continued on Page

Sign: 

12/12/07

Use:

Read and Understood By



Sign:

2/13/08



Eckert & Ziegler

Analytics

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.analyticsinc.com

CERTIFICATE OF CALIBRATION  
Standard Radionuclide Source

76253-307

Th-230 5 mL Liquid in Flame Sealed Vial

Customer: Paragon Analytics / Fort Collins, CO  
P.O. No.: 72809-REL 10-30-07, Item 1

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.18, Revision 1.

Isotope:	Th-230
Activity (Bq):	1.983 E4
Half-Life:	7.538 E4 years
Calibration Date:	November 8, 2007 12:00 EST
Relative Expanded Uncertainty (k=2):	2.0%

Comments:

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%,  
5.16119 grams 0.5M HNO<sub>3</sub> solution.

Source Prepared By: N. E. Klesman  
N. E. Klesman, Radiochemist

QA Approved: D. M. Montgomery  
D. M. Montgomery, QA Manager

Date: 11-19-07

End of Certificate

Corporate Office  
24937 Avenue Tibbitts Valencia, California 91355

Laboratory  
1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

# Radiochemistry Instrument Worksheet

Prep Batch: AB150310-2

ALS Environmental -- FC W 3/10/15

Prep Procedure: GROSS ~~ALPHA~~ BETA BASE EFFICIENCY

Analytical QASS / NCR? Y N

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Ins/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Ins/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Ins/Det	Cnt 3 Pos Chk By	Notes
1	1515003-1	SMP	200	200	ml	pCi/l	0										
1	1515003-2	SMP	200	200	ml	pCi/l	0										
1	1515003-3	SMP	200	200	ml	pCi/l	0										
1	1515003-4	SMP	200	200	ml	pCi/l	0										
1	1515003-5	SMP	200	200	ml	pCi/l	0										

Sec Narehena Log 3974 pg 38

Outlier

M 2/15/17

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Pipet ID
S1	Cs-137	1019.4095.83	3.929.815	DPM/ml	03/10/15	1 ml RS-005

## Sample Barcodes

1515003-1 AB150310-2PS1		1515003-2 AB150310-2PS2		1515003-3 AB150310-2PS3	
1515003-4 AB150310-2PS4		1515003-5 AB150310-2PS5			

## Reporting Units

LabID	TestGrpName	RptUnits
1515003-1	GrossAlpha_DW	pCi/l
1515003-2	GrossAlpha_DW	pCi/l
1515003-3	GrossAlpha_DW	pCi/l
1515003-4	GrossAlpha_DW	pCi/l
1515003-5	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-2

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb

Review Date: 3/10/2015

Non-Routine Pre-Treatment? Y ☒ Batch: AA Re-Prep? Y ☒ Prep QASS / NCR? Y ☒ NA

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1515003-1	SMP		200	200	As Received	S1	
2	1	1515003-2	SMP		200	200	As Received	S1	
3	1	1515003-3	SMP		200	200	As Received	S1	
4	1	1515003-4	SMP		200	200	As Received	S1	
5	1	1515003-5	SMP		200	200	As Received	S1	

Comments

Cs-137 efficiencies

Spiked By: Jennie Kill-Bowden Date: 3/10/2015

Witnessed By: Dayna K. Lewis Date: 3/10/2015

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Cs-137	1019.4095.83	3,929.815	DPM/ml	03/10/15
				1	ml
					RS-005

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-2

Prep Procedure: GROSS\_ALPHA

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch: Re-Prep? Y / N Batch: Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1515003-1	SMP	200	200	200	As Received	S1	
2	1	1515003-2	SMP	200	200	200	As Received	S1	
3	1	1515003-3	SMP	200	200	200	As Received	S1	
4	1	1515003-4	SMP	200	200	200	As Received	S1	
5	1	1515003-5	SMP	200	200	200	As Received	S1	

Comments

Cs-137 efficiencies

Spiked By:

Date:

3/10/15

Witnessed By:

Date:

3/10/15

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Cs-137	1019.4095.83	3.929.815	DPM/ml	03/10/15
				ml	RS-005

exp. 3/5/16

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC JP 3/15

Prep Batch: AB150310-2

Prep Procedure: GROSS ALPHA BETA

BASE EFFICIENCY

OUTLIER

Analytical QASS / NCR? Y NA

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cat 1 File	Cat 1 InsIDet	Cat 1 Pos Chk By	Cat 2 File	Cat 2 InsIDet	Cat 2 Pos Chk By	Cat 3 File	Cat 3 InsIDet	Cat 3 Pos Chk By	Notes
1	1515003-1	SMP	200	200	ml	pCi/l	0	ABC031Z			JP						
1	1515003-2	SMP	200	200	ml	pCi/l	0				A						OUTLIER
1	1515003-3	SMP	200	200	ml	pCi/l	0				B						
1	1515003-4	SMP	200	200	ml	pCi/l	0				C						
1	1515003-5	SMP	200	200	ml	pCi/l	0				D						

JP 4/2/10

## Spill Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1019.4095.83	3.929.815	DPM/ml	03/10/15	1	ml	RS-005

## Sample Barcodes

1515003-1 AB150310-2PS1	1515003-2 AB150310-2PS2	1515003-3 AB150310-2PS3
1515003-4 AB150310-2PS4	1515003-5 AB150310-2PS5	

## Reporting Units

Sample	Reporting Units
1515003-1 GrossAlpha_DW	pCi/l
1515003-2 GrossAlpha_DW	pCi/l
1515003-3 GrossAlpha_DW	pCi/l
1515003-4 GrossAlpha_DW	pCi/l
1515003-5 GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental - FC

Prep Batch: AB150310-2

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb Review Date: 3/10/2015

Non-Routine Pre-Treatment? Y ☒ Batch: AA Re-Prep? Y ☒ Prep QASS / NCR? Y ☒ NA

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Balance:

Balance:

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1515003-1	SMP		200	200	As Received	S1	
2	1	1515003-2	SMP		200	200	As Received	S1	
3	1	1515003-3	SMP		200	200	As Received	S1	
4	1	1515003-4	SMP		200	200	As Received	S1	
5	1	1515003-5	SMP		200	200	As Received	S1	

Comments

Cs-137 efficiencies

Spiked By: Jennie Kill-Bowden Date: 3/10/2015

Witnessed By: Dayna K. Lewis Date: 3/10/2015

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date
S1	Cs-137	1019.4095.83	3.929.815	DPM/ml	03/10/15
				1	ml
					RS-005

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-2

Prep Procedure: GROSS\_ALPH

**Prep Batch Not Validated!!!**

Reviewed By: \_\_\_\_\_ Review Date: \_\_\_\_\_

Non-Routine Pre-Treatment? Y / N Batch: \_\_\_\_\_

Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Balance:

Balance:

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1515003-1	SMP		200	200	As Received	S1	
2	1	1515003-2	SMP		200	200	As Received	S1	
3	1	1515003-3	SMP		200	200	As Received	S1	
4	1	1515003-4	SMP		200	200	As Received	S1	
5	1	1515003-5	SMP		200	200	As Received	S1	

Comments

Cs-137 efficiencies

Spiked By: SKS

Date: 3/10/15

Witnessed By: SKS

Date: 3/10/15

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Cs-137	1019.4095.83	3.929.815	DPM/ml	03/10/15
				1	ml
					RS-005

exp: 3/5/16

**OUTLIER TEST**

FILE	DET	SAMPLE ID	Beta CPM	Relative % diff. from mean	Within acceptability range	Outlier?
ABC0312	A1(1)	1515003-1	1620.1	0.64%	YES	NO
ABC0312A	A1(1)	1515003-2	1587.29	1.41%	YES	OUTLIER!
ABC0312B	A1(1)	1515003-3	1625.29	0.95%	YES	NO
ABC0312C	A1(1)	1515003-4	1622.57	0.79%	YES	NO
ABC0312D	A1(1)	1515003-5	1594.29	0.97%	YES	NO

**Mean of all five planchets:**

Average= 1609.91

Std dev= 17.7299

2 Std Dev= 35.46

Acceptability range

1645.37

1574.45

Relative range

+/- 1.49%

**2.20%****Sample 1515003-2 rejected as outlier.**

Criteria: Potential outliers fall outside acceptability range; which is the mean of all five measurements +/- 2 std dev per the Grubbs statistical test.

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^a (a'(\text{mass} \cdot x_0))$		$y = b \cdot m^a (a'(\text{mass} \cdot x_0))$	
Alpha b=	0.90570	Beta b=	0.9782
m=	0.99140	m=	0.9993
a=	0.8487	a=	1.0249
x0=	21.4875	x0=	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b' \cdot m'^{a'}(\text{mass} \cdot x_0)$		$y = b' \cdot m'^{a'}(\text{mass} \cdot x_0)$	
a -> b xtalk b=	0.2510	b -> a xtalk b=	-1.82E-05
a -> b xtalk m=	0.9987	b -> a xtalk m=	0.0032

Background logfile: BKGABW  
Date of Bkg. Cal: 3/12/2015  
Alpha efficiency logfile: Am241R-06/13  
Alpha attenuation calibration: AAM0610, 0611  
Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta efficiency logfile: Sr90R-06/13  
Beta attenuation calibration: ASR0611  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev.12/01/08 JCP  
Data file name: ABC0312  
Batch ID: AB150310-2 OUTLIER  
Count Preset (mj): 7  
Batch Ended: 3/12/2015 7:20  
2

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity			
					Gross CPM	Bkg. CPM	a>b xtlk CPM	a>b xtlk CPM	Base Eff	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.
A1	1515003-1	3/12/2015 7:20	7.00	0.0	3.000	0.109	5.180	0.2102	1.060	0.4355	0.978	n/a

JP 3/12/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100 -C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev:12/01/08 JCP

Data file name: ABC0312A  
Batch ID: AB150310-2 OUTLIER  
Count Preset (m): 7  
Batch Ended: 3/12/2015 7:33

Background logfile: BKGABW  
Date of Bkg Cal: 3/12/2015  
Alpha efficiency logfile: Am241R-06/13  
Alpha attenuation calibration: AAM0610, 0611  
Beta efficiency logfile: SR0R-06/13  
Beta attenuation calibration: ASR0611

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b'm^*(a'(m_{\text{mass}}-x_0))$		$y = b'm^*(a'(m_{\text{mass}}-x_0))$	
Alpha b=	0.90570	Beta b=	0.9782
m=	0.99140	m=	0.9993
a=	0.8487	a=	1.0249
x0=	21.4875	x0=	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b'm^*(m_{\text{mass}} - x_0)$		$y = b'm^*(m_{\text{mass}} - x_0)$	
a -> b xtalk b=	0.2510	b -> a xtalk b=	-1.82E-05
a -> b xtalk m=	0.9987	b -> a xtalk m=	0.0032

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity				Alpha Attenuation Calibration				Beta Attenuation Calibration			
					Gross CPM	Bkg. CPM	a>b xtalk CPM	Base Cor.Fact. Eff	Progeny Cor.Fact. Eff	Gross CPM	Bkg. CPM	a>b xtalk CPM	Base Cor.Fact. Eff	Progeny Cor.Fact. Eff	Gross CPM	Bkg. CPM	a>b xtalk CPM	Base Cor.Fact. Eff	Progeny Cor.Fact. Eff	Gross CPM
A1	1515003-2	3/12/2015 7:33	7.00	0.0	2.286	0.109	5.075	0.2102	1.060	n/a	n/a	0.5464	0.4355	0.978	1587.286	1.399	0.5464	0.4355	n/a	n/a

JP 3/12/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^a (a'(\text{mass} \rightarrow 0))$		$y = b \cdot m^a (a'(\text{mass} \rightarrow 0))$	
Alpha b = 0.90570		Beta b = 0.9782	
m = 0.99140		m = 0.9993	
a = 0.8487		a = 1.0249	
x0 = 21.4875		x0 = 0.0000	
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b \cdot m^a \cdot \text{mass}$		$y = b \cdot m^a \cdot \text{mass}$	
a $\rightarrow$ b xtalk b = 0.2510		b $\rightarrow$ a xtalk b = -1.82E-05	
a $\rightarrow$ b xtalk m = 0.9987		b $\rightarrow$ a xtalk m = 0.0032	

Background logfile: BKGABW  
Data of Bkg. Cal: 3/12/2015  
Alpha efficiency logfile: Am241R-06/13  
Alpha attenuation calibration: AAM0510\_0611  
Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta efficiency logfile: S90R-06/13  
Beta attenuation calibration: ASR0611  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev.12/01/08 JCP  
Data file name: ABC0312B  
Batch ID: AB150310-2 OUTLIER  
Count Preset (mj): 7  
Batch Ended: 3/12/2015 7:41  
2

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity				Alpha Attenuation Calibration				Beta Attenuation Calibration			
					Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Eff	Progeny Eff	Base Cor.Fact.	Gross CPM	a>b xtlk CPM	Base Eff	Progeny Eff	Base Cor.Fact.	Gross CPM	a>b xtlk CPM	Base Eff	Progeny Eff	Base Cor.Fact.
A1	1515003-3	3/12/2015 7:41	7.00	0.0	4.286	0.109	5.196	0.2102	1.060	n/a	1625.286	1.399	0.4355	0.978	n/a	n/a	n/a	n/a	n/a	n/a

JP 3/12/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100 -C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev.12/01/08 JCP

Data file name: ABC0312C  
Batch ID: AB150310-2 OUTLIER  
Count Preset (m): 7  
Batch Ended: 3/12/2015 7:51

Background logfile: BKGABW  
Date of Bkg. Cal: 3/12/2015  
Alpha efficiency logfile: Am241R-06/13  
Alpha attenuation calibration: AAM0610, 0611  
Beta efficiency logfile: S90R-06/13  
Beta attenuation calibration: ASR0611

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration	Beta Attenuation Calibration
$y = b \cdot m^a (a'(\text{mass} \cdot x_0))$	$y = b \cdot m^a (a'(\text{mass} \cdot x_0))$
Alpha b = 0.90570	Beta b = 0.9782
n = 0.99140	n = 0.9993
a = 0.8487	a = 1.0249
x0 = 21.4875	x0 = 0.0000
Alpha to Beta X-talk	Beta to Alpha X-talk
$y = b \cdot m^a \cdot \text{mass}$	$y = b \cdot m^a \cdot \text{mass} \cdot m$
a -> b xtalk b = 0.2510	b -> a xtalk b = -1.82E-05
a -> b xtalk n = 0.9987	b -> a xtalk n = 0.0032

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity			
					Gross CPM	Bkg. CPM	b-a xtlk CPM	Base Eff	Progeny Eff	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.
A1	1515003-4	3/12/2015 7:51	7.00	0.0	3.571	0.109	5.188	0.2102	1.060	n/a	n/a	n/a
										0.4355	0.978	n/a
										0.8681		n/a
										1622.571	1.389	

JP 3/12/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100 -C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev.12/01/08 JCP

Data file name: ABC0312D  
Batch ID: AB150310-2 OUTLIER  
Count Preset (m): 7  
Batch Ended: 3/12/2015 8:06

Background logfile: BKGABW  
Date of Bkg. Cal: 3/12/2015  
Alpha efficiency logfile: AM241R-06/13  
Alpha attenuation calibration: AAM0610\_0611  
Beta efficiency logfile: SR09R-06/13  
Beta attenuation calibration: ASR0611

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration	Beta Attenuation Calibration
$y = b'm^a(a'(mass-x0))$ Alpha b= m= a= x0=	$y = b'm^a(a'(mass-x0))$ Beta b= m= a= x0=
Alpha to Beta X-talk $y = b'm^a-mass$ a -> b xtalk b= a -> b xtalk m=	Beta to Alpha X-talk $y = b'mass * m$ b -> a xtalk b= b -> a xtalk m=

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity					Beta Activity				
					Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Eff	Progeny Cor.Fact.	Gross CPM	Bkg. CPM	a>b xtlk CPM	Base Eff	Progeny Cor.Fact.
A1	1515003-5	3/12/2015 8:06	7.00	0.0	3.571	0.109	5.097	0.2102	1.060	1594.286	1.399	0.8691	0.4355	0.978

DP 3/12/15

Date 3/12/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			*				P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK0311W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

	P-10 Supply	P-10 Flow	
Tank 1	2100	Dr A	0.1
		Dr B	
Tank 2	1900	Dr C	
		Dr D	

Comments: \* It is not necessary to run daily background checks on the morning following a weekly background calibration.

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Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 3/12/15

Date 3/12/15SOP 724r 11ALS  
Low Background Gas Flow Proportional Counter Log  
Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Dark Eff			30	6:52	JP	EFC0312	JP
1	1515003-1	AB150310-2	B-Q/H	7	7:13	JP	ABC0312	JP
1	-2				7:26	JP	A	JP
1	-3				7:34	JP	B	JP
1	-4				7:44	JP	C	JP
1	-5				7:59	JP	D	JP
1-4	1061		(S) 17 Eff	30	8:20	JP	ECS0312A	JP
5-8			Cal		8:28	JP	B	
9-12					8:36	JP	C	
13-16					8:43	JP	D	
1-16	1515002-1-24	AB150310-1	ATTN (Q/H)	30	8:53	JP	ACS0312	JP
1	1503144-1	AB150311-1	$\alpha$ 1B	240	15:15:42	JP	ABC0312E	JP
2	-10							
3	AB150311-1MB							
4	(L)							
5	1503192-1	AB150312-4		300	15:43	JP	ABC03124F	
6	-10							
7	-2							
8	AB150312-4MB							
9	(L)							
10	1503160-1	AB150311-3		1006	15:44	JP	ABC0312G	
11	-7							
12	-2D							
13	-7			120	15:45		H	
14	AB150311-3MB			1006	15:44		G	
15	(L)			120	15:45		H	

JP 3/12/15

JP 3/12/15

JP 3/13/15

Comments:

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(cont. from page NA **B**)

Form 780r8.doc (6/23/06)

Reviewed By / Date JP 3/13/15

Date

3/13/15

SOP 724r

11

## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

## Instrument Daily Response and Background Checks

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

## Weekly Background Calibration

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	1360311W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

## Gas Supply

P-10 Supply		P-10 Flow	
Tank 1	1850	Dr A	0.1
		Dr B	
Tank 2	1900	Dr C	
		Dr D	

Comments:

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Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 3/13/15

Prepare an intermediate dilution of Th-230 RSO# 853 of approximately 1200 dpm/ml

1) Prepare 0.5 M  $\text{HNO}_3$ . 31 ml  $\text{HNO}_3$  and 969 ml DI water.  
bottle # 073602

2) Determine density of 0.5 M  $\text{HNO}_3$ .

Mass of 100 ml vol. flask:

Mass of flask + 100 ml 0.5 M  $\text{HNO}_3$ :

Net mass of 0.5 M  $\text{HNO}_3$ :

Bal. 12

68.2999 g

169.4529 g

101.153 g

$$\rho = 1.015 \text{ g/ml}$$

3) Transfer contents of vial to 1000 ml Nalgene.

Mass of full standard vial:

Mass of empty standard vial:

Net mass of standard transferred:

81.2827

3.2327

5.05 g

4) Dilute with 0.5 M  $\text{HNO}_3$

Mass of Nalgene w/o lid (empty):

Mass of Nalgene with standard:

Mass of Nalgene, standard, and diluent:

Net mass of standard:

73.66 g

73.70 g

78.71 g

1085.2

1011.54 g

5) Final activity calculation

$$(1.983 \times 10^4 \text{ Bq}) \cdot (5.13119 \text{ g}) = 3849.60 \text{ Bq/g} \cdot \left( \frac{60 \text{ s}}{1 \text{ min}} \right) = 230,975.755 \text{ dpm}$$

$$(3849.60 \text{ Bq/g}) \cdot (5.05 \text{ g}) \cdot (1.015 \text{ g/ml}) = 1165.22 \text{ dpm/ml}$$

Std ID: 853.3020.89

Description: Th-230

Expiration: 2/5/2009

Activity: 1166.38 dpm/mL

2s Uncertainty: 23.33 dpm/mL

Ref. Date: 11/6/2007

Ref Time: N/A

Prep Date: 12/12/2007 Prep by: DC

Matrix/Comp. 0.5 M  $\text{HNO}_3$

Half Life (y): 7.70E+04

#### Reverification Log

Analysis Date	Initials	Expiration Date
5/5/09	RG	5/5/2010
11/19/10	RG	11/19/2011
12/13/14	JP	12/13/2015

Continued on Page

Sign: [Signature]

Date: 12/12/07

Date:

Read and Understood By

Sign: [Signature]

Sign:

Date: 7/13/08



Eckert & Ziegler

Analytics

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.analyticsinc.com

CERTIFICATE OF CALIBRATION  
Standard Radionuclide Source

76253-307

Th-230 5 mL Liquid in Flame Sealed Vial

Customer: Paragon Analytics / Fort Collins, CO  
P.O. No.: 72905-REL 10-30-07, Item 1

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

Isotope:	Th-230
Activity (Bq):	1.983 E4
Half-Life:	7.538 E4 years
Calibration Date:	November 8, 2007 12:00 EST
Relative Expanded Uncertainty (k=2):	2.0%

Comments:

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%.  
5.15119 grams 0.5M HNO<sub>3</sub> solution.

Source Prepared By: N. E. Kiesman  
N. E. Kiesman, Radiochemist

QA Approved: D. M. Montgomery  
D. M. Montgomery, QA Manager

Date: 11-19-07

End of Certificate

Corporate Office  
24937 Avenue Tibbitts Valencia, California 91355

Laboratory  
1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

Prepare a working dilution of RSO\*1019

12/3/15

1. Density of 0.1M HCl, lot # 0000094396

Mass of 100mL vol. flask:

56.4421g

Balance # 12

Mass of flask & 100mL acid:

156.2152g

Balance# 12

Net Mass:

99.7731g

Density:

0.9977g/mL

2. Mass of RSO\*1019 transferred:

Mass of empty nalgene:

74.1899g

Balance# 12

Mass of nalgene & standard

79.0859g

Balance# 12

Net mass of standard transferred:

4.8960g

3. Dilute to final volume:

Mass of nalgene, standard, & diluent:

629.3g

Balance# 26

Mass of empty nalgene:

74.1899g

Balance# 12

Net mass of new dilution:

555.1101g

4. Final activity calculation:

$$\frac{37270 \text{ Bq (60 dpm)}}{(1 \text{ Bq})} \times \frac{(4.8960 \text{ g})}{(4.99800 \text{ g})} \times \frac{(0.9977 \text{ g/mL})}{(555.1101 \text{ g})} = 3937.10 \text{ dpm/mL}$$

Std ID: 1019.4095.83

Description: Cs-137

Expiration: 3/6/2016

Activity: 3937.10 dpm/mL

2s Uncertainty: 70.87 dpm/mL

Ref. Date: 2/9/2015

Ref Time: N/A

Prep Date: 3/5/2015 Prep by: TE

Matrix/Comp. 0.1 MHC

Half Life (y): 3.01E+01

Reverification Log

Analysis Date	Initials	Expiration Date


Continued on Page \_\_\_\_\_

Signed

Date

Read and Understood By

Signed

Date



Eckert & Ziegler

Analytics

RSO#  
1019

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.ezag.com

## CERTIFICATE OF CALIBRATION

### Standard Reference Source

99576

Cs-137 5 mL Liquid in Flame Sealed Vial

**Customer:** ALS Laboratory Group  
**P.O. No.:** FC000610, Item 3      **Product Code:** 8137

This standard radionuclide source was prepared gravimetrically from a master solution calibrated with an ionization chamber. The ionization chamber was calibrated by the National Physical Laboratory, Teddington, U.K., and is traceable to national standards. Radionuclide calibration and purity were checked by germanium gamma-ray spectrometry, liquid scintillation counting, and/or alpha spectrometry, as applicable. The nuclear decay rate and reference date for this source are given below. Eckert & Ziegler Analytics (EZA) maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Revision 2, July 2007, and compliance with ANSI N42.22-1995, "Traceability of Radioactive Sources to NIST."

Isotope	Half-Life, Days	Activity (Bq)	Uncertainty*, %			Reference Date (12:00 PM EST)
			u <sub>A</sub>	u <sub>B</sub>	U	
Cs-137	1.099E+04	3.727E+04	0.1	0.9	1.8	02/09/2015

\*Uncertainty: U - Relative expanded uncertainty, k = 2. See NIST Technical Note 1297, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results."

**Comments:**

Impurities:  $\gamma$ -impurities < 0.1%.

4.99800 g 0.1M HCl solution with approximately 30  $\mu$ g/g Cs carrier.

Source Prepared by:

K. Eardley  
K. Eardley, Radiochemist

QC Approved:

A. Chen  
A. Chen, Spectroscopist

Date: 7 Feb 15

# Mass Attenuation Curves

LB4100A Alpha Attenuation Curve -- Th-230

1518004				Spike Information				1518004				1518004								
File ID	Detector ID	Sample ID	Mass (mg)	Count Date	Alpha Counts	Beta Counts	Count Time	Alpha CPM	Beta CPM	Base Alpha Eff.	Decay Corr. Act. added dom/L	Alpha EFF Actual	Alpha EFF Fitted	Actual/Fitted Ratio	Obs. Attenu. Fact.	Fitted Attenu. Fact.	% Diff.	$e > \beta \times \text{Th} > \beta \times \text{Th}$	$e > \beta \times \text{Th} > \beta \times \text{Th}$	% Diff.
ATH208	A1	1518004-2	12.4	12/8/2016 15:41	10019	2856	10.36	966.962042	273.5437	0.2282	5831.41	0.1658	0.1816	1.0544	0.7269	0.7680	-9.5%	0.2829	0.2870	-1.5%
ATH208	A2	1518004-2	12.4	12/8/2016 19:38	10006	3030	10.24	976.962481	293.8894	0.2214	5831.41	0.1735	0.1859	1.0519	0.7457	0.7900	-5.2%	0.3008	0.2870	4.6%
ATH208	A3	1518004-2	12.4	12/8/2016 19:57	10004	2937	9.88	1012.42681	294.9172	0.2235	5831.41	0.1621	0.1822	1.0705	0.7435	0.7900	-7.1%	0.2914	0.2870	1.5%
ATH208	A4	1518004-2	12.4	12/8/2016 19:22	10003	3073	10.58	945.369138	293.3647	0.2289	5831.41	0.1720	0.1862	1.0877	0.7318	0.7900	-8.8%	0.3050	0.2870	5.9%
ATH208	B1	1518004-2	12.4	12/8/2016 19:46	10003	3357	9.86	1014.38604	328.4065	0.2377	5831.41	0.1748	0.1847	1.0885	0.7449	0.7900	-8.9%	0.3063	0.2870	6.3%
ATH208	B3	1518004-2	12.4	12/8/2016 11:11	10009	3037	8.92	1007.85069	293.6721	0.2320	5831.41	0.1747	0.1862	1.0767	0.7449	0.7900	-2.3%	0.3063	0.2870	6.3%
ATH208	B4	1518004-2	12.4	12/8/2016 11:30	10003	2734	8.92	1016.77744	292.9964	0.2268	5831.41	0.1747	0.1862	1.0767	0.7449	0.7900	-2.3%	0.3063	0.2870	6.3%
ATH208	C1	1518004-2	12.4	12/8/2016 12:05	10010	3280	10.42	960.325651	312.7553	0.2268	5831.41	0.1747	0.1862	1.0767	0.7449	0.7900	-2.3%	0.3063	0.2870	6.3%
ATH208	C3	1518004-2	12.4	12/8/2016 12:30	10012	3018	10.42	960.325651	312.7553	0.2268	5831.41	0.1747	0.1862	1.0767	0.7449	0.7900	-2.3%	0.3063	0.2870	6.3%
ATH208	A1	1518004-1	13.2	12/8/2016 19:39	10014	2928	10.63	957.071567	293.5719	0.2282	5831.41	0.1822	0.1921	1.0499	0.7581	0.7900	-5.0%	0.2998	0.2870	4.3%
ATH208	A2	1518004-1	13.2	12/8/2016 19:58	10004	2891	10.63	957.071567	293.5719	0.2282	5831.41	0.1822	0.1921	1.0499	0.7581	0.7900	-5.0%	0.2998	0.2870	4.3%
ATH208	A3	1518004-1	13.2	12/8/2016 19:22	10018	2940	10.27	975.339512	274.2138	0.2235	5831.41	0.1844	0.1944	1.0533	0.7688	0.7900	-6.5%	0.2869	0.2870	-0.2%
ATH208	A4	1518004-1	13.2	12/8/2016 19:47	10010	2987	10.51	962.331261	293.1168	0.2289	5831.41	0.1844	0.1944	1.0533	0.7688	0.7900	-6.5%	0.2869	0.2870	-0.2%
ATH208	B1	1518004-1	13.2	12/8/2016 11:11	10009	3082	9.91	1004.89491	293.0381	0.2377	5831.41	0.1844	0.1944	1.0533	0.7688	0.7900	-6.5%	0.2869	0.2870	-0.2%
ATH208	B3	1518004-1	13.2	12/8/2016 11:00	10007	3030	10.16	984.806045	298.0243	0.2377	5831.41	0.1844	0.1944	1.0533	0.7688	0.7900	-6.5%	0.2869	0.2870	-0.2%
ATH208	B4	1518004-1	13.2	12/8/2016 12:05	10005	2748	10.32	989.415643	284.4541	0.2245	5831.41	0.1844	0.1944	1.0533	0.7688	0.7900	-6.5%	0.2869	0.2870	-0.2%
ATH208	C1	1518004-1	13.2	12/8/2016 12:30	10005	3215	10.56	945.055584	301.8732	0.2268	5831.41	0.1844	0.1944	1.0533	0.7688	0.7900	-6.5%	0.2869	0.2870	-0.2%
ATH208	C3	1518004-1	13.2	12/8/2016 12:57	10001	3122	10.16	945.055584	301.8732	0.2268	5831.41	0.1844	0.1944	1.0533	0.7688	0.7900	-6.5%	0.2869	0.2870	-0.2%
ATH208	A1	1518004-3	25.8	12/8/2016 15:22	10005	2774	11.23	900.795186	244.8949	0.2282	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	A2	1518004-3	25.8	12/8/2016 15:41	10003	2921	10.78	927.760078	269.9397	0.2214	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	A3	1518004-3	25.8	12/8/2016 19:38	10009	2962	10.78	927.760078	269.9397	0.2214	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	A4	1518004-3	25.8	12/8/2016 19:59	10002	3011	10.08	902.819591	269.8819	0.2289	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	B1	1518004-3	25.8	12/8/2016 10:22	10009	3045	10.37	971.642573	293.7131	0.2377	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	B3	1518004-3	25.8	12/8/2016 10:47	10017	3147	10.61	907.5667	285.1943	0.2370	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	B4	1518004-3	25.8	12/8/2016 11:12	10005	2910	10.81	925.373945	287.3702	0.2245	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	C1	1518004-3	25.8	12/8/2016 11:47	10005	3270	11.19	963.877677	280.2242	0.2268	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	C3	1518004-3	25.8	12/8/2016 12:35	10000	3123	10.53	949.552016	294.5592	0.2245	5831.41	0.1528	0.1632	1.0336	0.6867	0.7900	-4.4%	0.2749	0.2867	7.9%
ATH208	A1	1518004-5	43.9	12/8/2016 14:42	10010	3131	14.11	708.303699	218.7074	0.2282	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A2	1518004-5	43.9	12/8/2016 15:06	10006	3177	14.36	686.940657	218.4253	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A3	1518004-5	43.9	12/8/2016 15:25	10004	3077	13.86	684.941525	218.2559	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A4	1518004-5	43.9	12/8/2016 16:45	10001	3171	14.39	684.941525	218.2559	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	B1	1518004-5	43.9	12/8/2016 16:41	10008	3046	13.95	737.692763	238.5523	0.2370	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	B3	1518004-5	43.9	12/8/2016 16:26	10011	3234	13.57	708.303699	218.4253	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	B4	1518004-5	43.9	12/8/2016 16:26	10012	3480	14.52	686.940657	218.4253	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	C1	1518004-5	43.9	12/8/2016 16:45	10003	3452	14.35	686.940657	218.4253	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	C3	1518004-5	43.9	12/8/2016 16:45	10003	3452	14.35	686.940657	218.4253	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A1	1518004-8	49.5	12/8/2016 13:29	10012	2954	15.15	680.738066	192.8515	0.2282	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A2	1518004-8	49.5	12/8/2016 13:57	10012	3115	15.03	685.079388	205.2232	0.2214	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A3	1518004-8	49.5	12/8/2016 14:22	10006	2978	14.72	670.58936	200.0108	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A4	1518004-8	49.5	12/8/2016 14:43	9990	3046	14.6	670.58936	200.0108	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	B1	1518004-8	49.5	12/8/2016 15:04	10002	3046	13.82	723.629716	218.4872	0.2370	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	B3	1518004-8	49.5	12/8/2016 15:26	10001	3350	14.6	670.58936	200.0108	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	B4	1518004-8	49.5	12/8/2016 15:45	10001	3304	14.73	670.58936	200.0108	0.2235	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	C1	1518004-8	49.5	12/8/2016 16:45	10004	3543	15.61	680.893173	224.0868	0.2268	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	C3	1518004-8	49.5	12/8/2016 16:45	10003	3543	15.61	680.893173	224.0868	0.2268	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A1	1518004-7	49.9	12/8/2016 10:32	10009	2946	14.95	682.909183	220.5098	0.2282	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A2	1518004-7	49.9	12/8/2016 13:50	10009	2946	14.95	682.909183	220.5098	0.2282	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A3	1518004-7	49.9	12/8/2016 14:21	10002	2863	13.82	724.18232	203.8014	0.2214	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	A4	1518004-7	49.9	12/8/2016 14:42	10000	2916	13.83	724.18232	203.8014	0.2214	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	B1	1518004-7	49.9	12/8/2016 15:04	10007	3021	13.97	716.225667	214.1601	0.2277	5831.41	0.1133	0.1268	1.0755	0.5546	0.5546	-1.8%	0.3105	0.3102	-0.1%
ATH208	B3	1518004-7	49.9	12/8/2016 15																

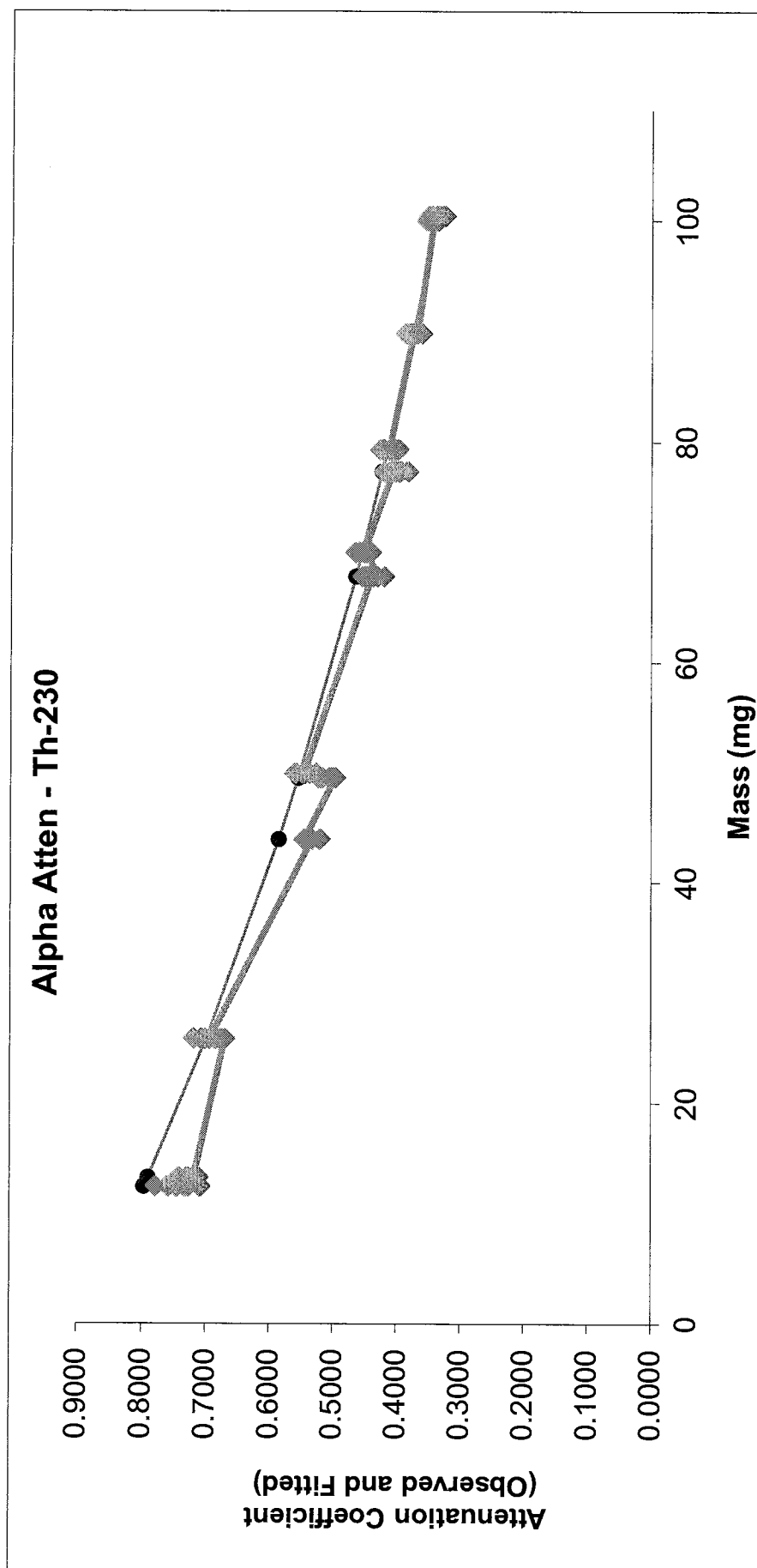
## LB4100A Alpha Attenuation Curve -- Th-230

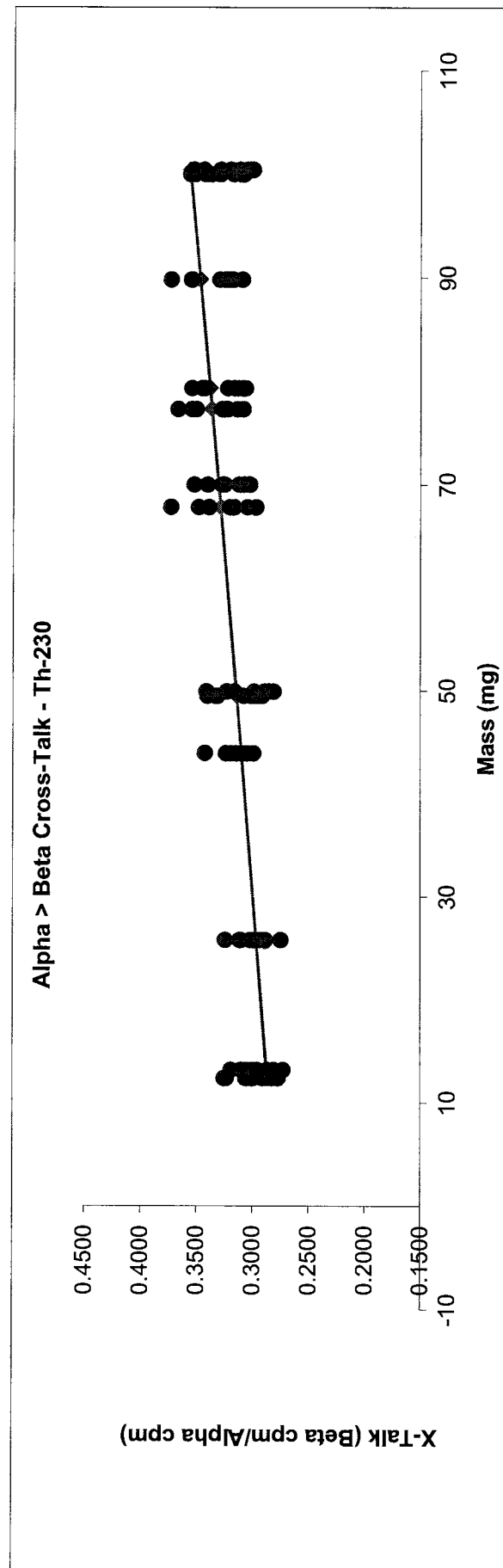
WO #		Mass Range		Spike Information		Ref. Date		yrs dp/mL nL Vol.		Act. Added		Alpha Counts		Beta Counts		Time		Alpha CPM		Beta CPM		Base Alpha Eff.		Decay Cor. Act. added dpm/L		Alpha EFF		Alpha Att.		Actual/Fit		Obs		Atten Fact.		Filled		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.		Diff.	
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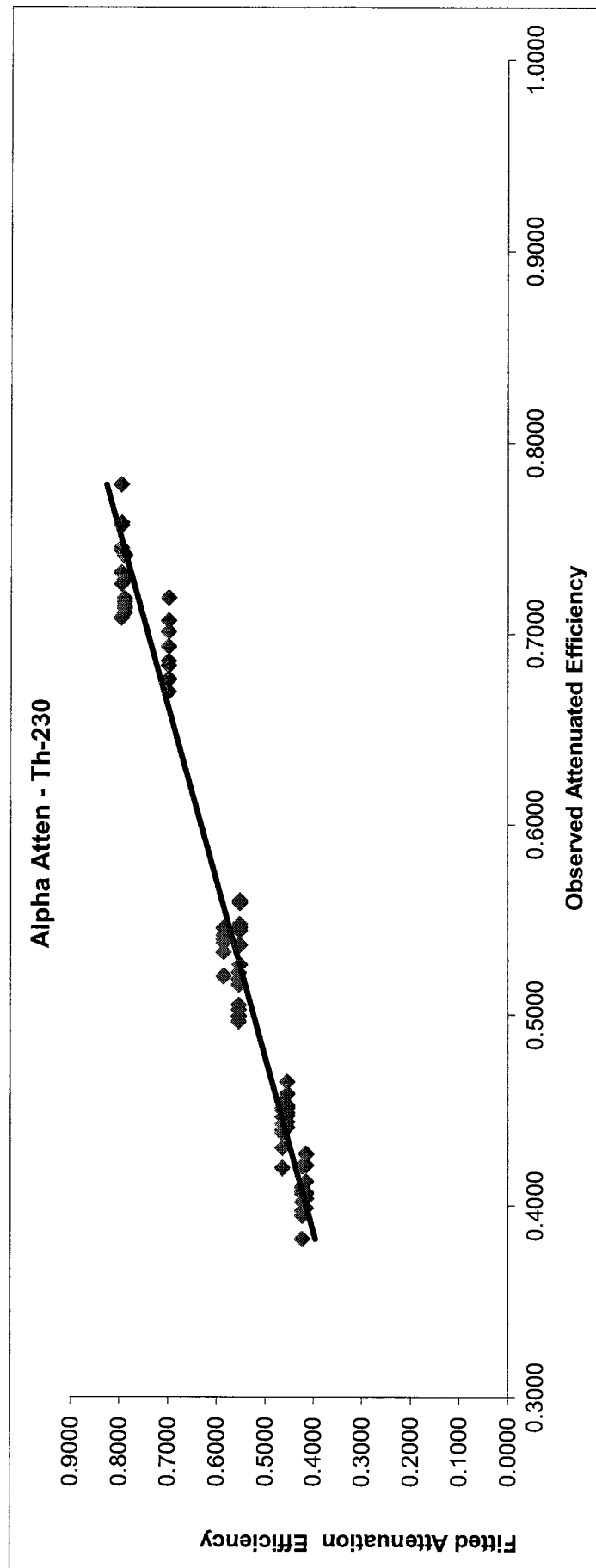
# LB4100A Alpha Attenuation Curve -- Th-230

WO #		1518004			Spike Information				Attenuation Equation: $y=b \cdot m^x$				Cross-Talk Equation: $y=b \cdot m^x$								
Mass Range		12.4 mg	100.4 mg		Std. ID	853.3020.89	Ref. Date	11/6/2007	ys	b =	0.8980	m =	0.9901	a =	0.9775	x0	0				
		Low	High		Activity	75380	Half-life	1166.38	dpm/mL												
					Vol.	5.0			mL												
					Act. Added	5831.90			dpm												

## OUTLIERS







										Alpha	Beta
									Mass	CPM	CPM
Detector ID	Sample ID	Alpha	Beta	Guard	Count Time	Event	Voltage	TOD	#VALUE!	#VALUE!	#VALUE!
A1	12.4	10019	2856	7306	10.36	0	1402.5	12/8/16 15:41	12.4	966.9629	273.5437
A1	13.2	10014	2926	7778	10.93	0	1402.5	12/8/16 9:39	13.2	916.072	265.5716
A1	25.8	10005	2774	8193	11.23	0	1402.5	12/8/16 15:22	25.8	890.7952	244.8849
A1	28.1	10008	3073	10279	13.74	0	1402.5	12/8/16 15:04	28.1	728.2623	221.5216
A1	36.8	10006	3225	11053	14.36	0	1402.5	12/8/16 14:21	36.8	696.6747	222.4502
A1	43.9	10010	3131	10036	14.11	0	1402.5	12/8/16 14:42	43.9	709.3039	219.7674
A1	49.5	10012	2954	11713	15.15	0	1402.5	12/8/16 13:29	49.5	660.7361	192.8515
A1	49.9	10009	2846	10445	13.82	0	1402.5	12/8/16 13:56	49.9	724.1182	203.8014
A1	67.8	10005	3010	12382	17.11	0	1402.5	12/8/16 13:04	67.8	584.6238	173.7885
A1	70	10003	3065	11977	16.8	0	1402.5	12/8/16 12:36	70	595.2947	180.3085
A1	77.3	10006	3132	13538	18.47	0	1402.5	12/8/16 11:48	77.3	541.6214	167.4403
A1	79.3	10004	3109	13825	18.5	0	1402.5	12/8/16 12:13	79.3	540.6348	165.9221
A1	83.5	10006	3050	12202	17.18	0	1402.5	12/8/16 11:18	83.5	582.2994	175.4
A1	89.8	10004	3143	14423	20.07	0	1402.5	12/8/16 10:56	89.8	498.3334	154.4699
A1	100	10002	3133	15055	21.9	0	1402.5	12/8/16 10:09	100	456.5903	140.9274
A1	100.4	10002	3053	16182	22.88	0	1402.5	12/8/16 10:34	100.4	437.0283	131.3033
A2	12.4	10006	3030	7330	10.24	0	1402.5	12/8/16 9:38	12.4	976.9924	293.8694
A2	13.2	10004	2891	7100	10.45	0	1402.5	12/8/16 9:58	13.2	957.1646	274.6217
A2	25.8	10003	2921	7601	10.78	0	1402.5	12/8/16 15:41	25.8	927.7661	268.9357
A2	28.1	10007	3044	10009	13.54	0	1402.5	12/8/16 15:25	28.1	738.9134	222.7864
A2	36.8	10013	3359	10439	14.66	0	1402.5	12/8/16 14:43	36.8	682.859	227.0979
A2	43.9	10006	3137	10659	14.36	0	1402.5	12/8/16 15:05	43.9	696.6407	216.425
A2	49.5	10012	3115	11299	15.03	0	1402.5	12/8/16 13:57	49.5	665.9784	205.2232
A2	49.9	10002	2893	10660	13.83	0	1402.5	12/8/16 14:21	49.9	723.0544	207.1539
A2	67.8	10008	3242	13371	17.36	0	1402.5	12/8/16 13:31	67.8	576.3417	184.7222
A2	70	10003	3161	12054	16.66	0	1402.5	12/8/16 13:03	70	600.2642	187.7069
A2	77.3	10000	3180	13761	18.41	0	1402.5	12/8/16 12:13	77.3	543.0271	170.7032
A2	79.3	10011	3136	12925	18.17	0	1402.5	12/8/16 12:37	79.3	550.8071	170.5632
A2	83.5	10005	3067	12553	17.21	0	1402.5	12/8/16 11:47	83.5	581.1921	176.1813
A2	89.8	10000	3254	14330	20.14	0	1402.5	12/8/16 11:21	89.8	496.3683	159.54
A2	100	10006	3423	15624	22.06	0	1402.5	12/8/16 10:33	100	453.4251	153.1387
A2	100.4	10003	3101	15870	22.07	0	1402.5	12/8/16 10:58	100.4	453.0837	138.4785
A3	12.4	10004	2937	6720	9.88	0	1402.5	12/8/16 9:57	12.4	1012.427	294.9772
A3	13.2	10018	2840	7430	10.27	0	1402.5	12/8/16 10:22	13.2	975.3385	274.2436
A3	25.8	10009	2962	7665	10.76	0	1402.5	12/8/16 9:38	25.8	930.0805	272.9888
A3	28.1	10002	3064	9508	13.49	0	1402.5	12/8/16 15:44	28.1	741.3141	224.8412
A3	36.8	10005	3175	10441	14.05	0	1402.5	12/8/16 15:05	36.8	711.9756	223.6886
A3	43.9	10004	3027	10120	13.66	0	1402.5	12/8/16 15:25	43.9	732.2332	219.3059
A3	49.5	10005	2978	11339	14.72	0	1402.5	12/8/16 14:22	49.5	679.5635	200.0198
A3	49.9	10000	2918	9510	13.41	0	1402.5	12/8/16 14:42	49.9	745.5882	215.3088
A3	67.8	10002	3207	12589	16.77	0	1402.5	12/8/16 13:59	67.8	596.2982	188.9443
A3	70	10006	3083	12850	16.66	0	1402.5	12/8/16 13:31	70	600.4762	182.764
A3	77.3	10001	3296	13235	18.6	0	1402.5	12/8/16 12:38	77.3	537.5642	174.9143
A3	79.3	10006	3128	13291	18.43	0	1402.5	12/8/16 13:05	79.3	542.7952	167.4333
A3	83.5	10007	3050	12526	16.9	0	1402.5	12/8/16 12:12	83.5	592.0062	178.1834
A3	89.8	10003	3223	14176	19.37	0	1402.5	12/8/16 11:49	89.8	516.2931	164.1013
A3	100	9999	3226	15342	21.31	0	1402.5	12/8/16 10:57	100	469.0923	149.0943
A3	100.4	10000	3342	16058	22.57	0	1402.5	12/8/16 11:24	100.4	442.942	145.7827
A4	12.4	10003	3073	7643	10.58	0	1402.5	12/8/16 10:22	12.4	945.3681	288.3647
A4	13.2	10010	2987	7725	10.51	0	1402.5	12/8/16 10:47	13.2	952.3313	282.1165
A4	25.8	10002	3011	7508	11.08	0	1402.5	12/8/16 9:59	25.8	902.6126	269.6619
A4	28.1	10001	3185	9356	13.35	0	1402.5	12/8/16 9:41	28.1	749.0436	236.4878
A4	36.8	10004	3272	10342	13.94	0	1402.5	12/8/16 15:25	36.8	717.5521	232.6312
A4	43.9	10001	3171	10137	14.39	0	1402.5	12/8/16 15:45	43.9	694.9015	218.2724
A4	49.5	9999	3035	10607	14.9	0	1402.5	12/8/16 14:43	49.5	670.9788	201.6023
A4	49.9	10007	3021	10395	13.97	0	1402.5	12/8/16 15:04	49.9	716.2257	214.1601
A4	67.8	10008	3088	12624	16.51	0	1402.5	12/8/16 14:24	67.8	606.0831	184.9492
A4	70	10007	3115	12540	16.71	0	1402.5	12/8/16 13:59	70	598.768	184.3263
A4	77.3	10000	3301	13587	18.85	0	1402.5	12/8/16 13:05	77.3	530.409	173.0304
A4	79.3	10003	3268	14207	18.56	0	1402.5	12/8/16 13:32	79.3	538.8597	173.9886
A4	83.5	10008	3138	12398	17.38	0	1402.5	12/8/16 12:36	83.5	575.7393	178.4634
A4	89.8	10001	3344	15131	20.12	0	1402.5	12/8/16 12:15	89.8	496.9726	164.1138
A4	100	10000	3339	15446	21.7	0	1402.5	12/8/16 11:23	100	460.7345	151.782
A4	100.4	10001	3167	16129	22.22	0	1402.5	12/8/16 11:52	100.4	449.995	140.4403
B1	12.4	10003	3257	7078	9.86	0	1500	12/8/16 10:46	12.4	1014.398	328.4065
B1	13.2	10009	3082	6835	9.91	0	1500	12/8/16 11:11	13.2	1009.885	309.081
B1	25.8	10009	3045	7138	10.3	0	1500	12/8/16 10:22	25.8	971.6426	293.7131

B1	28.1	10010	3162	8675	12.56	0	1500	12/8/16 10:00	28.1	796.8695	249.8336
B1	36.8	10006	3318	9590	13.59	0	1500	12/8/16 15:44	36.8	736.1717	242.2321
B1	43.9	10008	3177	9354	13.38	0	1500	12/8/16 9:41	43.9	747.8771	235.5259
B1	49.5	10002	3046	9681	13.82	0	1500	12/8/16 15:04	49.5	723.6287	218.4872
B1	49.9	10003	2846	9222	12.9	0	1500	12/8/16 15:24	49.9	775.3214	218.7022
B1	67.8	10008	3214	11405	16.01	0	1500	12/8/16 14:44	67.8	625.0043	198.8315
B1	70	10008	3117	11226	15.74	0	1500	12/8/16 14:23	70	635.7273	196.1125
B1	77.3	10003	3311	12243	17.59	0	1500	12/8/16 13:31	77.3	568.5704	186.3139
B1	79.3	10010	3175	12120	16.9	0	1500	12/8/16 13:59	79.3	592.2027	185.9518
B1	83.5	10001	3205	11680	16.53	0	1500	12/8/16 13:03	83.5	604.9162	191.9719
B1	100	10002	3340	14276	20.36	0	1500	12/8/16 11:50	100	491.1524	162.1292
B1	100.4	10005	3245	14470	20.91	0	1500	12/8/16 12:16	100.4	478.3742	153.2709
B1	8938	10002	3285	13093	18.67	0	1500	12/8/16 12:38	8938	535.6208	174.0327
B3	12.4	10009	3087	6848	9.93	0	1500	12/8/16 11:11	12.4	1007.822	308.6721
B3	13.2	10007	3030	7146	10.16	0	1500	12/8/16 11:40	13.2	984.8069	296.0243
B3	25.8	10017	3147	7762	10.8	0	1500	12/8/16 10:47	25.8	927.366	289.1849
B3	28.1	10001	3226	8920	12.76	0	1500	12/8/16 10:24	28.1	783.6434	250.6173
B3	36.8	10003	3433	9858	14.1	0	1500	12/8/16 9:42	36.8	709.2986	241.2712
B3	43.9	10011	3234	9376	13.57	0	1500	12/8/16 10:01	43.9	737.5963	236.1158
B3	49.5	10001	3350	10634	14.8	0	1500	12/8/16 15:26	49.5	675.6092	224.1474
B3	49.9	10010	3199	9589	13.59	0	1500	12/8/16 15:44	49.9	736.437	233.1897
B3	67.8	10003	3431	11573	16.42	0	1500	12/8/16 15:07	67.8	609.0621	206.7485
B3	70	9999	3439	11676	16.38	0	1500	12/8/16 14:45	70	610.3056	207.7472
B3	77.3	10007	3589	13187	18.39	0	1500	12/8/16 14:00	77.3	544.0204	192.9564
B3	79.3	10009	3496	12967	18.18	0	1500	12/8/16 14:25	79.3	550.4161	190.0952
B3	83.5	10002	3408	11810	16.91	0	1500	12/8/16 13:31	83.5	591.3503	199.3336
B3	89.8	10000	3590	13920	19.72	0	1500	12/8/16 13:06	89.8	506.9654	179.8447
B3	100	10004	3478	14579	21.08	0	1500	12/8/16 12:16	100	474.4391	162.7865
B3	100.4	10004	3491	15409	21.94	0	1500	12/8/16 12:41	100.4	455.8368	156.9118
B4	12.4	10003	2794	6924	9.82	0	1500	12/8/16 11:39	12.4	1018.477	282.6964
B4	13.2	10006	2748	7180	10.32	0	1500	12/8/16 12:05	13.2	969.4156	264.4541
B4	25.8	10005	2910	7465	10.81	0	1500	12/8/16 11:12	25.8	925.3739	267.3702
B4	28.1	10003	2884	9261	13.03	0	1500	12/8/16 10:49	28.1	767.5319	219.5104
B4	36.8	10009	3230	9829	14.21	0	1500	12/8/16 10:02	36.8	704.2051	225.4797
B4	43.9	10012	3080	9852	14.12	0	1500	12/8/16 10:26	43.9	708.9072	216.3053
B4	49.5	10004	2994	10347	14.73	0	1500	12/8/16 15:45	49.5	679.0002	201.4337
B4	49.9	10000	2920	9561	13.67	0	1500	12/8/16 9:41	49.9	731.3709	211.7814
B4	67.8	10004	3208	12383	17.26	0	1500	12/8/16 15:28	67.8	579.448	184.0383
B4	70	10000	3308	11882	16.87	0	1500	12/8/16 15:07	70	592.6102	194.2627
B4	77.3	10004	3262	13296	18.65	0	1500	12/8/16 14:26	77.3	536.2495	173.0812
B4	79.3	9999	3198	12847	18.13	0	1500	12/8/16 14:47	79.3	551.3588	174.5677
B4	83.5	10006	3201	12550	17.5	0	1500	12/8/16 13:59	83.5	571.6134	181.0893
B4	89.8	10000	3264	14008	20.15	0	1500	12/8/16 13:34	89.8	496.1199	160.1601
B4	100	10001	3149	15163	21.61	0	1500	12/8/16 12:41	100	462.637	143.8946
B4	100.4	10000	3066	15882	22.54	0	1500	12/8/16 13:09	100.4	443.4977	134.1998
C1	12.4	10010	3280	7534	10.42	0	1530	12/8/16 12:05	12.4	960.5286	312.7783
C1	13.2	10000	3215	7607	10.58	0	1530	12/8/16 12:30	13.2	945.0556	301.8742
C1	25.8	10005	3270	7977	11.19	0	1530	12/8/16 11:41	25.8	893.9779	290.2242
C1	28.1	10002	3386	9616	13.5	0	1530	12/8/16 11:15	28.1	740.7649	248.8138
C1	36.8	10000	3803	10632	14.9	0	1530	12/8/16 10:26	36.8	671.0169	253.2339
C1	43.9	10003	3452	10587	14.53	0	1530	12/8/16 10:51	43.9	688.3137	235.5764
C1	49.5	10003	3543	10988	15.61	0	1530	12/8/16 9:43	49.5	640.6832	224.9689
C1	49.9	10003	3444	10206	14.36	0	1530	12/8/16 10:02	49.9	696.4637	237.8319
C1	67.8	10003	3768	12722	18.01	0	1530	12/8/16 15:49	67.8	555.2897	207.2161
C1	70	9999	3557	12476	17.02	0	1530	12/8/16 15:28	70	587.3613	206.9884
C1	77.3	10002	3708	14315	19.75	0	1530	12/8/16 14:48	77.3	506.3064	185.7458
C1	79.3	10002	3584	13588	18.96	0	1530	12/8/16 15:10	79.3	527.4076	187.0285
C1	83.5	10000	3552	12929	18.04	0	1530	12/8/16 14:25	83.5	554.1997	194.8948
C1	89.8	10002	3773	15136	20.9	0	1530	12/8/16 14:03	89.8	478.4406	178.5253
C1	100	10003	3605	16202	22.45	0	1530	12/8/16 13:09	100	445.4439	158.5781
C1	100.4	10002	3576	16314	23.18	0	1530	12/8/16 13:37	100.4	431.3687	152.2699
C3	12.4	10012	3018	6950	9.64	0	1530	12/8/16 12:29	12.4	1038.474	311.3475
C3	13.2	10001	3122	7346	10.16	0	1530	12/8/16 12:57	13.2	984.2354	305.5605
C3	25.8	10000	3123	7635	10.53	0	1530	12/8/16 12:05	25.8	949.5526	294.8582
C3	28.1	10008	3394	8954	12.62	0	1530	12/8/16 11:42	28.1	792.9119	267.2152
C3	36.8	10000	3491	10188	13.95	0	1530	12/8/16 10:50	36.8	716.7309	248.5279
C3	43.9	10006	3264	9541	13.39	0	1530	12/8/16 11:14	43.9	747.1591	242.041
C3	49.5	10008	3358	10281	14.46	0	1530	12/8/16 10:02	49.5	692.0012	230.5038
C3	49.9	10000	3255	9553	13.37	0	1530	12/8/16 10:25	49.9	747.8282	241.7325
C3	67.8	10005	3516	11890	16.97	0	1530	12/8/16 9:45	67.8	589.4548	205.4662

C3	70	10004	3283	11410	16.16	0	1530	12/8/16 15:47	70	618.9444	201.4329
C3	77.3	10005	3537	12845	17.98	0	1530	12/8/16 15:09	77.3	556.3366	194.9956
C3	79.3	10008	3465	12958	17.7	0	1530	12/8/16 15:29	79.3	565.3087	194.0397
C3	83.5	10000	3377	12433	17.06	0	1530	12/8/16 14:45	83.5	586.0515	196.2254
C3	89.8	10002	3585	14178	19.77	0	1530	12/8/16 14:27	89.8	505.8031	179.6124
C3	100	10007	3558	14798	20.99	0	1530	12/8/16 13:35	100	476.6358	167.7863
C3	100.4	9999	3573	15806	21.87	0	1530	12/8/16 14:04	100.4	457.0866	161.6515

## LB4100A Beta Attenuation Curve -- Cs-137

WO #:		1617003		Calibrated Mass Range			Attenuation Equation				Cross-Talk Equation							
Nuclide: Cs-137				Low	0.0	mg	b = 0.9455				b = 1.6183E-06							
Std. ID: 1019.4095.83				High	299.7	mg	m = 0.9986				m = 0.0037							
Ref. Date: 02/09/15							a = 1.0026				% Diff Max. = 86.7%							
Half-life: 30.1 yrs							% Diff Max. = 10.9%											
Activity: 3937.1 dpm/mL																		
Vol.: 1																		
File ID	Detector ID	Sample ID	Mass (mg)	Count Date	Alpha Counts	Beta Counts	Count Time	Base Beta Eff.	Alpha CPM	Beta CPM	Decay Corr. added dpm/mL	Beta Obs. Atten. Eff.	Obs. Atten Fact.	Fitted Atten Fact.	% Diff.	β > α XTLK Observed	β > α XTLK Fitted	% Diff.
ACSI207	A1	1617003-1	0	12/17/2016 9:11	23	10011	6.74	0.3942	3.290463	1483.18	3774.88	0.3929	0.9967	0.9455	5.4%	0.0022	0.0037	-39.6%
ACSI207	A2	1617003-1	0	12/17/2016 9:25	20	10008	6.73	0.3972	2.815768	1485.04	3774.87	0.3934	0.9904	0.9455	4.8%	0.0019	0.0037	-48.4%
ACSI207	A3	1617003-1	0	12/17/2016 9:39	17	10017	6.53	0.4040	2.479369	1531.707	3774.87	0.4058	1.0044	0.9455	6.2%	0.0016	0.0037	-56.0%
ACSI207	A4	1617003-1	0	12/17/2016 9:52	23	10003	6.55	0.3921	3.41645	1525.087	3774.87	0.4040	1.0304	0.9455	9.0%	0.0022	0.0037	-39.1%
ACSI207	B1	1617003-1	0	12/17/2016 10:06	40	10011	6.4	0.4271	6.145	1562.301	3774.87	0.4139	0.9690	0.9455	2.5%	0.0039	0.0037	7.0%
ACSI207	B3	1617003-1	0	12/17/2016 10:19	11	10008	6.41	0.4171	1.582069	1559.106	3774.86	0.4130	0.9602	0.9455	4.7%	0.0010	0.0037	-72.4%
ACSI207	B4	1617003-1	0	12/17/2016 10:35	64	10009	6.86	0.3964	9.171446	1457.213	3774.86	0.3860	0.9738	0.9455	3.0%	0.0063	0.0037	71.2%
ACSI207	C1	1617003-1	0	12/17/2016 10:46	27	10019	6.64	0.3974	3.942265	1506.885	3774.86	0.3992	1.0045	0.9455	6.2%	0.0026	0.0037	-28.8%
ACSI207	C3	1617003-1	0	12/17/2016 11:07	19	10002	6.31	0.4191	2.896094	1583.38	3774.86	0.4195	1.0008	0.9455	5.9%	0.0018	0.0037	-50.2%
ACSI207	A1	1617003-2	16.3	12/17/2016 13:19	31	10008	6.99	0.3942	4.312907	1429.628	3774.83	0.3787	0.9607	0.9241	4.0%	0.0030	0.0037	-18.5%
ACSI207	A2	1617003-2	16.3	12/17/2016 13:11	24	10012	6.96	0.3972	3.292276	1436.477	3774.88	0.3805	0.9580	0.9241	3.7%	0.0023	0.0037	-38.1%
ACSI207	A3	1617003-2	16.3	12/17/2016 9:25	13	10011	6.74	0.4040	1.804783	1483.022	3774.87	0.3929	0.9724	0.9241	5.2%	0.0012	0.0037	-67.1%
ACSI207	A4	1617003-2	16.3	12/17/2016 9:40	27	10016	7.08	0.3921	3.718559	1412.6	3774.87	0.3742	0.9544	0.9241	3.3%	0.0026	0.0037	-28.9%
ACSI207	B1	1617003-2	16.3	12/17/2016 9:52	29	10009	6.78	0.4271	4.172286	1474.336	3774.87	0.3906	0.9145	0.9241	-1.0%	0.0028	0.0037	-23.6%
ACSI207	B3	1617003-2	16.3	12/17/2016 10:06	13	10022	6.82	0.4171	1.772158	1467.297	3774.87	0.3887	0.9319	0.9241	1.8%	0.0012	0.0037	-67.4%
ACSI207	B4	1617003-2	16.3	12/17/2016 10:20	55	10003	7.1	0.3964	7.586479	1407.048	3774.86	0.3727	0.9403	0.9241	1.8%	0.0054	0.0037	45.7%
ACSI207	C1	1617003-2	16.3	12/17/2016 10:35	27	10007	6.89	0.3974	3.794723	1450.394	3774.86	0.3842	0.9668	0.9241	4.6%	0.0026	0.0037	-29.3%
ACSI207	C3	1617003-2	16.3	12/17/2016 10:46	20	10014	6.74	0.4191	2.852359	1484.034	3774.86	0.3931	0.9393	0.9241	1.5%	0.0019	0.0037	-48.1%
ACSI207	A1	1617003-3	30.4	12/17/2016 13:05	21	10006	7.02	0.3942	2.869453	1423.224	3774.84	0.3770	0.9564	0.9060	5.6%	0.0020	0.0037	-45.9%
ACSI207	A2	1617003-3	30.4	12/17/2016 13:19	27	10021	6.88	0.3972	3.768419	1454.512	3774.83	0.3853	0.9701	0.9060	7.1%	0.0026	0.0037	-30.4%
ACSI207	A3	1617003-3	30.4	12/17/2016 9:11	16	10013	6.7	0.4040	2.264006	1492.188	3774.88	0.3923	0.9785	0.9060	8.0%	0.0015	0.0037	-59.3%
ACSI207	A4	1617003-3	30.4	12/17/2016 9:25	14	10022	6.94	0.3921	1.922291	1442.003	3774.87	0.3820	0.9742	0.9060	7.5%	0.0013	0.0037	-64.2%
ACSI207	B1	1617003-3	30.4	12/17/2016 9:39	29	10015	6.52	0.4271	4.342853	1534.125	3774.87	0.4064	0.9515	0.9060	5.0%	0.0028	0.0037	-24.0%
ACSI207	B3	1617003-3	30.4	12/17/2016 9:52	12	10003	6.73	0.4171	1.649061	1484.126	3774.87	0.3932	0.9426	0.9060	4.0%	0.0011	0.0037	-70.2%
ACSI207	B4	1617003-3	30.4	12/17/2016 10:06	40	10001	6.96	0.3964	5.589126	1435.1	3774.87	0.3802	0.9591	0.9060	5.9%	0.0039	0.0037	4.6%
ACSI207	C1	1617003-3	30.4	12/17/2016 10:19	33	10010	6.75	0.3974	4.764889	1480.962	3774.86	0.3923	0.9872	0.9060	9.0%	0.0032	0.0037	-13.6%
ACSI207	C3	1617003-3	30.4	12/17/2016 10:34	33	10019	6.59	0.4191	4.892587	1518.611	3774.86	0.4023	0.9599	0.9060	5.9%	0.0032	0.0037	-13.5%
ACSI207	A1	1617003-4	49.6	12/17/2016 12:51	15	10008	8.41	0.3942	1.661591	1187.88	3774.84	0.3147	0.7983	0.8819	-9.5%	0.0014	0.0038	-62.8%
ACSI207	A2	1617003-4	49.6	12/17/2016 13:06	28	10012	8.19	0.3972	3.262803	1220.437	3774.84	0.3233	0.8140	0.8819	-7.7%	0.0027	0.0038	-28.8%
ACSI207	A3	1617003-4	49.6	12/17/2016 13:20	9	10010	8.28	0.4040	0.962957	1206.647	3774.83	0.3197	0.7912	0.8819	-10.3%	0.0008	0.0038	-78.8%
ACSI207	A4	1617003-4	49.6	12/17/2016 9:13	9	10006	8.04	0.3921	1.024403	1242.438	3774.88	0.3291	0.8394	0.8819	-4.8%	0.0008	0.0038	-78.0%
ACSI207	B1	1617003-4	49.6	12/17/2016 9:26	44	10014	7.59	0.4271	5.692101	1317.45	3774.87	0.3490	0.8172	0.8819	-7.3%	0.0043	0.0038	15.0%
ACSI207	B3	1617003-4	49.6	12/17/2016 9:40	11	10010	7.89	0.4171	1.26017	1266.491	3774.87	0.3355	0.8044	0.8819	-8.8%	0.0010	0.0038	-73.5%
ACSI207	B4	1617003-4	49.6	12/17/2016 9:54	66	10019	8.25	0.3964	7.842	1212.599	3774.87	0.3212	0.8104	0.8819	-8.1%	0.0065	0.0038	72.2%
ACSI207	C1	1617003-4	49.6	12/17/2016 10:07	29	10013	7.82	0.3974	3.58444	1278.434	3774.87	0.3387	0.8522	0.8819	-3.4%	0.0028	0.0038	-25.4%
ACSI207	C3	1617003-4	49.6	12/17/2016 10:20	17	10011	7.63	0.4191	2.113047	1310.335	3774.86	0.3471	0.8283	0.8819	-6.1%	0.0016	0.0038	-57.1%
ACSI207	A1	1617003-5	63.4	12/17/2016 12:35	21	10012	8.31	0.3942	2.405076	1202.681	3774.84	0.3186	0.8082	0.8650	-6.6%	0.0020	0.0038	-47.1%
ACSI207	A2	1617003-5	63.4	12/17/2016 12:51	28	10001	8.64	0.3972	3.084741	1155.494	3774.84	0.3061	0.7707	0.8650	-10.9%	0.0027	0.0038	-29.3%
ACSI207	A3	1617003-5	63.4	12/17/2016 13:06	6	10014	7.94	0.4040	0.631668	1258.919	3774.84	0.3335	0.8255	0.8650	-4.6%	0.0005	0.0038	-86.7%
ACSI207	A4	1617003-5	63.4	12/17/2016 13:20	21	10011	8.2	0.3921	2.465976	1218.765	3774.83	0.3229	0.8234	0.8650	-4.8%	0.0020	0.0038	-46.5%
ACSI207	B1	1617003-5	63.4	12/17/2016 9:12	35	10011	7.82	0.4271	4.370703	1276.261	3774.88	0.3386	0.7928	0.8650	-8.3%	0.0034	0.0038	-9.5%
ACSI207	B3	1617003-5	63.4	12/17/2016 9:26	19	10003	8.05	0.4171	2.226248	1240.405	3774.87	0.3286	0.7878	0.8650	-8.9%	0.0018	0.0038	-52.5%
ACSI207	B4	1617003-5	63.4	12/17/2016 9:41	61	10011	8.16	0.3964	7.31749	1225.013	3774.87	0.3245	0.8187	0.8650	-5.4%	0.0060	0.0038	58.1%
ACSI207	C1	1617003-5	63.4	12/17/2016 9:54	25	10009	8.12	0.3974	2.954818	1230.634	3774.87	0.3260	0.8204	0.8650	-5.2%	0.0024	0.0038	-36.5%
ACSI207	C3	1617003-5	63.4	12/17/2016 10:07	15	10011	7.81	0.4191	1.805615	1280.095	3774.87	0.3391	0.8091	0.8650	-6.5%	0.0014	0.0038	-62.7%

## LB4100A Beta Attenuation Curve -- Cs-137

WO #:		1617003		Calibrated Mass Range				Attenuation Equation				Cross-Talk Equation											
				Low	0.0	mg					y=b*m*(a*x)												
				High	299.7	mg					b = 0.9455 m = 0.9866 a = 1.0026 % Diff Max. = 10.9%												
Nuclide:	Std. ID:	Ref. Date:	Half-life:	Activity:	Vol.:	File ID	Detector ID	Sample ID	Mass (mg)	Count Date	Alpha Counts	Beta Counts	Count Time	Base Beta Eff.	Alpha CPM	Beta CPM	Decay Corr. added dpm/mL	Beta Obs. Atten. Eff.	Obs. Atten. Fact.	Fitted Atten. Fact.	% Diff.	$\beta > \alpha \times \text{TLK}$	$\beta > \alpha \times \text{TLK}$
Cs-137	1019.4095.83	02/09/15	30.1	3937.1	1	ACS1207	A1	1617003-6	75.3	12/17/2016 12:21	29	10003	7.93	0.3942	3.534999	1259.28	3774.84	0.3336	0.8463	0.8507	-0.5%	0.0028	0.0038
						ACS1207	A2	1617003-6	75.3	12/17/2016 12:35	24	10016	7.95	0.3972	2.862868	1257.845	3774.84	0.3332	0.8389	0.8507	-1.4%	0.0023	0.0038
						ACS1207	A3	1617003-6	75.3	12/17/2016 12:50	11	10017	7.87	0.4040	1.273713	1270.518	3774.84	0.3366	0.8331	0.8507	-2.1%	0.0010	0.0038
						ACS1207	A4	1617003-6	75.3	12/17/2016 13:06	13	10019	7.87	0.3921	1.566842	1270.973	3774.84	0.3367	0.8587	0.8507	0.9%	0.0012	0.0038
						ACS1207	B1	1617003-6	75.3	12/17/2016 13:19	26	10012	7.61	0.4271	3.311557	1313.719	3774.83	0.3480	0.8148	0.8507	-4.2%	0.0025	0.0038
						ACS1207	B3	1617003-6	75.3	12/17/2016 9:12	14	10002	7.55	0.4171	1.720305	1322.564	3774.88	0.3504	0.8400	0.8507	-1.3%	0.0013	0.0038
						ACS1207	B4	1617003-6	75.3	12/17/2016 9:26	41	10014	8.11	0.3964	4.897487	1322.947	3774.87	0.3266	0.8240	0.8507	-3.1%	0.0040	0.0038
						ACS1207	C1	1617003-6	75.3	12/17/2016 9:40	35	10006	7.95	0.3974	4.278516	1256.615	3774.87	0.3329	0.8377	0.8507	-1.5%	0.0034	0.0038
						ACS1207	C3	1617003-6	75.3	12/17/2016 9:53	14	10019	7.46	0.4191	1.761676	1341.306	3774.87	0.3553	0.8478	0.8507	-0.3%	0.0013	0.0038
						ACS1207	A1	1617003-7	95.8	12/17/2016 12:09	23	10010	8.08	0.3942	2.724535	1236.729	3774.85	0.3276	0.8311	0.8266	0.5%	0.0022	0.0038
						ACS1207	A2	1617003-7	95.8	12/17/2016 12:21	25	10010	8.21	0.3972	2.889067	1217.216	3774.84	0.3225	0.8118	0.8266	-1.8%	0.0024	0.0038
						ACS1207	A3	1617003-7	95.8	12/17/2016 12:35	16	10013	7.94	0.4040	1.891113	1258.793	3774.84	0.3335	0.8254	0.8266	-0.1%	0.0015	0.0038
						ACS1207	A4	1617003-7	95.8	12/17/2016 12:51	13	10013	8.18	0.3921	1.494242	1221.994	3774.84	0.3237	0.8256	0.8266	-0.1%	0.0012	0.0038
						ACS1207	B1	1617003-7	95.8	12/17/2016 13:06	37	10007	7.92	0.4271	4.566717	1261.592	3774.84	0.3342	0.7825	0.8266	-5.3%	0.0036	0.0038
						ACS1207	B3	1617003-7	95.8	12/17/2016 13:20	9	10005	7.97	0.4171	0.995235	1253.128	3774.83	0.3320	0.7959	0.8266	-3.7%	0.0008	0.0038
						ACS1207	B4	1617003-7	95.8	12/17/2016 9:13	49	10009	8.21	0.3964	5.810331	1217.298	3774.88	0.3225	0.8135	0.8266	-1.6%	0.0048	0.0038
						ACS1207	C1	1617003-7	95.8	12/17/2016 9:26	27	10009	8.01	0.3974	3.246787	1247.562	3774.87	0.3305	0.8316	0.8266	0.6%	0.0026	0.0038
						ACS1207	C3	1617003-7	95.8	12/17/2016 9:40	18	10013	7.76	0.4191	2.204588	1288.612	3774.87	0.3414	0.8145	0.8266	-1.5%	0.0017	0.0038
						ACS1207	A1	1617003-8	102.6	12/17/2016 11:51	16	10010	8.75	0.3942	1.706571	1141.868	3774.85	0.3025	0.7674	0.8188	-6.3%	0.0015	0.0038
						ACS1207	A2	1617003-8	102.6	12/17/2016 12:09	29	10009	8.4	0.3972	3.296381	1189.519	3774.85	0.3151	0.7933	0.8188	-3.1%	0.0028	0.0038
						ACS1207	A3	1617003-8	102.6	12/17/2016 12:21	13	10012	8.38	0.4040	1.427313	1192.459	3774.84	0.3159	0.7819	0.8188	-4.5%	0.0012	0.0038
						ACS1207	A4	1617003-8	102.6	12/17/2016 12:35	13	10011	8.56	0.3921	1.423692	1167.42	3774.84	0.3093	0.7887	0.8188	-3.7%	0.0012	0.0038
						ACS1207	B1	1617003-8	102.6	12/17/2016 12:51	32	10002	8.43	0.4271	3.690967	1184.559	3774.84	0.3138	0.7347	0.8188	-10.3%	0.0031	0.0038
						ACS1207	B3	1617003-8	102.6	12/17/2016 13:07	12	10004	8.43	0.4171	1.289488	1184.51	3774.84	0.3138	0.7523	0.8188	-8.1%	0.0011	0.0038
						ACS1207	B4	1617003-8	102.6	12/17/2016 13:21	47	10000	8.81	0.3964	5.176847	1133.249	3774.83	0.3002	0.7573	0.8188	-7.5%	0.0046	0.0038
						ACS1207	C1	1617003-8	102.6	12/17/2016 9:13	19	10000	8.41	0.3974	2.135215	1187.06	3774.88	0.3145	0.7913	0.8188	-3.4%	0.0018	0.0038
						ACS1207	C3	1617003-8	102.6	12/17/2016 9:26	16	10004	8.2	0.4191	1.836222	1218.277	3774.87	0.3227	0.7701	0.8188	-5.9%	0.0015	0.0038
						ACS1207	A1	1617003-9	129.6	12/17/2016 11:38	25	10007	8.4	0.3942	2.85479	1189.178	3774.85	0.3150	0.7992	0.7883	1.4%	0.0024	0.0039
						ACS1207	A2	1617003-9	129.6	12/17/2016 11:51	27	10011	8.51	0.3972	3.016738	1174.352	3774.85	0.3111	0.7832	0.7883	-0.6%	0.0026	0.0039
						ACS1207	A3	1617003-9	129.6	12/17/2016 12:09	10	10014	8.19	0.4040	1.097001	1220.421	3774.85	0.3233	0.8003	0.7883	1.5%	0.0009	0.0039
						ACS1207	A4	1617003-9	129.6	12/17/2016 12:21	28	10003	8.38	0.3921	3.246289	1191.586	3774.84	0.3157	0.8051	0.7883	2.1%	0.0027	0.0039
						ACS1207	B1	1617003-9	129.6	12/17/2016 12:35	44	10007	8.08	0.4271	3.540545	1236.572	3774.84	0.3276	0.7670	0.7883	-2.7%	0.0043	0.0039
						ACS1207	B3	1617003-9	129.6	12/17/2016 12:51	19	10009	8.3	0.4171	2.155157	1203.7	3774.84	0.3189	0.7645	0.7883	-3.0%	0.0018	0.0039
						ACS1207	B4	1617003-9	129.6	12/17/2016 13:07	38	10012	8.52	0.3964	4.302094	1173.292	3774.84	0.3108	0.7841	0.7883	-0.5%	0.0037	0.0039
						ACS1207	C1	1617003-9	129.6	12/17/2016 13:20	24	10006	8.44	0.3974	2.719602	1183.544	3774.83	0.3135	0.7890	0.7883	0.1%	0.0023	0.0039
						ACS1207	C3	1617003-9	129.6	12/17/2016 9:13	17	9999	8.09	0.4191	1.98636	1234.247	3774.88	0.3270	0.7802	0.7883	-1.0%	0.0016	0.0039
						ACS1207	A1	1617003-10	139	12/17/2016 11:23	17	10004	8.57	0.3942	1.861664	1165.196	3774.85	0.3087	0.7830	0.7780	0.6%	0.0016	0.0039
						ACS1207	A2	1617003-10	139	12/17/2016 11:38	25	10015	8.56	0.3972	2.764561	1167.948	3774.85	0.3094	0.7790	0.7780	0.1%	0.0024	0.0039
						ACS1207	A3	1617003-10	139	12/17/2016 11:51	7	9999	8.47	0.4040	0.702446	1178.229	3774.85	0.3121	0.7726	0.7780	-0.7%	0.0006	0.0039
						ACS1207	A4	1617003-10	139	12/17/2016 12:09	20	10001	8.43	0.3921	2.27479	1184.269	3774.85	0.3137	0.8001	0.7780	2.8%	0.0019	0.0039
						ACS1207	B1	1617003-10	139	12/17/2016 12:21	32	10008	7.96	0.4271	3.915101	1255.368	3774.84	0.3326	0.7787	0.7780	0.1%	0.0031	0.0039
						ACS1207	B3	1617003-10	139	12/17/2016 12:35	8	10006	8.11	0.4171	0.852436	1231.581	3774.84	0.3263	0.7822	0.7780	0.5%	0.0007	0.0039
						ACS1207	B4	1617003-10	139	12/17/2016 12:51	42	10004	8.62	0.3964	4.714339	1158.732	3774.84	0.3070	0.7744	0.7780	-0.5%	0.0041	0.0039
						ACS1207	C1	1617003-10	139	12/17/2016 13:06	35	10010	8.21	0.3974	4.139094	1217.244	3774.84	0.3225	0.8114	0.7780	4.3%	0.0034	0.0039
						ACS1207	C3	1617003-10	139	12/17/2016 13:20	20	10004	8.12	0.4191	2.348054	1230.297	3774.83	0.3259	0.7777	0.7780	0.0%	0.0019	0.0039

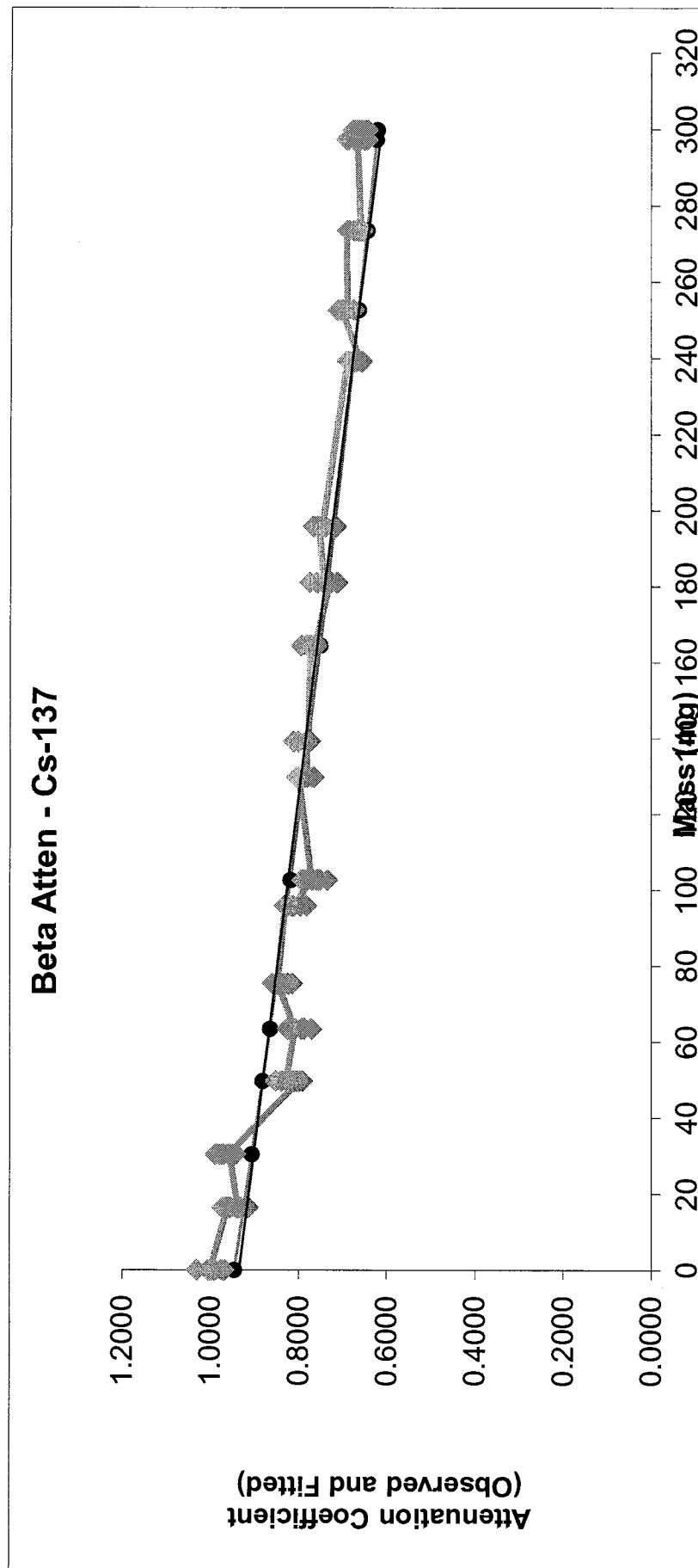
## LB4100A Beta Attenuation Curve -- Cs-137

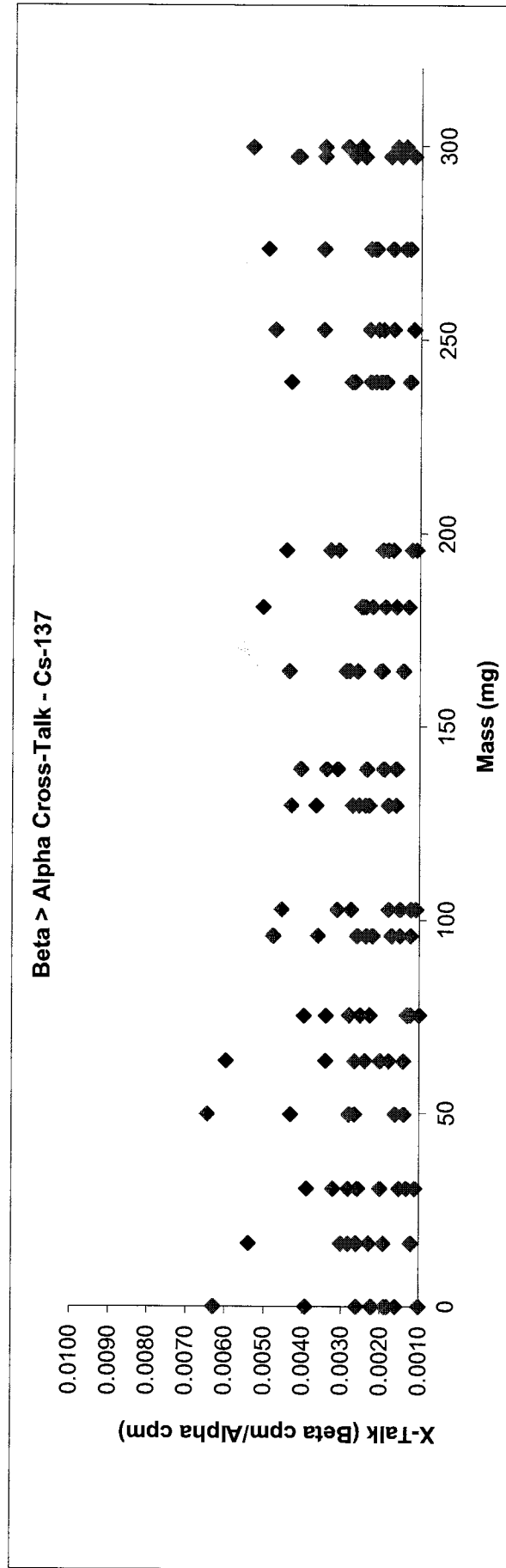
WO #:		1617003		Calibrated Mass Range		Attenuation Equation		Cross-Talk Equation										
Nucclide:		Cs-137		Low		b = 0.9455		b = 1.6183E-06										
Std. ID:		1019.4095.83		0.0		m = 0.9886		m = 0.0037										
Ref. Date:		02/09/15		High		a = 1.0026		% Diff Max. = 86.7%										
Half-life:		30.1		mg		% Diff Max. = 10.9%												
Activity:		3937.1		mg														
Vol.:		1																
File ID	Detector ID	Sample ID	Mass (mg)	Count Date	Alpha Counts	Beta Counts	Count Time	Base Beta Eff.	Alpha CPM	Beta CPM	Decay Corr. added dpm/mL	Beta Obs. Atten. Eff.	Obs. Atten. Fact.	Fitted Atten. Fact.	% Diff.	$\beta > \alpha$ XTLLK Observed	$\beta > \alpha$ XTLLK Fitted	% Diff.
ACSI207	A1	1617003-11	164.4	12/17/2016 11:10	21	10015	8.69	0.3942	2.294571	1150.342	3774.86	0.3047	0.7731	0.7508	3.0%	0.0020	0.0039	-49.4%
ACSI207	A2	1617003-11	164.4	12/17/2016 11:23	21	10011	8.57	0.3972	2.294408	1166.116	3774.85	0.3089	0.7777	0.7508	3.6%	0.0020	0.0039	-50.1%
ACSI207	A3	1617003-11	164.4	12/17/2016 11:38	11	10017	8.27	0.4040	1.206109	1208.955	3774.85	0.3203	0.7927	0.7508	5.6%	0.0010	0.0039	-74.7%
ACSI207	A4	1617003-11	164.4	12/17/2016 11:51	15	10004	8.64	0.3921	1.641111	1155.781	3774.85	0.3062	0.7809	0.7508	4.0%	0.0014	0.0039	-64.0%
ACSI207	B1	1617003-11	164.4	12/17/2016 12:09	29	10014	8.1	0.4271	3.475247	1234.378	3774.85	0.3270	0.7656	0.7508	2.0%	0.0028	0.0039	-28.6%
ACSI207	B3	1617003-11	164.4	12/17/2016 12:21	11	10012	8.4	0.4171	1.175524	1189.701	3774.84	0.3152	0.7556	0.7508	0.6%	0.0010	0.0039	-74.9%
ACSI207	B4	1617003-11	164.4	12/17/2016 12:35	45	10003	8.65	0.3964	5.044312	1154.591	3774.84	0.3059	0.7716	0.7508	2.8%	0.0044	0.0039	10.8%
ACSI207	C1	1617003-11	164.4	12/17/2016 12:51	30	10007	8.52	0.3974	3.397127	1172.53	3774.84	0.3106	0.7816	0.7508	4.1%	0.0029	0.0039	-26.5%
ACSI207	C3	1617003-11	164.4	12/17/2016 13:07	27	10006	8.29	0.4191	3.141936	1205.273	3774.84	0.3193	0.7619	0.7508	1.5%	0.0026	0.0039	-33.9%
ACSI207	A1	1617003-12	181	12/17/2016 10:49	25	10015	9.21	0.3942	2.592441	1085.273	3774.86	0.2875	0.7293	0.7335	-0.6%	0.0024	0.0040	-39.8%
ACSI207	A2	1617003-12	181	12/17/2016 11:10	26	10022	8.81	0.3972	2.795192	1135.542	3774.86	0.3008	0.7573	0.7335	3.2%	0.0025	0.0040	-38.0%
ACSI207	A3	1617003-12	181	12/17/2016 11:23	14	10015	8.98	0.4040	1.43502	1112.966	3774.85	0.2948	0.7298	0.7335	-0.5%	0.0013	0.0040	-67.5%
ACSI207	A4	1617003-12	181	12/17/2016 11:38	23	10014	8.71	0.3921	2.545643	1147.624	3774.85	0.3040	0.7754	0.7335	5.7%	0.0022	0.0040	-44.1%
ACSI207	B1	1617003-12	181	12/17/2016 11:51	26	10011	8.55	0.4271	2.935936	1168.959	3774.85	0.3097	0.7251	0.7335	-1.2%	0.0025	0.0040	-36.7%
ACSI207	B3	1617003-12	181	12/17/2016 12:10	11	10013	8.91	0.4171	1.100568	1121.589	3774.85	0.2971	0.7124	0.7335	-2.9%	0.0010	0.0040	-75.3%
ACSI207	B4	1617003-12	181	12/17/2016 12:22	52	10008	9.07	0.3964	5.575186	1101.593	3774.84	0.2918	0.7362	0.7335	0.4%	0.0051	0.0040	27.5%
ACSI207	C1	1617003-12	181	12/17/2016 12:36	20	10001	8.93	0.3974	2.115642	1117.932	3774.84	0.2962	0.7452	0.7335	1.6%	0.0019	0.0040	-52.3%
ACSI207	C3	1617003-12	181	12/17/2016 12:51	17	10001	8.51	0.4191	1.89285	1173.483	3774.84	0.3109	0.7418	0.7335	1.1%	0.0016	0.0040	-59.6%
ACSI207	A1	1617003-13	195.7	12/17/2016 10:37	18	10008	8.92	0.3942	1.895937	1119.841	3774.86	0.2967	0.7526	0.7186	4.7%	0.0017	0.0040	-57.6%
ACSI207	A2	1617003-13	195.7	12/17/2016 10:48	21	10011	8.81	0.3972	2.227655	1134.293	3774.86	0.3005	0.7565	0.7186	5.3%	0.0020	0.0040	-50.8%
ACSI207	A3	1617003-13	195.7	12/17/2016 11:10	9	10008	8.83	0.4040	0.895253	1131.119	3774.86	0.2996	0.7417	0.7186	3.2%	0.0008	0.0040	-80.2%
ACSI207	A4	1617003-13	195.7	12/17/2016 11:23	19	10010	8.81	0.3921	2.06164	1134.12	3774.85	0.3004	0.7662	0.7186	6.6%	0.0018	0.0040	-54.5%
ACSI207	B1	1617003-13	195.7	12/17/2016 11:38	34	10007	8.64	0.4271	3.830185	1156.3	3774.85	0.3063	0.7172	0.7186	-0.2%	0.0033	0.0040	-17.0%
ACSI207	B3	1617003-13	195.7	12/17/2016 11:51	12	10002	8.87	0.4171	1.218875	1125.417	3774.85	0.2981	0.7148	0.7186	-0.5%	0.0011	0.0040	-72.9%
ACSI207	B4	1617003-13	195.7	12/17/2016 12:10	46	10011	9.04	0.3964	4.930496	1105.587	3774.85	0.2929	0.7389	0.7186	2.8%	0.0045	0.0040	11.7%
ACSI207	C1	1617003-13	195.7	12/17/2016 12:22	32	10006	8.77	0.3974	3.524803	1138.934	3774.84	0.3017	0.7592	0.7186	5.7%	0.0031	0.0040	-22.5%
ACSI207	C3	1617003-13	195.7	12/17/2016 12:35	13	10008	8.47	0.4191	1.419829	1179.859	3774.84	0.3126	0.7458	0.7186	3.8%	0.0012	0.0040	-69.9%
ACSI207	A1	1617003-14	239.1	12/17/2016 10:22	24	10000	9.73	0.3942	2.344598	1025.617	3774.86	0.2717	0.6892	0.6761	1.9%	0.0023	0.0041	-43.7%
ACSI207	A2	1617003-14	239.1	12/17/2016 10:38	23	10002	9.87	0.3972	2.174294	1011.345	3774.86	0.2679	0.6745	0.6761	-0.2%	0.0021	0.0041	-47.1%
ACSI207	A3	1617003-14	239.1	12/17/2016 10:49	11	10017	9.64	0.4040	1.017079	1036.818	3774.86	0.2747	0.6799	0.6761	0.6%	0.0010	0.0041	-75.9%
ACSI207	A4	1617003-14	239.1	12/17/2016 11:11	21	10003	9.8	0.3921	2.047857	1018.625	3774.86	0.2698	0.6882	0.6761	1.8%	0.0020	0.0041	-50.5%
ACSI207	B1	1617003-14	239.1	12/17/2016 11:24	28	10011	9.43	0.4271	2.864247	1059.694	3774.85	0.2807	0.6573	0.6761	-2.8%	0.0027	0.0041	-33.5%
ACSI207	B3	1617003-14	239.1	12/17/2016 11:39	14	10006	9.61	0.4171	1.322816	1039.003	3774.85	0.2752	0.6599	0.6761	-2.4%	0.0013	0.0041	-68.7%
ACSI207	B4	1617003-14	239.1	12/17/2016 11:52	45	10009	10.18	0.3964	4.262432	981.3774	3774.85	0.2600	0.6558	0.6761	-3.0%	0.0043	0.0041	6.9%
ACSI207	C1	1617003-14	239.1	12/17/2016 12:11	29	10004	9.94	0.3974	2.793505	1004.438	3774.85	0.2661	0.6696	0.6761	-1.0%	0.0028	0.0041	-31.5%
ACSI207	C3	1617003-14	239.1	12/17/2016 12:22	20	10003	9.57	0.4191	1.974864	1043.523	3774.84	0.2764	0.6596	0.6761	-2.4%	0.0019	0.0041	-53.4%
ACSI207	A1	1617003-15	252.6	12/17/2016 10:09	22	10015	9.57	0.3942	2.176851	1044.367	3774.87	0.2767	0.7018	0.6635	5.8%	0.0021	0.0041	-49.0%
ACSI207	A2	1617003-15	252.6	12/17/2016 10:22	21	10008	9.39	0.3972	2.080422	1063.786	3774.86	0.2818	0.7095	0.6635	6.9%	0.0020	0.0041	-52.1%
ACSI207	A3	1617003-15	252.6	12/17/2016 10:37	11	10012	9.21	0.4040	1.070354	1084.789	3774.86	0.2874	0.7113	0.6635	7.2%	0.0010	0.0041	-75.8%
ACSI207	A4	1617003-15	252.6	12/17/2016 10:49	24	10007	9.65	0.3921	2.392047	1034.906	3774.86	0.2742	0.6992	0.6635	5.4%	0.0023	0.0041	-43.4%
ACSI207	B1	1617003-15	252.6	12/17/2016 11:10	36	10009	9.2	0.4271	3.808043	1086.017	3774.86	0.2877	0.6736	0.6635	1.5%	0.0035	0.0041	-14.2%
ACSI207	B3	1617003-15	252.6	12/17/2016 11:24	13	10003	9.39	0.4171	1.250452	1063.078	3774.85	0.2816	0.6752	0.6635	1.8%	0.0012	0.0041	-71.2%
ACSI207	B4	1617003-15	252.6	12/17/2016 11:39	49	10002	9.59	0.3964	4.951489	1041.136	3774.85	0.2758	0.6958	0.6635	4.9%	0.0048	0.0041	16.4%
ACSI207	C1	1617003-15	252.6	12/17/2016 11:52	22	10005	9.39	0.3974	2.218918	1063.494	3774.85	0.2817	0.7089	0.6635	6.9%	0.0021	0.0041	-48.9%
ACSI207	C3	1617003-15	252.6	12/17/2016 12:10	18	10005	9.15	0.4191	1.852213	1091.72	3774.85	0.2892	0.6901	0.6635	4.0%	0.0017	0.0041	-58.5%

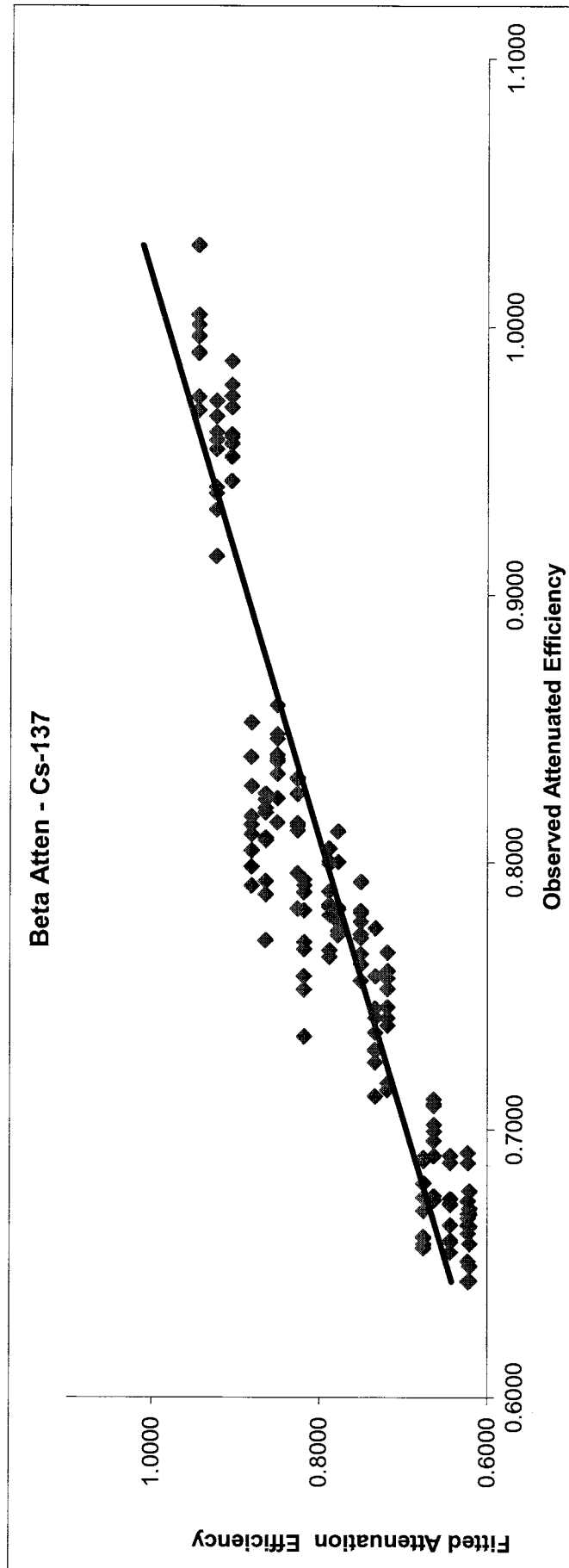
# LB4100A Beta Attenuation Curve -- Cs-137

WO #:		1617003	
Nuclide:		Cs-137	
Std. ID:		1019.4095.83	
Ref. Date:		02/09/15	
Half-life:		30.1 yrs	
Activity:		3937.1 dpm/mL	
Vol.:		1 mL	
Calibrated Mass Range		<div>Low 0.0 mg</div> <div>High 299.7 mg</div>	
Attenuation Equation		$y = b \cdot m^a (a \cdot x)$ <div>b = 0.9455</div> <div>m = 0.9986</div> <div>a = 1.0026</div> <div>% Diff Max. = 10.9%</div>	
Cross-Talk Equation		$y = b \cdot x^m$ <div>b = 1.6183E-06</div> <div>m = 0.0037</div> <div>% Diff Max. = 86.7%</div>	

File ID	Detector ID	Sample ID	Mass (mg)	Count Date	Alpha Counts	Beta Counts	Count Time	Base Beta Eff.	Alpha CPM	Beta CPM	Decay Corr. added dpm/mL	Beta Obs. Atten. Eff.	Obs. Atten. Fact.	Fitted Atten. Fact.	% Diff.	$\beta > \alpha$ XTLLK Observed	$\beta > \alpha$ XTLLK Fitted	% Diff.
ACSI1207	A1	1617003-16	273.4	12/7/2016 9:55	24	10004	9.72	0.3942	2.347136	1027.086	3774.87	0.2721	0.6902	0.6444	7.1%	0.0023	0.0041	-44.5%
ACSI1207	A2	1617003-16	273.4	12/7/2016 10:09	23	10013	9.92	0.3972	2.162548	1007.346	3774.87	0.2669	0.6718	0.6444	4.3%	0.0021	0.0041	-47.9%
ACSI1207	A3	1617003-16	273.4	12/7/2016 10:22	14	10001	9.85	0.4040	1.29732	1013.04	3774.86	0.2684	0.6643	0.6444	3.1%	0.0013	0.0041	-68.9%
ACSI1207	A4	1617003-16	273.4	12/7/2016 10:37	18	10005	9.81	0.3921	1.739862	1017.789	3774.86	0.2696	0.6876	0.6444	6.7%	0.0017	0.0041	-58.5%
ACSI1207	B1	1617003-16	273.4	12/7/2016 10:49	36	10008	9.47	0.4271	3.698478	1054.993	3774.86	0.2795	0.6543	0.6444	1.5%	0.0035	0.0041	-14.9%
ACSI1207	B3	1617003-16	273.4	12/7/2016 11:10	15	10005	9.43	0.4171	1.456668	1058.772	3774.86	0.2805	0.6725	0.6444	4.4%	0.0014	0.0041	-66.6%
ACSI1207	B4	1617003-16	273.4	12/7/2016 11:25	51	10004	10.14	0.3964	4.871586	984.7628	3774.85	0.2609	0.6581	0.6444	2.1%	0.0049	0.0041	20.1%
ACSI1207	C1	1617003-16	273.4	12/7/2016 11:39	23	10001	9.87	0.3974	2.206294	1011.272	3774.85	0.2679	0.6741	0.6444	4.6%	0.0022	0.0041	-47.0%
ACSI1207	C3	1617003-16	273.4	12/7/2016 11:52	14	10009	9.59	0.4191	1.344854	1041.968	3774.85	0.2760	0.6586	0.6444	2.2%	0.0013	0.0041	-68.7%
ACSI1207	A1	1617003-17	297.2	12/7/2016 9:43	19	10004	10.06	0.3942	1.766668	992.3014	3774.87	0.2629	0.6668	0.6232	7.0%	0.0018	0.0042	-57.2%
ACSI1207	A2	1617003-17	297.2	12/7/2016 9:56	26	10011	10.03	0.3972	2.436223	996.0767	3774.87	0.2639	0.6643	0.6232	6.6%	0.0024	0.0042	-41.2%
ACSI1207	A3	1617003-17	297.2	12/7/2016 10:09	13	10016	9.91	0.4040	1.187806	1008.406	3774.87	0.2671	0.6612	0.6232	6.1%	0.0012	0.0042	-71.7%
ACSI1207	A4	1617003-17	297.2	12/7/2016 10:22	16	10006	9.76	0.3921	1.544344	1023.116	3774.86	0.2710	0.6912	0.6232	10.9%	0.0015	0.0042	-63.7%
ACSI1207	B1	1617003-17	297.2	12/7/2016 10:37	43	10006	9.52	0.4271	4.411807	1049.132	3774.86	0.2779	0.6507	0.6232	4.4%	0.0042	0.0042	1.2%
ACSI1207	B3	1617003-17	297.2	12/7/2016 10:49	11	10009	9.86	0.4171	0.981619	1012.908	3774.86	0.2683	0.6433	0.6232	3.2%	0.0010	0.0042	-76.7%
ACSI1207	B4	1617003-17	297.2	12/7/2016 11:11	43	10003	9.91	0.3964	4.181051	1007.559	3774.86	0.2669	0.6733	0.6232	8.0%	0.0041	0.0042	-0.2%
ACSI1207	C1	1617003-17	297.2	12/7/2016 11:24	36	10003	9.68	0.3974	3.595008	1031.367	3774.85	0.2732	0.6875	0.6232	10.3%	0.0035	0.0042	-16.1%
ACSI1207	C3	1617003-17	297.2	12/7/2016 11:39	28	10012	9.45	0.4191	2.847963	1057.748	3774.85	0.2802	0.6686	0.6232	7.3%	0.0027	0.0042	-35.2%
ACSI1207	A1	1617003-18	299.7	12/7/2016 9:28	36	10006	10.01	0.3942	3.474404	997.4684	3774.87	0.2642	0.6703	0.6211	7.9%	0.0035	0.0042	-16.3%
ACSI1207	A2	1617003-18	299.7	12/7/2016 9:42	27	10002	9.96	0.3972	2.554843	1002.188	3774.87	0.2655	0.6684	0.6211	7.6%	0.0025	0.0042	-38.7%
ACSI1207	A3	1617003-18	299.7	12/7/2016 9:55	10	10004	9.79	0.4040	0.89745	1019.569	3774.87	0.2701	0.6685	0.6211	7.6%	0.0009	0.0042	-78.8%
ACSI1207	A4	1617003-18	299.7	12/7/2016 10:09	17	10000	9.96	0.3921	1.611827	1001.927	3774.87	0.2654	0.6769	0.6211	9.0%	0.0016	0.0042	-61.3%
ACSI1207	B1	1617003-18	299.7	12/7/2016 10:22	30	10002	9.42	0.4271	3.079713	1059.865	3774.86	0.2808	0.6574	0.6211	5.8%	0.0029	0.0042	-30.2%
ACSI1207	B3	1617003-18	299.7	12/7/2016 10:38	9	10002	9.85	0.4171	0.779706	1013.227	3774.86	0.2884	0.6435	0.6211	3.6%	0.0008	0.0042	-81.5%
ACSI1207	B4	1617003-18	299.7	12/7/2016 10:50	55	10001	10.05	0.3964	5.314637	993.2994	3774.86	0.2631	0.6638	0.6211	6.9%	0.0054	0.0042	28.6%
ACSI1207	C1	1617003-18	299.7	12/7/2016 11:11	30	10007	9.93	0.3974	2.897148	1005.753	3774.86	0.2864	0.6704	0.6211	8.0%	0.0029	0.0042	-30.8%
ACSI1207	C3	1617003-18	299.7	12/7/2016 11:24	15	10007	9.73	0.4191	1.426624	1026.746	3774.85	0.2720	0.6490	0.6211	4.5%	0.0014	0.0042	-66.6%







Detector ID	Sample ID	Alpha	Beta	Guard	Count Time	Event	Voltage	TOD	ALPHA CPM	BETA CPM
A1	0	23	10011	4809	6.74	0	1402.5	12/7/16 9:11	3.290463	1483.18
A1	16.3	31	10008	5380	6.99	0	1402.5	12/7/16 13:19	4.312907	1429.628
A1	30.4	21	10006	5335	7.02	0	1402.5	12/7/16 13:05	2.869453	1423.224
A1	49.6	15	10008	6267	8.41	0	1402.5	12/7/16 12:51	1.661591	1187.88
A1	63.4	21	10012	6197	8.31	0	1402.5	12/7/16 12:35	2.405076	1202.681
A1	75.3	29	10003	5699	7.93	0	1402.5	12/7/16 12:21	3.534999	1259.28
A1	95.8	23	10010	5873	8.08	0	1402.5	12/7/16 12:09	2.724535	1236.729
A1	102.6	16	10010	6748	8.75	0	1402.5	12/7/16 11:51	1.706571	1141.868
A1	129.6	25	10007	6195	8.4	0	1402.5	12/7/16 11:38	2.85419	1189.178
A1	139	17	10004	6324	8.57	0	1402.5	12/7/16 11:23	1.861664	1165.196
A1	164.4	21	10015	6711	8.69	0	1402.5	12/7/16 11:10	2.294571	1150.342
A1	181	25	10015	7089	9.21	0	1402.5	12/7/16 10:49	2.592441	1085.273
A1	195.7	18	10008	6761	8.92	0	1402.5	12/7/16 10:37	1.895937	1119.841
A1	239.1	24	10000	7379	9.73	0	1402.5	12/7/16 10:22	2.344598	1025.617
A1	252.6	22	10015	7071	9.57	0	1402.5	12/7/16 10:09	2.176851	1044.367
A1	273.4	24	10004	7730	9.72	0	1402.5	12/7/16 9:55	2.347136	1027.086
A1	297.2	19	10004	7621	10.06	0	1402.5	12/7/16 9:43	1.766668	992.3014
A1	299.7	36	10006	7341	10.01	0	1402.5	12/7/16 9:28	3.474404	997.4684
A2	0	20	10008	4929	6.73	0	1402.5	12/7/16 9:25	2.815768	1485.044
A2	16.3	24	10012	4958	6.96	0	1402.5	12/7/16 9:11	3.292276	1436.477
A2	30.4	27	10021	5290	6.88	0	1402.5	12/7/16 13:19	3.768419	1454.512
A2	49.6	28	10012	6181	8.19	0	1402.5	12/7/16 13:06	3.262803	1220.437
A2	63.4	28	10001	6420	8.64	0	1402.5	12/7/16 12:51	3.084741	1155.494
A2	75.3	24	10016	5936	7.95	0	1402.5	12/7/16 12:35	2.862868	1257.845
A2	95.8	25	10010	5922	8.21	0	1402.5	12/7/16 12:21	2.889067	1217.216
A2	102.6	29	10009	6120	8.4	0	1402.5	12/7/16 12:09	3.296381	1189.519
A2	129.6	27	10011	6561	8.51	0	1402.5	12/7/16 11:51	3.016738	1174.352
A2	139	25	10015	6299	8.56	0	1402.5	12/7/16 11:38	2.764561	1167.948
A2	164.4	21	10011	6322	8.57	0	1402.5	12/7/16 11:23	2.294408	1166.116
A2	181	26	10022	6801	8.81	0	1402.5	12/7/16 11:10	2.795192	1135.542
A2	195.7	21	10011	6793	8.81	0	1402.5	12/7/16 10:48	2.227655	1134.293
A2	239.1	23	10002	7536	9.87	0	1402.5	12/7/16 10:38	2.174294	1011.345
A2	252.6	21	10008	7143	9.39	0	1402.5	12/7/16 10:22	2.080422	1063.786
A2	273.4	23	10013	7353	9.92	0	1402.5	12/7/16 10:09	2.162548	1007.346
A2	297.2	26	10011	7981	10.03	0	1402.5	12/7/16 9:56	2.436223	996.0767
A2	299.7	27	10002	7555	9.96	0	1402.5	12/7/16 9:42	2.554843	1002.188
A3	0	17	10017	4978	6.53	0	1402.5	12/7/16 9:39	2.479369	1531.707
A3	16.3	13	10011	4936	6.74	0	1402.5	12/7/16 9:25	1.804783	1483.022
A3	30.4	16	10013	4783	6.7	0	1402.5	12/7/16 9:11	2.26406	1492.188
A3	49.6	9	10010	6333	8.28	0	1402.5	12/7/16 13:20	0.962957	1206.647
A3	63.4	6	10014	5996	7.94	0	1402.5	12/7/16 13:06	0.631668	1258.919
A3	75.3	11	10017	5875	7.87	0	1402.5	12/7/16 12:50	1.273713	1270.518
A3	95.8	16	10013	5926	7.94	0	1402.5	12/7/16 12:35	1.891113	1258.793
A3	102.6	13	10012	6046	8.38	0	1402.5	12/7/16 12:21	1.427313	1192.459
A3	129.6	10	10014	5954	8.19	0	1402.5	12/7/16 12:09	1.097001	1220.421
A3	139	7	9999	6535	8.47	0	1402.5	12/7/16 11:51	0.702446	1178.229
A3	164.4	11	10017	6090	8.27	0	1402.5	12/7/16 11:38	1.206109	1208.955
A3	181	14	10015	6601	8.98	0	1402.5	12/7/16 11:23	1.43502	1112.966
A3	195.7	9	10008	6813	8.83	0	1402.5	12/7/16 11:10	0.895253	1131.119
A3	239.1	11	10017	7425	9.64	0	1402.5	12/7/16 10:49	1.017079	1036.818
A3	252.6	11	10012	6989	9.21	0	1402.5	12/7/16 10:37	1.070354	1084.789
A3	273.4	14	10001	7476	9.85	0	1402.5	12/7/16 10:22	1.29732	1013.04
A3	297.2	13	10016	7344	9.91	0	1402.5	12/7/16 10:09	1.187806	1008.406
A3	299.7	10	10004	7789	9.79	0	1402.5	12/7/16 9:55	0.89745	1019.569
A4	0	23	10003	5337	6.55	0	1402.5	12/7/16 9:52	3.41645	1525.087
A4	16.3	27	10016	5371	7.08	0	1402.5	12/7/16 9:40	3.718559	1412.6
A4	30.4	14	10022	5089	6.94	0	1402.5	12/7/16 9:25	1.922291	1442.003
A4	49.6	9	10006	5712	8.04	0	1402.5	12/7/16 9:13	1.024403	1242.438
A4	63.4	21	10011	6264	8.2	0	1402.5	12/7/16 13:20	2.465976	1218.765
A4	75.3	13	10019	5950	7.87	0	1402.5	12/7/16 13:06	1.556842	1270.973
A4	95.8	13	10013	6096	8.18	0	1402.5	12/7/16 12:51	1.494242	1221.994
A4	102.6	13	10011	6371	8.56	0	1402.5	12/7/16 12:35	1.423692	1167.42
A4	129.6	28	10003	6046	8.38	0	1402.5	12/7/16 12:21	3.246289	1191.586

A4	139	20	10001	6133	8.43	0	1402.5	12/7/16 12:09	2.277479	1184.269
A4	164.4	15	10004	6672	8.64	0	1402.5	12/7/16 11:51	1.641111	1155.781
A4	181	23	10014	6415	8.71	0	1402.5	12/7/16 11:38	2.545643	1147.624
A4	195.7	19	10010	6481	8.81	0	1402.5	12/7/16 11:23	2.06164	1134.12
A4	239.1	21	10003	7554	9.8	0	1402.5	12/7/16 11:11	2.047857	1018.625
A4	252.6	24	10007	7435	9.65	0	1402.5	12/7/16 10:49	2.392047	1034.906
A4	273.4	18	10005	7489	9.81	0	1402.5	12/7/16 10:37	1.739862	1017.789
A4	297.2	16	10006	7398	9.76	0	1402.5	12/7/16 10:22	1.544344	1023.116
A4	299.7	17	10000	7388	9.96	0	1402.5	12/7/16 10:09	1.611827	1001.927
B1	0	40	10011	4660	6.4	0	1500	12/7/16 10:06	6.145	1562.301
B1	16.3	29	10009	4985	6.78	0	1500	12/7/16 9:52	4.172286	1474.336
B1	30.4	29	10015	4810	6.52	0	1500	12/7/16 9:39	4.342853	1534.125
B1	49.6	44	10014	5517	7.59	0	1500	12/7/16 9:26	5.692101	1317.45
B1	63.4	35	10011	5729	7.82	0	1500	12/7/16 9:12	4.370703	1278.261
B1	75.3	26	10012	5555	7.61	0	1500	12/7/16 13:19	3.311557	1313.719
B1	95.8	37	10007	5615	7.92	0	1500	12/7/16 13:06	4.566717	1261.592
B1	102.6	32	10002	6293	8.43	0	1500	12/7/16 12:51	3.690967	1184.559
B1	129.6	44	10007	5953	8.08	0	1500	12/7/16 12:35	5.340545	1236.572
B1	139	32	10008	5814	7.96	0	1500	12/7/16 12:21	3.915101	1255.368
B1	164.4	29	10014	5919	8.1	0	1500	12/7/16 12:09	3.475247	1234.378
B1	181	26	10011	6234	8.55	0	1500	12/7/16 11:51	2.935936	1168.959
B1	195.7	34	10007	6474	8.64	0	1500	12/7/16 11:38	3.830185	1156.3
B1	239.1	28	10011	6973	9.43	0	1500	12/7/16 11:24	2.864247	1059.694
B1	252.6	36	10009	6720	9.2	0	1500	12/7/16 11:10	3.808043	1086.017
B1	273.4	36	10008	6961	9.47	0	1500	12/7/16 10:49	3.696478	1054.893
B1	297.2	43	10006	6984	9.52	0	1500	12/7/16 10:37	4.411807	1049.132
B1	299.7	30	10002	6836	9.42	0	1500	12/7/16 10:22	3.079713	1059.865
B3	0	11	10008	4622	6.41	0	1500	12/7/16 10:19	1.582069	1559.106
B3	16.3	13	10022	4957	6.82	0	1500	12/7/16 10:06	1.772158	1467.297
B3	30.4	12	10003	4948	6.73	0	1500	12/7/16 9:52	1.649061	1484.126
B3	49.6	11	10010	5803	7.89	0	1500	12/7/16 9:40	1.26017	1266.491
B3	63.4	19	10003	5839	8.05	0	1500	12/7/16 9:26	2.226248	1240.405
B3	75.3	14	10002	5532	7.55	0	1500	12/7/16 9:12	1.720305	1322.564
B3	95.8	9	10005	5805	7.97	0	1500	12/7/16 13:20	0.995235	1253.128
B3	102.6	12	10004	5948	8.43	0	1500	12/7/16 13:07	1.289488	1184.51
B3	129.6	19	10009	6198	8.3	0	1500	12/7/16 12:51	2.155157	1203.7
B3	139	8	10006	5976	8.11	0	1500	12/7/16 12:35	0.852436	1231.581
B3	164.4	11	10012	6154	8.4	0	1500	12/7/16 12:21	1.175524	1189.701
B3	181	11	10013	6499	8.91	0	1500	12/7/16 12:10	1.100568	1121.589
B3	195.7	12	10002	6476	8.87	0	1500	12/7/16 11:51	1.218875	1125.417
B3	239.1	14	10006	7210	9.61	0	1500	12/7/16 11:39	1.322816	1039.003
B3	252.6	13	10003	6950	9.39	0	1500	12/7/16 11:24	1.250452	1063.078
B3	273.4	15	10005	6884	9.43	0	1500	12/7/16 11:10	1.456668	1058.772
B3	297.2	11	10009	7257	9.86	0	1500	12/7/16 10:49	0.981619	1012.908
B3	299.7	9	10002	7236	9.85	0	1500	12/7/16 10:38	0.779706	1013.227
B4	0	64	10009	5023	6.86	0	1500	12/7/16 10:35	9.171446	1457.213
B4	16.3	55	10003	5131	7.1	0	1500	12/7/16 10:20	7.588479	1407.048
B4	30.4	40	10001	5058	6.96	0	1500	12/7/16 10:06	5.589126	1435.1
B4	49.6	66	10019	6053	8.25	0	1500	12/7/16 9:54	7.842	1212.599
B4	63.4	61	10011	5994	8.16	0	1500	12/7/16 9:41	7.31749	1225.013
B4	75.3	41	10014	5881	8.11	0	1500	12/7/16 9:26	4.897487	1232.947
B4	95.8	49	10009	6004	8.21	0	1500	12/7/16 9:13	5.810331	1217.298
B4	102.6	47	10000	6439	8.81	0	1500	12/7/16 13:21	5.176847	1133.249
B4	129.6	38	10012	6016	8.52	0	1500	12/7/16 13:07	4.302094	1173.292
B4	139	42	10004	6432	8.62	0	1500	12/7/16 12:51	4.71439	1158.732
B4	164.4	45	10003	6396	8.65	0	1500	12/7/16 12:35	5.044312	1154.591
B4	181	52	10008	6637	9.07	0	1500	12/7/16 12:22	5.575186	1101.593
B4	195.7	46	10011	6610	9.04	0	1500	12/7/16 12:10	4.930496	1105.587
B4	239.1	45	10009	7399	10.18	0	1500	12/7/16 11:52	4.262432	981.3774
B4	252.6	49	10002	7200	9.59	0	1500	12/7/16 11:39	4.951489	1041.136
B4	273.4	51	10004	7507	10.14	0	1500	12/7/16 11:25	4.871586	984.7628
B4	297.2	43	10003	7240	9.91	0	1500	12/7/16 11:11	4.181051	1007.559
B4	299.7	55	10001	7394	10.05	0	1500	12/7/16 10:50	5.314637	993.2994
C1	0	27	10019	4903	6.64	0	1530	12/7/16 10:46	3.942265	1506.885
C1	16.3	27	10007	5049	6.89	0	1530	12/7/16 10:35	3.794723	1450.394

C1	30.4	33	10010	4919	6.75	0	1530	12/7/16 10:19	4.764889	1480.962
C1	49.6	29	10013	5686	7.82	0	1530	12/7/16 10:07	3.58444	1278.434
C1	63.4	25	10009	5974	8.12	0	1530	12/7/16 9:54	2.954818	1230.634
C1	75.3	35	10006	5832	7.95	0	1530	12/7/16 9:40	4.278516	1256.615
C1	95.8	27	10009	5867	8.01	0	1530	12/7/16 9:26	3.246787	1247.562
C1	102.6	19	10000	6112	8.41	0	1530	12/7/16 9:13	2.135215	1187.06
C1	129.6	24	10006	6243	8.44	0	1530	12/7/16 13:20	2.719602	1183.544
C1	139	35	10010	5891	8.21	0	1530	12/7/16 13:06	4.139094	1217.244
C1	164.4	30	10007	6371	8.52	0	1530	12/7/16 12:51	3.397127	1172.53
C1	181	20	10001	6658	8.93	0	1530	12/7/16 12:36	2.115642	1117.932
C1	195.7	32	10006	6381	8.77	0	1530	12/7/16 12:22	3.524803	1138.934
C1	239.1	29	10004	7391	9.94	0	1530	12/7/16 12:11	2.793505	1004.438
C1	252.6	22	10005	6858	9.39	0	1530	12/7/16 11:52	2.218918	1063.494
C1	273.4	23	10001	7317	9.87	0	1530	12/7/16 11:39	2.206294	1011.272
C1	297.2	36	10003	7128	9.68	0	1530	12/7/16 11:24	3.595008	1031.367
C1	299.7	30	10007	7298	9.93	0	1530	12/7/16 11:11	2.897148	1005.753
C3	0	19	10002	4665	6.31	0	1530	12/7/16 11:07	2.896094	1583.38
C3	16.3	20	10014	4970	6.74	0	1530	12/7/16 10:46	2.852359	1484.034
C3	30.4	33	10019	4836	6.59	0	1530	12/7/16 10:34	4.892587	1518.611
C3	49.6	17	10011	5590	7.63	0	1530	12/7/16 10:20	2.113047	1310.335
C3	63.4	15	10011	5674	7.81	0	1530	12/7/16 10:07	1.805615	1280.095
C3	75.3	14	10019	5450	7.46	0	1530	12/7/16 9:53	1.761676	1341.306
C3	95.8	18	10013	5689	7.76	0	1530	12/7/16 9:40	2.204588	1288.612
C3	102.6	16	10004	6002	8.2	0	1530	12/7/16 9:26	1.83622	1218.277
C3	129.6	17	9999	5885	8.09	0	1530	12/7/16 9:13	1.98636	1234.247
C3	139	20	10004	6004	8.12	0	1530	12/7/16 13:20	2.348054	1230.297
C3	164.4	27	10006	5943	8.29	0	1530	12/7/16 13:07	3.141936	1205.273
C3	181	17	10001	6360	8.51	0	1530	12/7/16 12:51	1.88265	1173.483
C3	195.7	13	10008	6277	8.47	0	1530	12/7/16 12:35	1.419829	1179.859
C3	239.1	20	10003	6957	9.57	0	1530	12/7/16 12:22	1.974864	1043.523
C3	252.6	18	10005	6790	9.15	0	1530	12/7/16 12:10	1.852213	1091.72
C3	273.4	14	10009	7016	9.59	0	1530	12/7/16 11:52	1.344854	1041.968
C3	297.2	28	10012	7017	9.45	0	1530	12/7/16 11:39	2.847963	1057.748
C3	299.7	15	10007	7158	9.73	0	1530	12/7/16 11:24	1.426624	1026.746

Date

12/2/16

SOP 724r

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## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100A

## Instrument Daily Response and Background Checks

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									OL
7									P
8									
9									
10									OL
11									P
12									OL
13	OL				OL				
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

## Weekly Background Calibration

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK1201W			
Dr B				
Dr C				
Dr D	OL			

Dr = Drawer

## Gas Supply

P-10 Supply		P-10 Flow	
Tank 1	9	Dr A	10
		Dr B	
Tank 2	2050	Dr C	
		Dr D	

## Comments:

12 | 7 | 16

SOP 7241

# ALS

# Low Background Gas Flow Proportional Counter Log

**Instrument: LB4100A**

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-12	Daily EF	—	—	30	7:08	JP	EFAI207	JJ
7-12	Daily BK <sub>s</sub>	—	—	60	7:20	JF	BKA1207	JJ
1-4	GZE	AB150603-5	Tn230	30	8:27	JF	ETH1207A	JF
5,7,8			EF		9:40	JF	B	
9,11					9:51	JF	C	
9,11	G29	AB150310-2	C137		8:28	JM	ECS1207C	
1-4			EF		9:40	JF	A	
5,7,8					8:52	JM	B	
1-4, 5	IL617003-1-18	AB160510-2	G13AHn	30	9:04	JF	ACS1207	
7-9,11								
JP 12/8/04								

Comments:

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Reviewed By / Date

JP 12/8/16

Date 12/8/16SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100A**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13	OL				OL				
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKA1201W			
Dr B				
Dr C				
Dr D	OL			

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	0	Dr A	LO
		Dr B	
Tank 2	16/16	Dr C	
		Dr D	

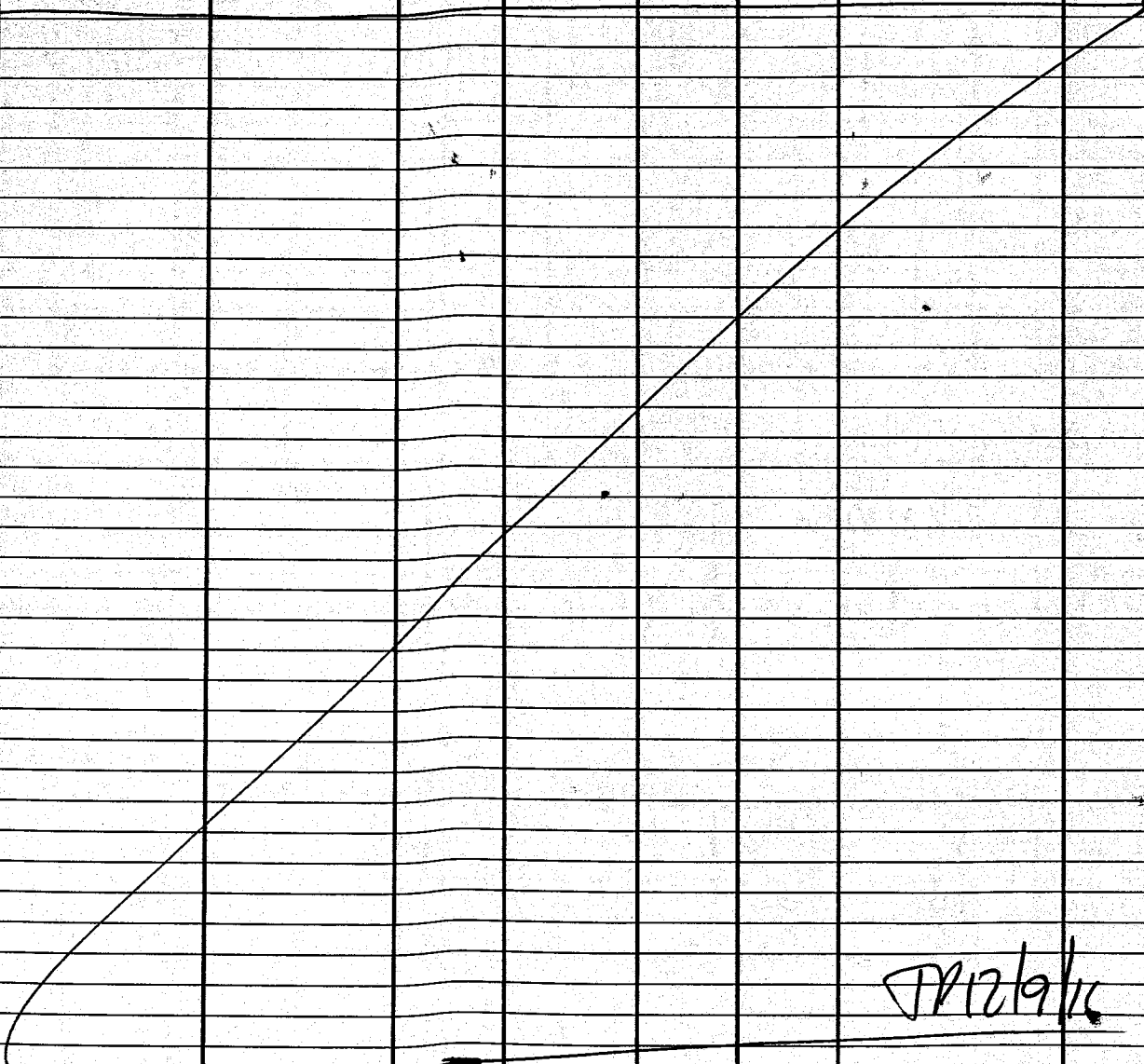
Comments:

Date 12/8/16SOP 724r 16

ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: **LB4100A**

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-12	Daily EFP	---	---	30	7:09	JP	EFA1208	JP
1-12	Daily BKGs	---	---	60	7:22	JP	BKA1208	JP
1	1611044-6	RA161205-1	RA224	90	9:04	SKB	RAA1208	7
2	1611061-6	↓	↓	↓	↓	↓	↓	
3	-7							
4	1611085-3							
5	1611141-2							
7	RA161205-1 MB							
9	LCS							
11	LSSD							
1-5,7,9,11	1518004-1-16	AB150603-6	RA2307H	30	9:27	JP	ATTA1208	JP
								

JP 12/9/16

Comments:

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(cont. from page VA B)

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Reviewed By / Date

JP 12/9/16

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Date 12/9/16SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100A**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	HB	JPB	OL	OL
2						HL	↓	P	P
3									
4									
5						HB	JPB	HB	OL
6									
7									
8									
9						HB	JPB	HB	OL
10									
11									
12									
13	OL				OL				OL
14									
15									
16									

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started*	Status	File ID
Dr A	3KA1201W			
Dr B				
Dr C				
Dr D	2			

Dr = Drawer

*Gas Supply*

	P-10 Supply	P-10 Flow	
Tank 1	0	Dr A	10
		Dr B	
Tank 2	1500	Dr C	
		Dr D	

Comments:

12/7/16

Cs137 Mass Attenuation Curve Filename: ACS1207

Bench sheet: AB160510.2 Sources: 1617003-1-18

Det	9:04	9:18	9:32	9:45	9:59	10:12	10:27	10:39	11:00	11:14	11:29	11:42	12:00	12:13	12:26	12:42	12:58	13:11
A1	1	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
A2	2	1	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3
A3	3	2	1	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4
A4	4	3	2	1	18	17	16	15	14	13	12	11	10	9	8	7	6	5
B1	5	4	3	2	1	18	17	16	15	14	13	12	11	10	9	8	7	6
B3	6	5	4	3	2	1	18	17	16	15	14	13	12	11	10	9	8	7
B4	7	6	5	4	3	2	1	18	17	16	15	14	13	12	11	10	9	8
C1	8	7	6	5	4	3	2	1	18	17	16	15	14	13	12	11	10	9
C3	9	8	7	6	5	4	3	2	1	18	17	16	15	14	13	12	11	10

12/8/16

Th230 Mass Attenuation Curve Filename: ATH1208

Bench sheet: ~~AB16~~ AB150603-6 Sources: 1518004-1-16 JP12/kk

Det	9:27	9:47	10:11	10:36	11:01	11:29	11:54	12:19	12:46	13:13	13:41	14:06	14:28	14:50	15:11	15:30
A1	1	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
A2	2	1	16	15	14	13	12	11	10	9	8	7	6	5	4	3
A3	3	2	1	16	15	14	13	12	11	10	9	8	7	6	5	4
A4	4	3	2	1	16	15	14	13	12	11	10	9	8	7	6	5
B1	5	4	3	2	1	16	15	14	13	12	11	10	9	8	7	6
B3	6	5	4	3	2	1	16	15	14	13	12	11	10	9	8	7
B4	7	6	5	4	3	2	1	16	15	14	13	12	11	10	9	8
C1	8	7	6	5	4	3	2	1	16	15	14	13	12	11	10	9
C3	9	8	7	6	5	4	3	2	1	16	15	14	13	12	11	10

Continued on Page

Signed

Date

Read and Understood By

Signed

Date

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# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

Prep Procedure: GROSS\_ALPHA

Analytical QASS / NCR? *Y*

*Mass Attenuation Curve*

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes
1	1518004-1	SMP	200	200	ml	pCi/l	13.2	<i>See Maintenance Log # 3974 pg 39</i>									
1	1518004-2	SMP	200	200	ml	pCi/l	12.4										
1	1518004-3	SMP	200	200	ml	pCi/l	25.8										
1	1518004-4	SMP	200	200	ml	pCi/l	28.1										
1	1518004-5	SMP	200	200	ml	pCi/l	43.9										
1	1518004-6	SMP	200	200	ml	pCi/l	36.8										
1	1518004-7	SMP	200	200	ml	pCi/l	49.9										
1	1518004-8	SMP	200	200	ml	pCi/l	49.5										
1	1518004-9	SMP	200	200	ml	pCi/l	67.8										
1	1518004-10	SMP	200	200	ml	pCi/l	70										
1	1518004-11	SMP	200	200	ml	pCi/l	79.3										
1	1518004-12	SMP	200	200	ml	pCi/l	77.3										
1	1518004-13	SMP	200	200	ml	pCi/l	83.5										
1	1518004-14	SMP	200	200	ml	pCi/l	89.8										
1	1518004-15	SMP	200	200	ml	pCi/l	100.4										
1	1518004-16	SMP	200	200	ml	pCi/l	100										

*Handwritten signature*

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPM/ml	06/03/15	5	ml	RS-027

## Sample Barcodes

1518004-1 AB150603-6PS1		1518004-2 AB150603-6PS2		1518004-3 AB150603-6PS3	
1518004-4 AB150603-6PS4		1518004-5 AB150603-6PS5		1518004-6 AB150603-6PS6	
1518004-7 AB150603-6PS7		1518004-8 AB150603-6PS8		1518004-9 AB150603-6PS9	
1518004-10 AB150603-6PS10		1518004-11 AB150603-6PS11		1518004-12 AB150603-6PS12	

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

Prep Procedure: GROSS\_ALPH

Analytical QASS / NCR? Y (N) *NA*

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes	
1518004-13	AB150603-6PS13							1518004-14 AB150603-6PS14							1518004-15 AB150603-6PS15			
1518004-16	AB150603-6PS16																	

## Reporting Units

LabID:	TstGrpName:	RptUnits:
1518004-1	GrossAlpha_DW	pCi/l
1518004-2	GrossAlpha_DW	pCi/l
1518004-3	GrossAlpha_DW	pCi/l
1518004-4	GrossAlpha_DW	pCi/l
1518004-5	GrossAlpha_DW	pCi/l
1518004-6	GrossAlpha_DW	pCi/l
1518004-7	GrossAlpha_DW	pCi/l
1518004-8	GrossAlpha_DW	pCi/l
1518004-9	GrossAlpha_DW	pCi/l
1518004-10	GrossAlpha_DW	pCi/l
1518004-11	GrossAlpha_DW	pCi/l
1518004-12	GrossAlpha_DW	pCi/l
1518004-13	GrossAlpha_DW	pCi/l
1518004-14	GrossAlpha_DW	pCi/l
1518004-15	GrossAlpha_DW	pCi/l
1518004-16	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb *jk* Review Date: 6/8/2015

Non-Routine Pre-Treatment? Y / ☒ Batch: *NA*

Prep QASS / NCR? Y / ☒ *NA*

Prep SOP: PAI 702 Rev: 20

Prep Analyst: Jennie Kill-Bowden

Balance:

Prep SOP: NONE

Prep Date: 6/3/2015

Balance:

Matrix Class: liquid

Prep Dept: RS

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1518004-1	SMP		200	200		S1	Salt added based on 51mg/mL -->0.23ml
2	1	1518004-2	SMP		200	200		S1	0.23 mL salt
3	1	1518004-3	SMP		200	200		S1	0.5 mL salt
4	1	1518004-4	SMP		200	200		S1	0.5 mL salt
5	1	1518004-5	SMP		200	200		S1	0.78 mL salt
6	1	1518004-6	SMP		200	200		S1	0.78 mL salt
7	1	1518004-7	SMP		200	200		S1	1.08 mL salt
8	1	1518004-8	SMP		200	200		S1	1.08 mL salt
9	1	1518004-9	SMP		200	200		S1	1.37 mL salt
10	1	1518004-10	SMP		200	200		S1	1.37 mL salt
11	1	1518004-11	SMP		200	200		S1	1.57 mL salt
12	1	1518004-12	SMP		200	200		S1	1.57 mL salt
13	1	1518004-13	SMP		200	200		S1	1.76 mL salt
14	1	1518004-14	SMP		200	200		S1	1.76 mL salt
15	1	1518004-15	SMP		200	200		S1	2.02 mL salt
16	1	1518004-16	SMP		200	200		S1	2.02 mL salt

## Comments

Th-230 mass attenuation curve USGS method (approximately 200 mL DI H2O + 20 mL conc HNO3 cooked down in a glass beaker and transferred to a planchet) Salt added based on weight per mL of salt solution, additional salt added as needed.

Spiked By: Jennie Kill-Bowden Date: 6/3/2015

Witnessed By: Peter Workman Date: 6/3/2015

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPM/ml	06/03/15
				5	ml
					RS-027

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

**Prep Batch Not Validated!!!**

Prep Procedure: GROSS\_ALPHA

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch: Prep QASS / NCR? Y / N

Prep Analyst: Jennie Kill-Bowden *JKB*  
 Prep Date: 6/3/2015  
 Matrix Class: liquid  
 Balance:  
 Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1518004-1	SMP	200	200	200		S1	
2	1	1518004-2	SMP	200	200	200		S1	
3	1	1518004-3	SMP	200	200	200		S1	
4	1	1518004-4	SMP	200	200	200		S1	
5	1	1518004-5	SMP	200	200	200		S1	
6	1	1518004-6	SMP	200	200	200		S1	
7	1	1518004-7	SMP	200	200	200		S1	
8	1	1518004-8	SMP	200	200	200		S1	
9	1	1518004-9	SMP	200	200	200		S1	
10	1	1518004-10	SMP	200	200	200		S1	
11	1	1518004-11	SMP	200	200	200		S1	
12	1	1518004-12	SMP	200	200	200		S1	
13	1	1518004-13	SMP	200	200	200		S1	
14	1	1518004-14	SMP	200	200	200		S1	
15	1	1518004-15	SMP	200	200	200		S1	
16	1	1518004-16	SMP	200	200	200		S1	

Comments

Th-230 mass attenuation curve USGS method

Spiked By: *JKB* Date: *6/3/15*  
 Witnessed By: *BL* Date: *6/3/15*

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPM/ml	06/03/15
				5	ml
					RS-027

ALS Environmental -- FC

GROSS\_ALPHA Bench Sheet

Page 1 of 1

Supersedes:

Date Printed: 6/3/2015 13:00

LIMS Version: 6.764

# Radiochemistry Gravimetric Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

Prep Procedure: GROSS ALPH

Reviewed By: jkb *jk* Review Date: 6/8/2015

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Gross Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1518004-1	SMP	10	9.1569	0.0000	0	0	0	200	9.1701	13.2	0.23	
1	2	1518004-2	SMP	10	9.1115	0.0000	0	0	0	200	9.1239	12.4	0.23	
1	3	1518004-3	SMP	10	9.1509	0.0000	0	0	0	200	9.1767	25.8	0.5	
1	4	1518004-4	SMP	10	9.1834	0.0000	0	0	0	200	9.2115	28.1	0.5	
1	5	1518004-5	SMP	10	9.1505	0.0000	0	0	0	200	9.1944	43.9	0.78	
1	6	1518004-6	SMP	10	9.1176	0.0000	0	0	0	200	9.1544	36.8	0.78	
1	7	1518004-7	SMP	10	9.1596	0.0000	0	0	0	200	9.2095	49.9	1.08	
1	8	1518004-8	SMP	10	9.1459	0.0000	0	0	0	200	9.1954	49.5	1.08	
1	9	1518004-9	SMP	10	9.1503	0.0000	0	0	0	200	9.2181	67.8	1.37	
1	10	1518004-10	SMP	10	9.0442	0.0000	0	0	0	200	9.1142	70	1.37	
1	11	1518004-11	SMP	10	9.0531	0.0000	0	0	0	200	9.1324	79.3	1.57	
1	12	1518004-12	SMP	10	9.0094	0.0000	0	0	0	200	9.0867	77.3	1.57	
1	13	1518004-13	SMP	10	9.0334	0.0000	0	0	0	200	9.1169	83.5	1.76	
1	14	1518004-14	SMP	10	9.4305	0.0000	0	0	0	200	9.5203	89.8	1.76	
1	15	1518004-15	SMP	10	9.3886	0.0000	0	0	0	200	9.4890	100.4	2.02	
1	16	1518004-16	SMP	10	9.3856	0.0000	0	0	0	200	9.4856	100	2.02	

Prepare an Intermediate dilution of Th-230 P50# 853 of approximately 1200 dpm/ml

1) Prepare 0.5 M  $\text{HNO}_3$ , 31 ml  $\text{HNO}_3$  and 969 ml DI water, lot # 073602

2) Determine density of 0.5 M  $\text{HNO}_3$ .

Mass of 100 ml vol. flask:

Mass of flask + 100 ml 0.5 M  $\text{HNO}_3$ :

Net mass of 0.5 M  $\text{HNO}_3$ :

Bal. 12

68.2999 g

169.4539 g

101.153 g

$$\rho = 1.015 \text{ g/ml}$$

3) Transfer contents of vial to 1000 ml Nalgene.

Mass of full standard vial:

Mass of empty standard vial:

Net mass of standard transferred:

8.2827

3.2327

5.05 g

4) Dilute with 0.5 M  $\text{HNO}_3$

Mass of Nalgene w/ lid (empty):

Mass of Nalgene with standard:

Mass of Nalgene, standard, and diluent:

Net mass of standard:

73.66 g

73.70 g

78.71 g

108.52

101.54 g

5) Final activity calculation

$$(1.983 \times 10^4 \text{ Bq}) / (5.15119 \text{ g}) = 3849.60 \text{ Bq/g} \times (60 \text{ s} / 1 \text{ min}) = 230,975.755 \text{ dpm}$$

$$(3849.60 \text{ Bq/g}) \cdot (5.05 \text{ g}) \cdot (1.015 \text{ g/ml}) = 1985.22 \text{ dpm/ml}$$

Std ID: 853.3020.89

Description: Th-230

Expiration: 2/5/2009

Activity: 1166.38 dpm/mL

2s Uncertainty: 23.33 dpm/mL

Ref. Date: 11/6/2007

Ref Time: N/A

Prep Date: 12/12/2007 Prep by: DC

Matrix/Comp. 0.5 M  $\text{HNO}_3$

Half Life (y): 7.70E+04

#### Reverification Log

Analysis Date	Initials	Expiration Date
5/5/09	RG	5/5/2010
11/19/10	RG	11/19/2011
12/13/14	JP	12/13/2015

Continued on Page

Signature: [Signature]

Date: 12/12/07

Read and Understood By

Signature: [Signature]

Date: 2/13/08



Eckert & Ziegler  
Analytics

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.analyticsinc.com

CERTIFICATE OF CALIBRATION  
Standard Radionuclide Source

76253-307

Th-230 5 mL Liquid in-Flame Sealed Vial

Customer: Paragon Analytics / Fort Collins, CO  
P.O. No.: 72908-REL 10-30-07, Item 1

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

Isotope:	Th-230
Activity (Bq):	1.983 E4
Half-Life:	7.538 E4 years
Calibration Date:	November 8, 2007 12:00 EST
Relative Expanded Uncertainty (k=2):	2.0%

Comments:

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%,  
5.15119 grams 0.5M HNO<sub>3</sub> solution.

Source Prepared By:

N. E. Klesman  
N. E. Klesman, Radiochemist

QA Approved:

D. M. Montgomery  
D. M. Montgomery, QA Manager

Date: 11-19-07

End of Certificate

Corporate Office

24937 Avenue Tibbitts Valencia, California 91355

Laboratory

1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB160510-2

Prep Procedure: GAB

Gross Beta (Cs137) Attenuation

Analytical QASS / NCR? Y *NA*

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes
1	1617003-1	SMP	200	200	ml	pCi/l	0										
1	1617003-2	SMP	200	200	ml	pCi/l	16.3										
1	1617003-3	SMP	200	200	ml	pCi/l	30.4										
1	1617003-4	SMP	200	200	ml	pCi/l	49.6										
1	1617003-5	SMP	200	200	ml	pCi/l	63.4										
1	1617003-6	SMP	200	200	ml	pCi/l	75.3										
1	1617003-7	SMP	200	200	ml	pCi/l	95.8										
1	1617003-8	SMP	200	200	ml	pCi/l	102.6										
1	1617003-9	SMP	200	200	ml	pCi/l	129.6										
1	1617003-10	SMP	200	200	ml	pCi/l	139										
1	1617003-11	SMP	200	200	ml	pCi/l	164.4										
1	1617003-12	SMP	200	200	ml	pCi/l	181										
1	1617003-13	SMP	200	200	ml	pCi/l	195.7										
1	1617003-14	SMP	200	200	ml	pCi/l	239.1										
1	1617003-15	SMP	200	200	ml	pCi/l	252.6										
1	1617003-16	SMP	200	200	ml	pCi/l	273.4										
1	1617003-17	SMP	200	200	ml	pCi/l	297.2										
1	1617003-18	SMP	200	200	ml	pCi/l	299.7										

See Mantec Log # 3974 pg 39

*JPZ/zh*

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1019.4095.83	3.825.389	DPM/ml	05/10/16	1	ml	RS-019

## Sample Barcodes

1617003-1 AB160510-2PS1		1617003-2 AB160510-2PS2		1617003-3 AB160510-2PS3	
1617003-4 AB160510-2PS4		1617003-5 AB160510-2PS5		1617003-6 AB160510-2PS6	
1617003-7 AB160510-2PS7		1617003-8 AB160510-2PS8		1617003-9 AB160510-2PS9	

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB160510-2

Prep Procedure: GAB

Analytical QASS / NCR? Y / N

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes
1617003-10	AB160510-2PS10							1617003-11 AB160510-2PS11						1617003-12 AB160510-2PS12			
1617003-13	AB160510-2PS13							1617003-14 AB160510-2PS14						1617003-15 AB160510-2PS15			
1617003-16	AB160510-2PS16							1617003-17 AB160510-2PS17						1617003-18 AB160510-2PS18			

## Reporting Units

LabID:	TstGrpName:	RptUnits:
1617003-1	GrossAlpha/Beta_DW	pCi/l
1617003-2	GrossAlpha/Beta_DW	pCi/l
1617003-3	GrossAlpha/Beta_DW	pCi/l
1617003-4	GrossAlpha/Beta_DW	pCi/l
1617003-5	GrossAlpha/Beta_DW	pCi/l
1617003-6	GrossAlpha/Beta_DW	pCi/l
1617003-7	GrossAlpha/Beta_DW	pCi/l
1617003-8	GrossAlpha/Beta_DW	pCi/l
1617003-9	GrossAlpha/Beta_DW	pCi/l
1617003-10	GrossAlpha/Beta_DW	pCi/l
1617003-11	GrossAlpha/Beta_DW	pCi/l
1617003-12	GrossAlpha/Beta_DW	pCi/l
1617003-13	GrossAlpha/Beta_DW	pCi/l
1617003-14	GrossAlpha/Beta_DW	pCi/l
1617003-15	GrossAlpha/Beta_DW	pCi/l
1617003-16	GrossAlpha/Beta_DW	pCi/l
1617003-17	GrossAlpha/Beta_DW	pCi/l
1617003-18	GrossAlpha/Beta_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB160510-2

Prep Procedure: GAB

Reviewed By: jkb

Review Date: 5/18/2016

Non-Routine Pre-Treatment? Y / N Batch: Re-Prep? Y / N Batch: Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 5/10/2016

Prep Dept: RS

Balance: 13

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1617003-1	SMP		200	200	Unfiltered	S1	
2	1	1617003-2	SMP		200	200	Unfiltered	S1	
3	1	1617003-3	SMP		200	200	Unfiltered	S1	
4	1	1617003-4	SMP		200	200	Unfiltered	S1	
5	1	1617003-5	SMP		200	200	Unfiltered	S1	
6	1	1617003-6	SMP		200	200	Unfiltered	S1	
7	1	1617003-7	SMP		200	200	Unfiltered	S1	
8	1	1617003-8	SMP		200	200	Unfiltered	S1	
9	1	1617003-9	SMP		200	200	Unfiltered	S1	
10	1	1617003-10	SMP		200	200	Unfiltered	S1	
11	1	1617003-11	SMP		200	200	Unfiltered	S1	
12	1	1617003-12	SMP		200	200	Unfiltered	S1	
13	1	1617003-13	SMP		200	200	Unfiltered	S1	
14	1	1617003-14	SMP		200	200	Unfiltered	S1	
15	1	1617003-15	SMP		200	200	Unfiltered	S1	
16	1	1617003-16	SMP		200	200	Unfiltered	S1	
17	1	1617003-17	SMP		200	200	Unfiltered	S1	
18	1	1617003-18	SMP		200	200	Unfiltered	S1	

Comments

Cs-137 calibration planchets

Spiked By: Jennie Kill-Bowden Date: 5/17/2016

Witnessed By: Clayton D. Jacobs Date: 5/14/2016

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Cs-137	1019.4095.83	3.825.389	DPM/ml	05/10/16
				1	ml
					RS-019

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB160510-2

Prep Procedure: GAB

**Prep Batch Not Validated!!!**

Reviewed By: Review Date:

Non-Routine Pre-Treatment? Y / N Batch: Re-Prep? Y / N Batch: Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 5/10/2016

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1617003-1	SMP	200	200	200	Unfiltered	S1	
2	1	1617003-2	SMP	200	200	200	Unfiltered	S1	
3	1	1617003-3	SMP	200	200	200	Unfiltered	S1	
4	1	1617003-4	SMP	200	200	200	Unfiltered	S1	
5	1	1617003-5	SMP	200	200	200	Unfiltered	S1	
6	1	1617003-6	SMP	200	200	200	Unfiltered	S1	
7	1	1617003-7	SMP	200	200	200	Unfiltered	S1	
8	1	1617003-8	SMP	200	200	200	Unfiltered	S1	
9	1	1617003-9	SMP	200	200	200	Unfiltered	S1	
10	1	1617003-10	SMP	200	200	200	Unfiltered	S1	
11	1	1617003-11	SMP	200	200	200	Unfiltered	S1	
12	1	1617003-12	SMP	200	200	200	Unfiltered	S1	
13	1	1617003-13	SMP	200	200	200	Unfiltered	S1	
14	1	1617003-14	SMP	200	200	200	Unfiltered	S1	
15	1	1617003-15	SMP	200	200	200	Unfiltered	S1	
16	1	1617003-16	SMP	200	200	200	Unfiltered	S1	
17	1	1617003-17	SMP	200	200	200	Unfiltered	S1	
18	1	1617003-18	SMP	200	200	200	Unfiltered	S1	

Comments

Spiked By: 763 Date: 5/17/16  
 Witnessed By: CDS Date: 5/12/2016

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date
S1	Cs-137	1019.4095.83	3.825.389	DPM/ml	05/10/16
				ml	RS-019

4/11/2017

# Radiochemistry Gravimetric Worksheet

ALS Environmental -- FC

Prep Batch: AB160510-2

Prep Procedure: GAB

Reviewed By: jkb jk

Review Date: 5/18/2016

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Gross Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1617003-1	SMP	10	9.4100	0.0000	0	0	0	0	0.0000	0	0	0
1	2	1617003-2	SMP	10	9.4242	9.4391	14.9	0	0	0	9.4405	16.3	0	0
1	3	1617003-3	SMP	10	9.4391	9.4711	32	0	0	0	9.4695	30.4	0	0
1	4	1617003-4	SMP	10	9.3826	9.4298	47.2	0	0	0	9.4322	49.6	0	0
1	5	1617003-5	SMP	10	9.3332	9.3942	61	0	0	0	9.3966	63.4	0	0
1	6	1617003-6	SMP	10	9.3931	9.4638	70.7	0	0	0	9.4684	75.3	0	0
1	7	1617003-7	SMP	10	9.4174	9.5130	95.6	0	0	0	9.5132	95.8	0	0
1	8	1617003-8	SMP	10	9.4186	9.5263	107.7	0	0	0	9.5212	102.6	0	0
1	9	1617003-9	SMP	10	9.4485	9.5765	128	0	0	0	9.5781	129.6	0	0
1	10	1617003-10	SMP	10	9.4189	9.5572	138.3	0	0	0	9.5579	139	0	0
1	11	1617003-11	SMP	10	9.4339	9.5938	159.9	0	0	0	9.5983	164.4	0	0
1	12	1617003-12	SMP	10	9.4347	9.6170	182.3	0	0	0	9.6157	181	0	0
1	13	1617003-13	SMP	10	9.4474	9.6500	202.6	0	0	0	9.6431	195.7	0	0
1	14	1617003-14	SMP	10	9.4350	9.6593	224.3	0	0	0	9.6741	239.1	0	0
1	15	1617003-15	SMP	10	9.4210	9.6725	251.5	0	0	0	9.6736	252.6	0	0
1	16	1617003-16	SMP	10	9.3651	9.6307	265.6	0	0	0	9.6385	273.4	0	0
1	17	1617003-17	SMP	10	9.3731	9.6609	287.8	0	0	0	9.6703	297.2	0	0
1	18	1617003-18	SMP	10	9.3909	9.6913	300.4	0	0	0	9.6906	299.7	0	0

Prepare an Intermediate dilution of Th-230 P50# 853 of approximately 1200 dpm/ml

1) Prepare 0.5M HNO<sub>3</sub>, 31ml HNO<sub>3</sub> and 969ml DI water, lot # 073602

2) Determine density of 0.5M HNO<sub>3</sub>.

Mass of 100 ml vol. flask:

Bal. 12

68.2999g

Mass of flask + 100 ml 0.5M HNO<sub>3</sub>:

169.4539g

Net mass of 0.5M HNO<sub>3</sub>:

101.153g

$$\rho = 1.0115 \text{ g/ml}$$

3) Transfer contents of vial to 1000ml Nalgene.

Bal. 12

Mass of full standard vial:

8.2827

Mass of empty standard vial:

3.2327

Net mass of standard transferred:

5.05g

4) Dilute with 0.5 M HNO<sub>3</sub>

P50# 853

Bal. 26

Mass of Nalgene w/o lid (empty):

73.66g

73.70g

Mass of Nalgene with standard:

78.71g

Mass of Nalgene, standard, and diluent:

1085.2

Net mass of standard:

1011.54g

5) Final activity calculation

$$(1.983 \times 10^4 \text{ Bq}) / (5.15119 \text{ g}) = 3849.60 \text{ Bq/g} \times \left( \frac{60 \text{ s}}{1 \text{ min}} \right) = 230,975.755 \text{ dpm}$$

$$(3849.60 \text{ Bq/g}) \cdot \left( \frac{5.05 \text{ g}}{1011.54 \text{ g}} \right) \cdot (1.0115 \text{ g/ml}) = 1166.38 \text{ dpm/ml}$$

Std ID: 853.3020.89

Description: Th-230

Expiration: 2/5/2009

Activity: 1166.38 dpm/mL

2s Uncertainty: 23.33 dpm/mL

Ref. Date: 11/6/2007

Ref Time: N/A

Prep Date: 12/12/2007 Prep by: DC

Matrix/Comp. 0.5 M HNO<sub>3</sub>

Half Life (y): 7.70E+04

#### Reverification Log

Analysis Date	Initials	Expiration Date
5/5/09	RG	5/5/2010
11/19/10	RG	11/19/2011
12/13/14	JP	12/13/2015

Continued on Page

Read and Understood By

Sign:

Date:

Sign:



Eckert & Ziegler

Analytics

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Fax 404-352-2837  
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CERTIFICATE OF CALIBRATION  
Standard Radionuclide Source

76253-307

Th-230 5 mL Liquid in Flame Sealed Vial

Customer: Paragon Analytics / Fort Collins, CO  
P.O. No.: 72905-REL 10-30-07, Item 1

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

Isotope:	Th-230
Activity (Bq):	1.989 E4
Half-Life:	7.538 E4 years
Calibration Date:	November 8, 2007 12:00 EST
Relative Expanded Uncertainty (k=2):	2.0%

Comments:

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%,  
5.15119 grams 0.5M HNO<sub>3</sub> solution.

Source Prepared By: N. E. Kiesman  
N. E. Kiesman, Radiochemist

QA Approved: D. M. Montgomery  
D. M. Montgomery, QA Manager

Date: 11-19-07

End of Certificate

Corporate Office  
24937 Avenue Tibbitts Valencia, California 91355

Laboratory  
1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

Prepare a working dilution of RSO\*1019

12/3/15

1. Density of 0.1M HCl, lot # 0000094396

Mass of 100mL vol. flask:

56.4421 g

Balance # 12

Mass of flask & 100mL acid:

156.2152 g

Balance # 12

Net Mass:

99.7731 g

Density:

0.9977 g/mL

2. Mass of RSO\*1019 transferred:

Mass of empty nalgene:

74.1899 g

Balance # 12

Mass of nalgene & standard

79.0859 g

Balance # 12

Net mass of standard transferred:

4.8960 g

3. Dilute to final volume:

Mass of nalgene, standard, & diluent:

629.3 g

Balance # 26

Mass of empty nalgene:

74.1899 g

Balance # 12

Net mass of new dilution:

555.1101 g

4. Final activity calculation:

$$3,727,039 \text{ Bq} \left( \frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left( \frac{4.8960 \text{ g}}{4.99800 \text{ g}} \right) \left( \frac{0.9977 \text{ g/mL}}{555.1101 \text{ g}} \right) = 3,937.10 \text{ dpm/mL}$$

Std ID: 1019.4095.83

Description: Cs-137

Expiration: 3/6/2016

Activity: 3937.10 dpm/mL

2s Uncertainty: 70.87 dpm/mL

Ref. Date: 2/9/2015

Ref Time: N/A

Prep Date: 3/5/2015 Prep by: TE

Matrix/Comp. 0.1 MHCl

Half Life (y): 3.01E+01

Reverification Log		
Analysis Date	Initials	Expiration Date
04/01/16	JP	04/01/2017

JP 4/2/15  
JP 4/2/15

Continued on Page

Signed

Date

Read and Understood By

Signed

Date



Eckert & Ziegler

Analytics

RSO#  
1019

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.ezag.com

## CERTIFICATE OF CALIBRATION

### Standard Reference Source

99575

Cs-137 5 mL Liquid in Flame Sealed Vial

Customer: ALS Laboratory Group  
P.O. No.: FC000610, Item 3 Product Code: 8137

This standard radionuclide source was prepared gravimetrically from a master solution calibrated with an ionization chamber. The ionization chamber was calibrated by the National Physical Laboratory, Teddington, U.K., and is traceable to national standards. Radionuclide calibration and purity were checked by germanium gamma-ray spectrometry, liquid scintillation counting, and/or alpha spectrometry, as applicable. The nuclear decay rate and reference date for this source are given below. Eckert & Ziegler Analytics (EZA) maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Revision 2, July 2007, and compliance with ANSI N42.22-1995, "Traceability of Radioactive Sources to NIST."

Isotope	Half-Life, Days	Activity (Bq)	Uncertainty*, %			Reference Date (12:00 PM EST)
			$u_A$	$u_B$	U	
Cs-137	1.099E+04	3.727E+04	0.1	0.9	1.8	02/09/2015

\*Uncertainty: U - Relative expanded uncertainty,  $k = 2$ . See NIST Technical Note 1297, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results."

#### Comments:

Impurities:  $\gamma$ -impurities < 0.1%.

4.99800 g 0.1M HCl solution with approximately 30  $\mu$ g/g Cs carrier.

Source Prepared by:

K. Eardley, Radiochemist

QC Approved:

A. Chen, Spectroscopist

Date: 7 Feb 15

**Internal Calculation Verifications**

**ICBs**

**&**

**ICVs**

# Gross Alpha/Beta LB4100C ICV's/ICB's Th-230/CS137

Atten. Constants				
	Alpha	Beta	m	a
	0.8980	0.9901	0.9775	0
	0.9455	0.9986	1.0026	0.0

X-Talk Constants		
	$\alpha > \beta$	$\beta > \alpha$
	0.9975	0.2784
	0.0037	-1.618E-06

Detector	Sample ID	Initial Aliquot	Final Sam. Size	Count Date	Count Dur.	Alpha				Beta								
						Residual Mass (mg)	Gross CPM	Bkg CPM	$\beta > \alpha$ X-Talk	Net CPM	Atten.	Efficiency	Gross CPM	Bkg CPM	$\alpha > \beta$ X-Talk	Net CPM	Atten.	Efficiency
A1	1624002-1	0.200	0.200	2/14/2017	300	52.1	14.157	0.129	0.163	13.865	0.541	0.2282	45.113	2.032	4.4953	38.6317	0.8788	0.3942
B1	1624002-2	0.200	0.200	2/14/2017	300	51.2	14.323	0.157	0.163	14.003	0.546	0.2377	46.530	2.215	4.4832	38.5848	0.8799	0.4271
C1	1624002-3	0.200	0.200	2/14/2017	300	51.7	13.913	0.115	0.169	13.629	0.543	0.2269	46.530	1.981	4.3722	40.1768	0.8793	0.3974
A2	1624002-4	0.200	0.200	2/14/2017	300	52.1	11.470	0.127	0.156	11.187	0.541	0.2335	43.657	2.343	3.5978	37.7162	0.8788	0.4040
A3	AB161208-2AMB	0.200	0.200	2/14/2017	300	51.2	0.143	0.120	0.000	0.023	0.546	0.2214	2.017	2.181	0.0074	-0.1714	0.8799	0.3972
B3	AB161208-2BMB	0.200	0.200	2/14/2017	300	49.7	0.087	0.127	0.000	-0.040	0.554	0.2320	1.590	1.920	0.0000	-0.3300	0.8817	0.4171
C3	AB161208-2CMB	0.200	0.200	2/14/2017	300	50.7	0.113	0.090	0.001	0.022	0.548	0.2349	1.823	1.619	0.0074	0.1966	0.8805	0.4191
A4	AB161208-2EMB	0.200	0.200	2/14/2017	300	50.4	0.097	0.113	0.000	-0.016	0.550	0.2289	2.120	2.100	0.0000	0.0200	0.8809	0.3921

Spike Information				
Alpha Std ID	Ref. Date	Act (dpm/ml)	Spike Vol (mL)	Decay Corr. Spike Act. Added
760.4095.67	7/13/2014	96.660	1.0	94.727

Spike Information				
Beta Std ID	Ref. Date	Act (dpm/ml)	Spike Vol (mL)	Decay Corr. Spike Act. Added
1013.4095.77	9/30/2005	131.750	1.0	101.387

## Acceptance criteria for LCS's -> 80-120%

Sample ID	Alpha				Beta			
	Act (pCi/L)	TPU (2 sig)	MDC	% Recov.	Act (pCi/L)	TPU (2 sig)	MDC	% Recov.
1624002-1	252.93	41.1	2.81	118.6%	NA	251.17	4.50	110.0%
1624002-2	243.10	39.5	2.79	113.9%	NA	231.25	4.22	101.3%
1624002-3	249.08	40.4	2.78	116.7%	NA	258.96	4.42	113.4%
1624002-4	199.45	32.5	2.71	93.5%	NA	239.27	4.21	104.8%
AB161208-2AMB	0.43	0.91	1.90	NA	PASS	-1.10	2.62	NA
AB161208-2BMB	-0.70	0.72	1.84	NA	PASS	-2.02	2.33	NA
AB161208-2CMB	0.38	0.76	1.57	NA	PASS	1.20	2.14	NA
AB161208-2EMB	-0.29	0.75	1.78	NA	PASS	0.13	2.60	NA

Alpha CU		Alpha TPU		Beta CU		Beta TPU	
(1 sig)	(1 sig)	(1 sig)	(1 sig)	(1 sig)	(1 sig)	(1 sig)	(1 sig)
3.9910	20.5301	2.6888	20.1742	3.9910	2.6888	20.1742	3.9910
3.8211	19.7294	2.4572	18.5753	3.8211	2.4572	18.5753	3.8211
3.9644	20.2242	2.6705	20.7912	3.9644	2.6705	20.7912	3.9644
3.5154	16.2644	2.5364	19.2188	3.5154	2.5364	19.2188	3.5154
0.4553	0.4566	0.6089	0.6153	0.4553	0.6089	0.6153	0.4553
0.3580	0.3623	0.5204	0.5447	0.3580	0.5204	0.5447	0.3580
0.3790	0.3802	0.5363	0.5447	0.3790	0.5363	0.5447	0.3790
0.3737	0.3744	0.6243	0.6244	0.3737	0.6243	0.6244	0.3737

OK JP 2/15/17

# PAI - Gas Flow Proportional Sample Analysis LB4100-A

Unit Type: LB4100-AW  
Counting Unit ID: Orange  
High Voltage Mode: Simultaneous  
Application Revision: C  
Rev: 05/09/13 JP

Data file name: ABA0214A  
Batch ID: AB161208-2  
Count Preset (m): 300  
Batch Ended: 2/14/17 19:59

Background logfile: BKGBW  
Date of Bkg. Cal: 2/2/17  
Alpha efficiency logfile: TH-230-12/16  
Alpha attenuation calibration: ATH1208  
Beta efficiency logfile: CS137-12/16  
Beta attenuation calibration: ACS1207

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^a \cdot (x^b \cdot (m^{c1} \cdot x^{c2}))$		$y = b \cdot m^a \cdot (x^b \cdot (m^{c1} \cdot x^{c2}))$	
Alpha b=	0.89800	Beta b=	0.9455
m=	0.90910	m=	0.9986
a=	0.9775	a=	1.0026
x0=	0.0000	x0=	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b \cdot m^a \cdot x$		$y = b \cdot m^a \cdot x$	
a -> b xtalk m=	0.2784	b -> a xtalk m=	1.818E-06
a -> b xtalk m=	0.9975	b -> a xtalk m=	0.0037

Det. ID	Sample	Count		Resid. Mass (mg)	Alpha Activity										Beta Activity									
		Date & Time	Dur. (min)		Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Eff	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.	Gross CPM	Bkg. CPM	a>b xtlk CPM	Base Eff	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.						
C1	1624002-3	2/14/17 19:58	300.00	51.7	13.913	0.115	0.169	0.2289	0.543	n/a	n/a	46.530	1.981	4.3722	0.3974	0.879	n/a	n/a						
A3	AB161208-2CMB	2/14/17 19:58	300.00	50.7	0.113	0.090	0.001	0.2349	0.548	n/a	n/a	1.823	1.619	0.0074	0.4191	0.881	n/a	n/a						
A1	16124002-1	2/14/17 19:58	300.00	52.1	14.157	0.129	0.163	0.2282	0.541	n/a	n/a	45.113	2.032	4.4493	0.3942	0.879	n/a	n/a						
A2	AB161208-2AMB	2/14/17 19:58	300.00	51.2	0.143	0.120	0.000	0.2214	0.546	n/a	n/a	2.017	2.181	0.0074	0.3972	0.880	n/a	n/a						
A3	1624002-4	2/14/17 19:58	300.00	52.1	11.470	0.127	0.156	0.2335	0.541	n/a	n/a	43.657	2.343	3.5978	0.4040	0.879	n/a	n/a						
A4	AB161208-2EMB	2/14/17 19:58	300.00	50.4	0.097	0.113	0.000	0.2289	0.550	n/a	n/a	2.120	2.100	0.0000	0.3921	0.881	n/a	n/a						
B1	1624002-2	2/14/17 19:59	300.00	51.2	14.323	0.157	0.163	0.2377	0.546	n/a	n/a	45.283	2.215	4.4832	0.4271	0.880	n/a	n/a						
B3	AB161208-2BMB	2/14/17 19:59	300.00	49.7	0.087	0.127	0.000	0.2320	0.554	n/a	n/a	1.590	1.920	0.0000	0.4171	0.882	n/a	n/a						

JP 2/15/17

Date

2/14/17

SOP 724r

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## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100A

## Instrument Daily Response and Background Checks

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6						(Hα)			OL
7						P			P
8									
9									
10									OL
11									P
12									OL
13	OL				OL				
14									
15									
16									

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

## Weekly Background Calibration

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK10201W			
Dr B				
Dr C				
Dr D	OL			

Dr = Drawer

## Gas Supply

P-10 Supply		P-10 Flow	
Tank 1	2300	Dr A	10
		Dr B	
Tank 2	850	Dr C	
		Dr D	

Comments:

Page No.:

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A

Form 780r8.doc (6/23/06)

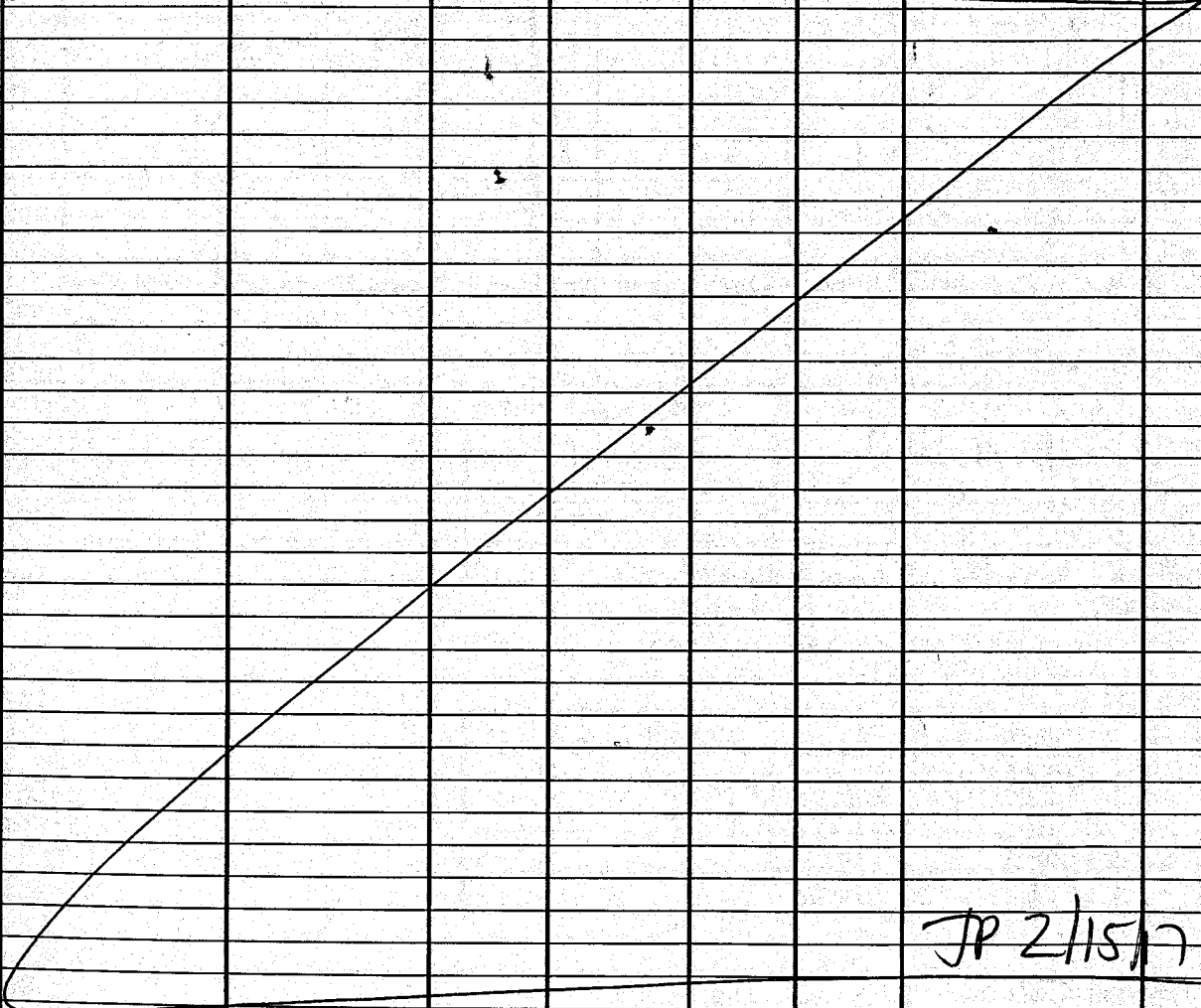
Reviewed By / Date

JP 2/14/17

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Date 2/14/17SOP 724r H

ALS  
Low Background Gas Flow Proportional Counter Log  
Instrument: LB4100A

Det.	Sample ID	Batch	Test	Count Dur. (min) -	Start Time	Analyst Initials	File ID	Output Initials
1-12	Daily Eff	—	—	30	7:16	JP	EFA0214	JP
1-12	Daily Bkg	—	—	60	7:29	JP	BKA0214	JP
1	1701228-1	AB170208-1	a-b	240	1036	JP	AB A0214	JP
2	-1D	↓	↓	↓	↓	↓	↓	↓
3	-2MS	↓	↓	↓	↓	↓	↓	↓
4	-2MSD	↓	↓	↓	↓	↓	↓	↓
1	1701228-1	AB170208-2	a-b	300	1452	JP	AB A0214A	JP
5	-2	↓	↓	↓	↓	↓	↓	↓
9	-3	↓	↓	↓	↓	↓	↓	↓
3	-4	↓	↓	↓	↓	↓	↓	↓
2	AB170208-2MSD	↓	↓	↓	↓	↓	↓	↓
7	B	↓	↓	↓	↓	↓	↓	↓
11	C	↓	↓	↓	↓	↓	↓	↓
4	E	↓	↓	↓	↓	↓	↓	↓
								

Comments:

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(cont. from page NA B)

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Reviewed By / Date

JP 2/15/17

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Date

2/15/17

SOP 724r

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## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100A

## Instrument Daily Response and Background Checks

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3						H α	αKB	P	
4						P			
5									
6									OL
7		(L, W)	JP	P					P
8		P							
9						L β	αKB	P	
10						P			OL
11						H β	αKB	P	P
12						P			OL
13	OL				OL				
14									
15									
16									

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

## Weekly Background Calibration

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKADZ01W	αKB	P	BKADZ013W
Dr B				
Dr C				
Dr D	OL	α		

Dr = Drawer

## Gas Supply

P-10 Supply		P-10 Flow	
Tank 1	1900	Dr A	10
		Dr B	
Tank 2	800	Dr C	
		Dr D	

## Comments:

# Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: AB161208-2

Prep Procedure: GAB

ICVs / ICBs

Analytical QASS / NCR? Y

N

Notes

Prep Num	QC Type	Init Alq	Fin Alq	Units	Report Units	Residual Mass (mg)	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By
1	1624002-1	SMP	200	200	ml	52.1	AB161208-2PS1	JP						
1	1624002-2	SMP	200	200	ml	51.2								
1	1624002-3	SMP	200	200	ml	51.7								
1	1624002-4	SMP	200	200	ml	52.1								
1	AB161208-2a	MB	200	200	ml	51.2								
1	AB161208-2b	MB	200	200	ml	49.7								
1	AB161208-2c	MB	200	200	ml	50.7								
1	AB161208-2e	MB	200	200	ml	50.4								

JP 115/17  
JP 215/17

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1013.4095.77		101.810	DPM/ml	12/08/16	1	ml	RS-033
S2	Th-230	760.4095.67		96.653	DPM/ml	12/08/16	1	ml	RS-033

## Sample Barcodes

1624002-1  
AB161208-2PS1

1624002-4  
AB161208-2PS4

AB161208-2cMB  
AB161208-2PS7

1624002-2  
AB161208-2PS2

AB161208-2aMB  
AB161208-2PS5

AB161208-2eMB  
AB161208-2PS8

1624002-3  
AB161208-2PS3

AB161208-2bMB  
AB161208-2PS6

## Reporting Units

LabID: TstGrpName: RptUnits:

1624002-1 GrossAlpha/Beta\_DW pCi/l

1624002-2 GrossAlpha/Beta\_DW pCi/l

1624002-3 GrossAlpha/Beta\_DW pCi/l

1624002-4 GrossAlpha/Beta\_DW pCi/l

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: AB161208-2

Prep Procedure: GAB

Reviewed By: bat ~~BAT~~

Review Date: 12/12/2016

Non-Routine Pre-Treatment? Y / ☒ Batch: ~~MA~~ Prep QASS / NCR? Y / ☒ ~~MA~~

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Bryan A. Terry ~~BAT~~

Prep Date: 12/8/2016

Prep Dept: RS

Batch: ~~MA~~

Re-Prep? Y / ☒

Balance: 13

Balance: N/A

Prep Notes

Standards

Prep Basis

Fin Alq

ml

Init Alq

ml

Dish

No.

QC

Type

LabID

Samp Num

1	1	1624002-1	SMP	MA	200	200	200	Unfiltered	S1,S2
2	1	1624002-2	SMP		200	200	200	Unfiltered	S1,S2
3	1	1624002-3	SMP		200	200	200	Unfiltered	S1,S2
4	1	1624002-4	SMP		200	200	200	Unfiltered	S1,S2
5	1	AB161208-2a	MB		200	200	200	Unfiltered	MA
6	1	AB161208-2b	MB		200	200	200	Unfiltered	
7	1	AB161208-2c	MB		200	200	200	Unfiltered	
8	1	AB161208-2e	MB		200	200	200	Unfiltered	

Comments

Spiked By: Bryan A. Terry Date: 12/8/2016

Witnessed By: Andrew R. Steger Date: 12/8/2016

## Spiked Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1013.4095.77		101.810	DPM/ml	12/08/16	1	ml	RS-033
S2	Th-230	760.4095.67		96.653	DPM/ml	12/08/16	1	ml	RS-033

## Reagent Solution IDs\*

0000046694

\*Except where otherwise noted, all reagents were applied in accordance with the specifications of the preparation methods associated with this batch.

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: AB161208-2

Prep Procedure: GAB

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch: Re-Prep? Y / N Batch: Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep Analyst: Bryan A. Terry

Balance: 13

Prep SOP: NONE

Prep Date: 12/8/2016

Balance: N/A

Matrix Class: liquid

Prep Dept: RS

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1624002-1	SMP	0	0	0		S1,S2	
2	1	1624002-2	SMP	0	0	0		S1,S2	
3	1	1624002-3	SMP	0	0	0		S1,S2	
4	1	1624002-4	SMP	0	0	0		S1,S2	
5	1	AB161208-2a	MB	0	0	0			
6	1	AB161208-2b	MB	0	0	0			
7	1	AB161208-2c	MB	0	0	0			
8	1	AB161208-2e	MB	0	0	0			

Comments

Spiked By: BA Date: 12/8/2016

Witnessed By: ALC R. R. R. Date: 12/8/16

Spike Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
S1	Cs-137	1013.4095.77	1/7/17	101.810	DPM/ml	RS-033
S2	Th-230	760.4095.67	4/7/17	96.653	DPM/ml	RS-033

Reagent Solution IDs\*

0000046694

\*Except where otherwise noted, all reagents were applied in accordance with the specifications of the preparation methods associated with this batch.

# Radiochemistry Gravimetric Worksheet

ALS -- Fort Collins

Prep Batch: AB161208-2

Prep Procedure: GAB

Reviewed By: bat

Review Date: 12/12/2016

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Gross Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1624002-1	SMP	10	9.3802	9.4323	52.1	14	200	200	9.4323	52.1	1	
1	2	1624002-2	SMP	10	9.4308	9.4820	51.2	15	200	200	9.4820	51.2	1	
1	3	1624002-3	SMP	10	9.4130	9.4647	51.7	15	200	200	9.4647	51.7	1	
1	4	1624002-4	SMP	10	9.4013	9.4534	52.1	14	200	200	9.4534	52.1	1	
1	5	AB161208-2a	MB	10	9.4458	9.4970	51.2	15	200	200	9.4970	51.2	1	
1	6	AB161208-2b	MB	10	9.3486	9.3983	49.7	15	200	200	9.3983	49.7	1	
1	7	AB161208-2c	MB	10	9.3869	9.4376	50.7	15	200	200	9.4376	50.7	1	
1	8	AB161208-2e	MB	10	9.4117	9.4621	50.4	15	200	200	9.4621	50.4	1	

## Sample Condition Form (Liquid)

Analyst: BAT

Analysis Date: 12/8/2016 Method: Preo

Analysis Date: 12/8/2016 Method: Preo

	Sample Condition (Visual Appearance of Analysis Aliquot at Time of Prep)
--	--

Work Order	Sample ID	pH	Color	Remarks
1624002	1	22	Colorless	None
↓	2	↓	↓	↓
↓	3	↓	↓	↓
↓	4	↓	↓	↓
BAT 12/8/2016				

Prepare a working dilution of 760.3020.08

1. Density of 0.5M HNO<sub>3</sub> lot # 0000084176

Mass of 100mL vol. flask:

68.5632g

Balance # 12

Mass of flask &amp; 100mL acid:

169.6732g

Balance # 12

Net Mass:

101.1100g

Density:

1.011g/mL

2. Mass of 760.3020.08 transferred:

Mass of open empty nalgene:

74.1983g

Balance # 12

Mass of nalgene &amp; standard:

77.2060g

Balance # 12

Net mass of standard transferred:

3.0077g

Balance # NA

3. Dilute to final volume:

Mass of nalgene, standard, &amp; diluent:

908.9g

Balance # 26

Mass of empty nalgene (from above):

74.1983g

Balance # 12

Net mass of new dilution:

834.7017g

Balance # NA

4. Final activity calculation:

$$26,534.43 \text{ dpm/g} (1.011 \text{ g/mL}) \left( \frac{3.0077 \text{ g}}{834.7017 \text{ g}} \right) = 96.66 \text{ dpm/mL}$$

Std ID: 760.4095.67

Description: Th-230

Expiration: 4/12/2016

Activity: 96.66 dpm/mL

2s Uncertainty: 3.19 dpm/mL

Ref. Date: 7/13/2004

Ref Time: N/A

Prep Date: 12/8/2014 Prep by: TE

Matrix/Comp. 0.5 M HNO<sub>3</sub>

Half Life (y): 7.54E+04

## Reverification Log

Analysis Date	Initials	Expiration Date
4/07/16	JP	04/07/2017

Continued on Page

Signed

Date

Read and Understood By

Signed

Date

Prepare a primary dilution of R50 #760 (Analytical # 68750-307) to a concentration of approx 30,000 dpm/ml.

1) Prepare 0.5M HNO<sub>3</sub> by diluting 5 ml of conc. (16M) HNO<sub>3</sub> (EMD lot # 44351) to a final volume of 1000 mL.

2) Determine density of 0.5M HNO<sub>3</sub>

Mass of 100ml volumetric flask =	66.4289 g (Bal 12)
Mass of flask + 0.5M HNO <sub>3</sub> =	107.5792 g
Net mass of solution =	101.5039 g
÷ 100 ml = density =	1.015 g/ml

3) Transfer # 760 to a 40 ml VOA vial.

Mass of bottle without lid =	21.5801 g (Bal 12)
Mass of std + bottle	26.5278 g
Net mass of std transferred	4.9477 g

4) Dilute to volume w/ 0.5M HNO<sub>3</sub>

Mass of bottle + std + soln =	61.8912 g (Bal 12)
Mass of bottle (from above)	21.5801 g
Net mass of std	40.3111 g

5) Final activity calc.

$$\frac{(1.852 \times 10^4 \text{ dpm/g}) (4.9477 \text{ g})}{(5.08447) (40.3111 \text{ g})} \left( \frac{1.015 \text{ g/ml}}{1.015 \text{ g/ml}} \right) = 26,534.83 \text{ dpm/g}$$

Continued on Page \_\_\_\_\_

Read and Understood By

Alister Baker

Signed

1/24/06

Date

[Signature]

Signed

1/27/06

Date



ANALYTICS

RSO# 760 Rec'd 7/14/04 JCB

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318 - U.S.A.

Phone (404) 352-8577  
Fax (404) 352-2837

## CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

68750-307

Th-230 5 mL Liquid in Flame Sealed Vial

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

ISOTOPE:	Th-230
ACTIVITY (dps):	1.832 Bq
HALF-LIFE:	7.538 Bq years
CALIBRATION DATE:	July 13, 2004 12:00 EST
RELATIVE EXPANDED UNCERTAINTY (k=2):	3.3%

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%

5.08447 grams 0.5M HNO<sub>3</sub> solution.

P O NUMBER 70635, Item 1

SOURCE PREPARED BY:

M. D. Currie  
M. D. Currie, Radiochemist

Q A APPROVED:

A. Currie 7/13/04

Project CS-137 working standard 1013.4095.77  
Continued from Page \_\_\_\_\_

Prepare a working dilution of 1013.4095.76

1. Density of 4% HCl, lot # 0000094396  
Mass of 100mL vol. flask: 68.5652g  
Mass of flask & 100mL acid: 169.0154g  
Net Mass: 100.4502g  
Density: 1.0045g/mL

Balance # 12  
Balance# 12

2. Mass of 1013.4095.76 transferred:  
Mass of empty nalgene: 74.1532g  
Mass of nalgene & standard: 75.4532g  
Net mass of standard transferred: 1.3000g

Balance# 12  
Balance# 12

3. Dilute to final volume:

Mass of nalgene, standard, & diluent: 1069.7g  
Mass of empty nalgene: 74.1532g  
Net mass of new dilution: 995.5468g

Balance# 26  
Balance# 12

4. Final activity calculation:

$$100,443.6 \text{ dpm/g} (1.0045 \text{ g/mL}) \left( \frac{1.3000 \text{ g}}{995.5468 \text{ g}} \right) = 131.75 \text{ dpm/mL}$$

Std ID: 1013.4095.77

Description: Cs-137  
Expiration: 1/20/2018  
Activity: 131.75 dpm/mL

2s Uncertainty: 0.92 dpm/mL

Ref. Date: 9/30/2005

Ref Time: N/A

Prep Date: 1/16/2015 Prep by: TE

Matrix/Comp. 4% HCl

Half Life (y): 3.01E+01

Reverification Log		
Analysis Date	Initials	Expiration Date
1/7/2016	JK	1/07/2017

Continued on Page \_\_\_\_\_

Signed

Date

Signed

Date

Prepare an intermediate dilution of

RSD# 1013

1. Density of 4% HCl, lot # 0000094396

Mass of 100mL vol. flask:

68.5652g

Balance # 12

Mass of flask &amp; 100mL acid:

169.0154g

Balance# 12

Net Mass:

100.4502g

Density:

1.0045g/mL

2. Mass of RSD# 1013 -transferred:

Mass of open empty bottle:

398.34g

Balance# 26

Mass of bottle and standard:

403.33g

Balance# 26

Net mass of standard transferred:

4.99g

3. Dilute to final volume:

Mass of open empty bottle:

398.34g

Balance# 26

Mass of bottle, standard, &amp; diluent:

1288.4g

Balance# 26

Net mass of new dilution:

890.06g

4. Final activity calculation:

$$298.6 \text{ kBq/g} \left( \frac{1000 \text{ Bq}}{1 \text{ kBq}} \right) \left( \frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left( \frac{4.99 \text{ g}}{890.06 \text{ g}} \right) = 100,443.61 \text{ dpm/g}$$

Continued on Page

T. O. H. T.

Signed

1/16/15

Date

Read and Understood By

M. J. H.

Signed

1-16-15

Date

RSO<sup>2</sup>  
1013



# National Institute of Standards & Technology Certificate

## Standard Reference Material 4233E Cesium-137 Radioactivity Standard

This Standard Reference Material (SRM) consists of radioactive cesium-137 chloride, non-radioactive cesium chloride, and hydrochloric acid dissolved in 5 mL of distilled water. The solution is contained in a flame-sealed NIST borosilicate-glass ampoule. The SRM is intended for the calibration of ionization chambers and solid-state gamma-ray spectrometry systems.

**Radiological Hazard:** The SRM ampoule contains cesium-137 with a total activity of approximately 1.5MBq. Cesium-137 decays by beta-particle emission to barium-137m, which decays by internal conversion. During the decay process X-rays and gamma rays with energies from approximately 3 keV to 662 keV are emitted. Most of these photons escape from the SRM ampoule and can represent a radiation hazard. Approximate unshielded dose rates at several distances (as of the reference time) are given in note [a]\*. Appropriate shielding and/or distance should be used to minimize personnel exposure. The SRM should be used only by persons qualified to handle radioactive material.

**Chemical Hazard:** The SRM ampoule contains hydrochloric acid with a concentration of 1 mole per liter of water. The solution is corrosive and represents a health hazard if it comes in contact with eyes or skin. If the ampoule is to be opened to transfer the solution, the recommended procedure is given on page 2. The ampoule should be opened only by persons qualified to handle both radioactive material and strong acid solution.

**Storage and Handling:** The SRM should be stored and used at a temperature between 5 and 65 °C. The solution in an unopened ampoule should remain stable and homogeneous until at least September 2015. The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material. If the ampoule is transported, it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The solution in the ampoule is a dangerous good (hazardous material) because of both the radioactivity and the strong acid.

**Preparation:** This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, M.P. Unterweger, Acting Group Leader. The overall technical direction and physical measurements leading to certification were provided by L.L. Lucas, R. Collé and L. Laureano-Pérez of the Radioactivity Group. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program.

Lisa R. Karam, Deputy Chief  
Ionizing Radiation Division

Gaithersburg, Maryland 20899  
October 2005

Robert L. Watters, Jr., Chief  
Measurement Services Division

### Recommended Procedure for Opening the SRM Ampoule

- 1) If the SRM solution is to be diluted, it is recommended that the diluting solution have a composition comparable to that of the SRM solution.
- 2) Wear eye protection, gloves, and protective clothing and work over a tray with absorbent paper in it. Work in a fume hood. In addition to the radioactive material, the solution contains strong acid and is corrosive.
- 3) Shake the ampoule to wet all of the inside surface of the ampoule. Return the ampoule to the upright position.
- 4) Check that all of the liquid has drained out of the neck of the ampoule. If necessary, gently tap the neck to speed the process.
- 5) Holding the ampoule upright, score the narrowest part of the neck with a scribe or diamond pencil.
- 6) Lightly wet the scored line. This reduces the crack propagation velocity and makes for a cleaner break.
- 7) Hold the ampoule upright with a paper towel, a wiper, or a support jig. Position the scored line away from you. Using a paper towel or wiper to avoid contamination, snap off the top of the ampoule by pressing the narrowest part of the neck away from you while pulling the tip of the ampoule towards you.
- 8) Transfer the solution from the ampoule using a pycnometer or a pipet with dispenser handle. NEVER PIPETTE BY MOUTH.
- 9) Seal any unused SRM solution in a flame-sealed glass ampoule, if possible, to minimize the evaporation loss.

See also reference [4]\*.

PROPERTIES OF SRM 4233E

Certified values

Radionuclide	Cesium-137
Reference time	1200 EST, 30 September 2005
Massic activity of the solution [c]*	298.6 kBq·g <sup>-1</sup>
Relative expanded uncertainty (k=2)	0.70% [d] [e]
Solution mass	(5.0668 ± 0.0009) g [b]
Solution density	(1.015 ± 0.002) g·mL <sup>-1</sup> at 20 °C [b]

Uncertified values

Physical Properties:			
Source description	Liquid in flame-sealed NIST borosilicate-glass ampoule		
Ampoule specifications	Body outside diameter	(16.5 ± 0.5) mm	
	Wall thickness	(0.60 ± 0.04) mm	
	Barium content	Less than 2.5%	
	Lead-oxide content	Less than 0.02%	
	Other heavy elements	Trace quantities	
Chemical Properties:			
Solution composition	Chemical Formula	Concentration (mol·L <sup>-1</sup> )	Mass Fraction (g·g <sup>-1</sup> )
	H <sub>2</sub> O	54	0.96
	HCl	1.0	0.04
	CsCl	1.6 × 10 <sup>-4</sup>	2.7 × 10 <sup>-5</sup>
	<sup>137</sup> CsCl	6.9 × 10 <sup>-7</sup>	1.2 × 10 <sup>-7</sup>
Radiological Properties:			
Photon-emitting impurities	None detected [f]		
Half lives used	Cesium-137: (10983 ± 11) d [g] [5] Radium-226: (1600 ± 7) a [g] [5]		
Calibration method and measuring instrument(s)	Pressurized "4π"γ ionization chamber A calibrated using an cesium-137 solution whose activity was determined by the 4π(e+X)-γ-coincidence efficiency-extrapolation technique.		

**EVALUATION OF THE UNCERTAINTY OF THE MASSIC ACTIVITY [d]\***

Input Quantity $x_i$ , the source of uncertainty  (and individual uncertainty components where appropriate)	Method Used To Evaluate $u(x_i)$ , the standard uncertainty of $x_i$ (A) denotes evaluation by statistical methods (B) denotes evaluation by other methods	Relative Uncertainty Of Input Quantity, $u(x_i)/x_i$ , (%) [h]	Relative Sensitivity Factor, $ \partial y/\partial x_i  \cdot$ $(x_i/y)$ [i]	Relative Uncertainty Of Output Quantity, $u(y)/y$ , (%) [j]
PIC A net response per gram of SRM 4233E, measured relative to RRS20 [k]	Standard deviation of the mean (within-measurement precision ) for 20 to 100 repeated measurements (A)	0.02	1.0	0.02
	Standard deviation (between- measurement precision) for 4 sets of measurement (A)	0.13	1.0	0.13
PIC A net response per Bq of cesium-137 in solution, measured relative to RRS20.	Standard deviation of the mean (for both between- and within- measurement precision) for >100 repeated measurements (A)	0.01	1.0	0.01
Activity used to calibrate PIC A net response per Bq of cesium-137 in solution	Standard uncertainty of the activity determined by the $4\pi(e+X)$ - $\gamma$ -coincidence efficiency-extrapolation technique. (B)	0.31	1.0	0.31
Half life of cesium-137 Half life of radium-226	Standard uncertainty of the half life (A)	0.10 [m] 0.44 [m]	0.0001 [n] 0.010 [n]	0.00001 0.004
Gravimetric measurements	Estimated (B)	0.03	1.0	0.03
PIC A charge collection	Estimated (B)	0.05	1.0	0.05
Charge collection measurement time [p]	Estimated (B)	0.05	1.0	0.05
Long-term RRS positioning	Estimated (B)	0.05	1.0	0.05
Photon-emitting impurities	Limit of detection (B) [q]	100.	0.0001	0.01
Relative Combined Standard Uncertainty of the Output Quantity, $u_c(y)/y$ , (%)				0.35
Coverage Factor, $k$				<u>x 2</u>
Relative Expanded Uncertainty of the Output Quantity, $U/y$ , (%)				0.70

## NOTES

- [a] The Sievert is the SI unit for dose equivalent. See reference [1]. One  $\mu\text{Sv}$  is equal to 0.1 mrem.
- |   |     |    |     |
|---|-----|----|-----|
| Distance from Ampoule (cm):                 | 1   | 30 | 100 |
| Approximate Dose Rate ( $\mu\text{Sv/h}$ ): | 300 | 4  | 0.3 |
- [b] The stated uncertainty is two times the standard uncertainty.
- [c] **Massic activity** is the preferred name for the quantity activity divided by the total mass of the sample. See reference [1].
- [d] The reported value,  $y$ , of massic activity (activity per unit mass) at the reference time was not measured directly but was derived from measurements and calculations of other quantities. This can be expressed as  $y = f(x_1, x_2, x_3, \dots, x_n)$ , where  $f$  is a mathematical function derived from the assumed model of the measurement process. The value,  $x_i$ , used for each input quantity  $i$  has a **standard uncertainty**,  $u(x_i)$ , that generates a corresponding uncertainty in  $y$ ,  $u_i(y) = |\partial y / \partial x_i| \cdot u(x_i)$ , called a **component of combined standard uncertainty** of  $y$ . The **combined standard uncertainty** of  $y$ ,  $u_c(y)$ , is the positive square root of the sum of the squares of the components of combined standard uncertainty. The combined standard uncertainty is multiplied by a **coverage factor** of  $k = 2$  to obtain  $U$ , the **expanded uncertainty** of  $y$ .
- Since it can be assumed that the possible estimated values of the massic activity are approximately normally distributed with approximate standard deviation  $u_c(y)$ , the unknown value of the massic activity is believed to lie in the interval  $y \pm U$  with a level of confidence of approximately 95 percent.
- For further information on the expression of uncertainties, see references [2] and [3].
- [e] The value of each component of combined standard uncertainty, and hence the value of the expanded uncertainty itself, is a best estimate based upon all available information, but is only approximately known. That is to say, the "uncertainty of the uncertainty" is large and not well known. This is true for uncertainties evaluated by statistical methods (e.g., the relative standard deviation of the standard deviation of the mean for the massic response is approximately 50%) and for uncertainties evaluated by other methods (which could easily be over estimated or under estimated by substantial amounts). The unknown value of the expanded uncertainty is believed to lie in the interval  $U/2$  to  $2U$  (i.e., within a factor of 2 of the estimated value).
- [f] Estimated limits of detection for photon-emitting impurities, as of 3 October 2005 (3 days after the reference time), expressed as massic photon emission rates, are:  
 $< 40 \gamma \cdot \text{s}^{-1} \cdot \text{g}^{-1}$  for energies between 40 keV and 1350 keV, and  
 $< 4 \gamma \cdot \text{s}^{-1} \cdot \text{g}^{-1}$  for energies between 1350 keV and 3600 keV,
- [g] The stated uncertainty is the standard uncertainty.
- [h] Relative standard uncertainty of the input quantity  $x_i$ .
- [i] The relative change in the output quantity  $y$  divided by the relative change in the input quantity  $x_i$ . If  $|\partial y / \partial x_i| \cdot (x_i / y) = 1.0$ , then a 1% change in  $x_i$  results in a 1% change in  $y$ . If  $|\partial y / \partial x_i| \cdot (x_i / y) = 0.05$ , then a 1% change in  $x_i$  results in a 0.05% change in  $y$ .

- [j] Relative component of combined standard uncertainty of output quantity  $y$ , rounded to two significant figures or less. The relative component of combined standard uncertainty of  $y$  is given by  $u_i(y)/y = |\partial y/\partial x_i| \cdot u(x_i)/y = |\partial y/\partial x_i| \cdot (x_i/y) \cdot u(x_i)/x_i$ . The numerical values of  $u(x_i)/x_i$ ,  $|\partial y/\partial x_i| \cdot (x_i/y)$ , and  $u_i(y)/y$ , all dimensionless quantities, are listed in columns 3, 4, and 5, respectively. Thus, the value in column 5 is equal to the value in column 4 multiplied by the value in column 3. The input quantities are independent, or very nearly so. Hence the covariances are zero or negligible.
- [k] The response of pressurized ionization chamber A (PIC A) is determined from measurement of the time required to collect a given amount of charge on a stable fixed capacitor. All of the response measurements in the NIST pressurized ionization chambers are made relative to the response of one or more artifact standards. These artifact standards consist of microgram quantities of aged radium-226 in small welded stainless-steel capsules. These capsules are encapsulated in plastic rods whose dimensions are similar to those of the standard NIST ampoule. The artifact standards are called **Radium Reference Sources** and are designated as RRSx, where x is the nominal mass (in micrograms) of radium-226 in the capsule.
- [m] The relative standard uncertainty of  $\lambda \cdot t$  is determined by the relative standard uncertainty of  $\lambda$  (i.e., of the half life). The relative standard uncertainty of  $t$  is negligible.
- [n]  $|\partial y/\partial x_i| \cdot (x_i/y) = |\lambda \cdot t|$
- [p] The charge collection measurement time is determined by counting the pulses from a gated crystal-controlled oscillator.
- [q] The standard uncertainty for each undetected impurity that might reasonably be expected to be present is estimated to be equal to the estimated limit of detection for that impurity, i.e.  $u(x_i)/x_i = 100\%$ .  $|\partial y/\partial x_i| \cdot (x_i/y) = \{(\text{response per Bq of impurity})/(\text{response per Bq of cesium-137})\} \cdot \{(\text{Bq of impurity})/(\text{Bq of cesium-137})\}$ . Thus  $u_i(y)/y$  is the relative change in  $y$  if the impurity were present with a massic activity equal to the estimated limit of detection.

#### REFERENCES

- [1] International Organization for Standardization (ISO), *ISO Standards Handbook - Quantities and Units*, 1993. Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
- [2] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993 (corrected and reprinted, 1995). Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
- [3] B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407, U.S.A.
- [4] National Council on Radiation Protection and Measurements Report No. 58, *A Handbook of Radioactivity Measurements Procedures*, Second Edition, 1985. Available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Bethesda, MD 20814 U.S.A.
- [5] Evaluated Nuclear Structure Data File (ENSDF), September 2005.

Instrument: LB4100-C

Calibration: Gross Alpha (Th-230) -- ringed planchet  
Gross Beta (Cs-137) -- ringed planchet  
Drinking Water EPA Method 900.0 Compliant

Date of Calibration: Gross Alpha 06/09/15  
Gross Beta 06/06/15

Efficiency Log Files: **Th230-06/15**  
**Cs-137-06/15**

Efficiency Instrument Files: ETH0609A-D  
ECS0606A-D

Source ID's: (Th-230 853.3020.89)  
(Cs-137 1019.4095.83)

**NOTE: Calibration Re-Verified 06/09/16.**  
(See Supporting Documentation in Package)

OK  
Expires  
06/02/2017  
JP 06/13/16

ALS

# QUALITY ASSURANCE SUMMARY SHEET

ALS W.O. #/BATCH Inst. C Calibration  
 TEST All tests  
 METHOD GFPC  
 SOP/REV (PREP) -  
 SOP/REV (ANAL) 724

Briefly document any QA or other problems or deviations associated with the analysis of samples. Problems could result from: log-in, color, odor, dilution, consistency, scheduling, equipment, or instrumentation, or may include documentation of minor deviations necessary due to unique DQO's or sample characteristics.

4-6-3-16  
 ALS Fort Collins SOP 724 requires an efficiency calibration for each Gas Flow test to be performed annually for each instrument. Per Technical Manager, the efficiency calibrations performed in 2015 for Instrument C will be acceptable for another year providing the following acceptance criteria was met: 1) Plateau checks were performed and were within acceptance criteria (The beta slope at the beta voltage and the alpha slope at the beta voltage had a slope of less than 3.5%). 2) CCV's and CCB's were performed for each calibration and were within the acceptance criteria. These results for the plateau checks and the CCV's/CCB's can be found in the "Addendum" section in the back of the calibration.

The instrument will be monitored with daily efficiency checks, daily background checks, and weekly background checks, as well as quarterly plateau checks as required per SOP 724. If any detectors fail any of these checks, the specific detector will be taken offline for the day and not be used to count client samples. If a detector fails its quarterly plateau check, the detector will be taken off-line until the instrument is re-calibrated for Voltage Plateaus, ROI's, and efficiency calibrations.

4-6-3-16  
6-3-16

TECHNICIAN/ANALYST

DATE 6-3-16

DEPARTMENT MANAGER

DATE 06/03/16

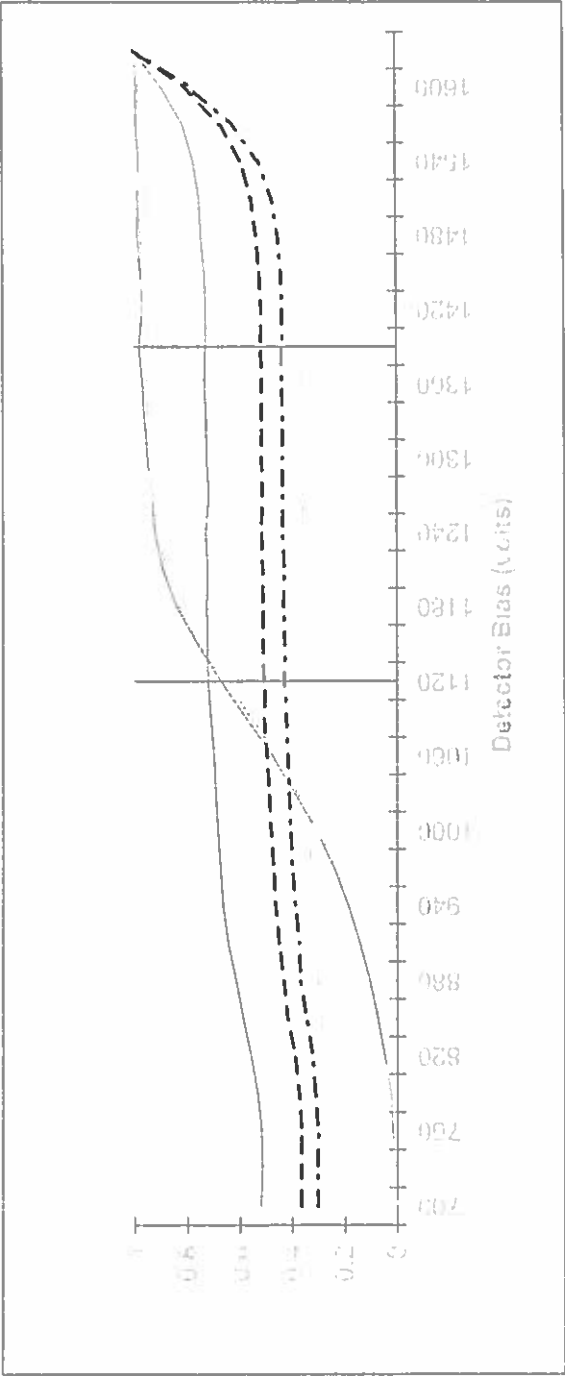
FORM 302r6.doc (4/22/04)

433598

# **Instrument Plateaus**

Unit Type: LB4100/W  
Date Performed: 6/4/15 07:19  
FileName: PTC0604A  
Batch ID: DRAWER A PLATEAU

Unit Id: Magenta  
Application Revision: 2  
Application Version: Standard



Optimum alpha beta simultaneous operating voltage: 1402.5

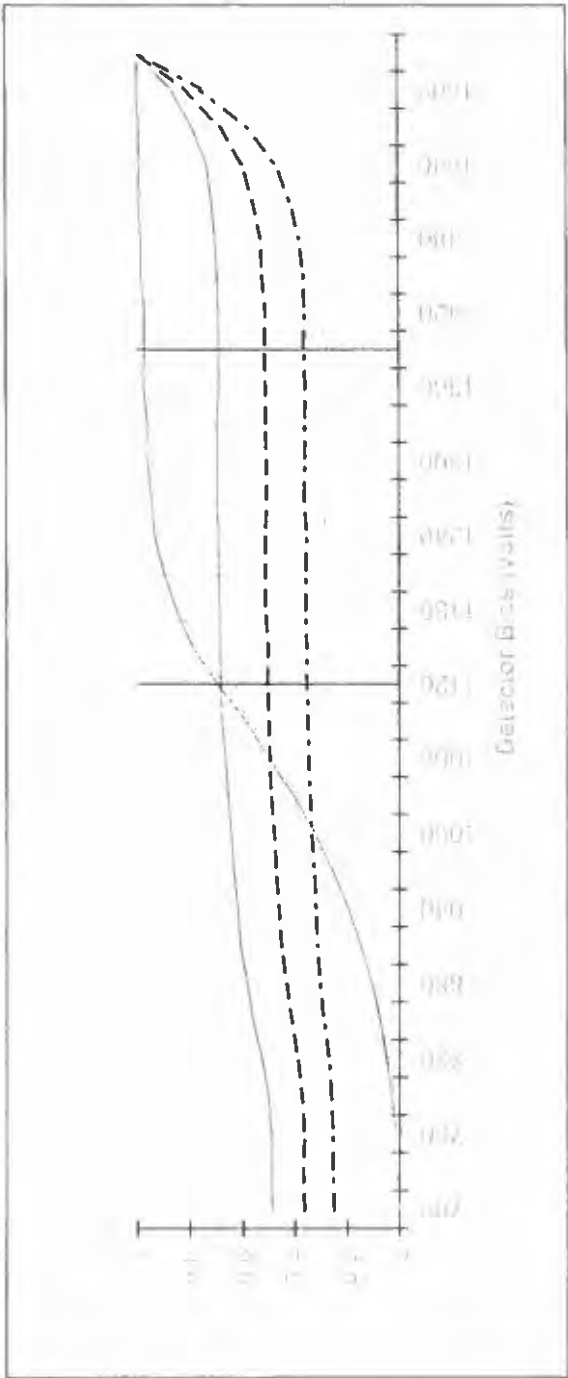
Optimum alpha only operating voltage: 1117.5

	A1	A2	A3	A4
Beta slope at beta voltage	0.98%	2.32%	2.15%	2.01%
Alpha slope at beta voltage	0.45%	0.91%	1.62%	0.57%
Alpha slope at alpha voltage	3.19%	2.18%	2.42%	3.19%

OK 8/6/15

Unit Type: LB4100/W  
Date Performed: 6/4/15 07:19  
File Name: PTC0604B  
Batch ID: DRAWER B PLATEAU

Unit Id: Magenta  
Application Revision: 2  
Application Version: Standard



Optimum alpha beta simultaneous operating voltage: 1402.5

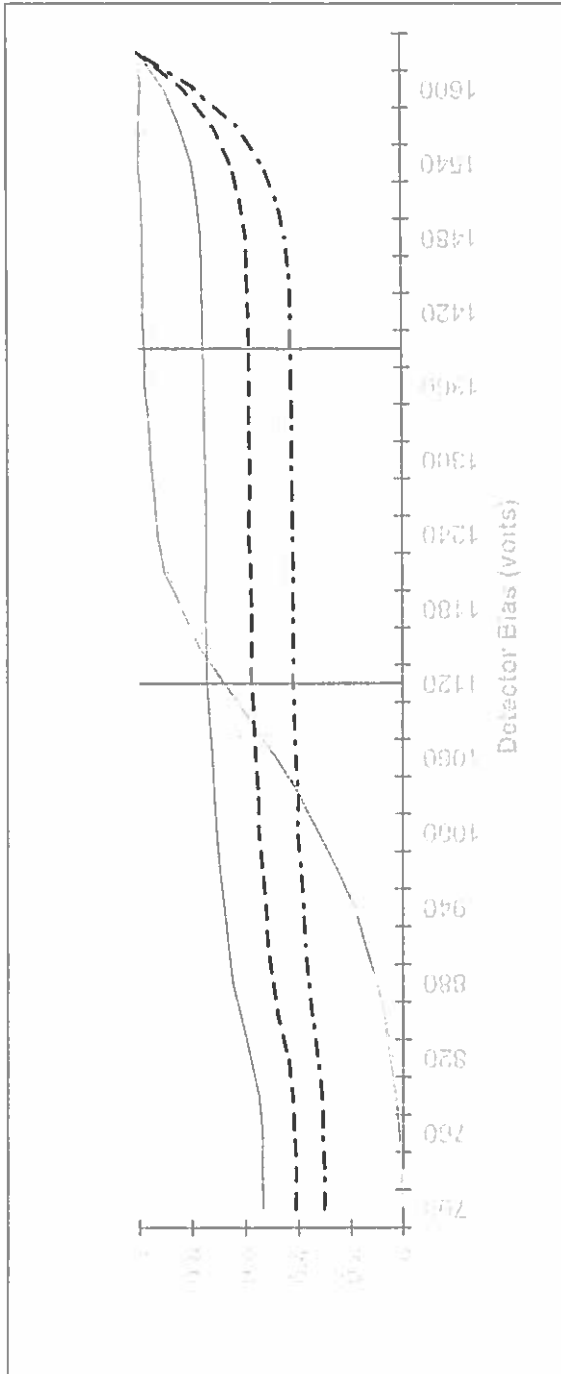
Optimum alpha only operating voltage: 1120

	B1	B2	B3	B4
Beta slope at beta voltage	1.40%	1.36%	1.60%	1.37%
Alpha slope at beta voltage	-0.18%	1.56%	1.68%	0.87%
Alpha slope at alpha voltage	2.53%	2.15%	1.16%	2.36%

OK 6/6/15 7/6/15

Unit Type: LB4100/W  
 Date Performed: 6/4/15 13:32  
 File Name: PTC0604C  
 Batch ID: DRAWER C PLATEAU

Unit Id: Magenta  
 Application Revision: 2  
 Application Version: Standard



Optimum alpha beta simultaneous operating voltage: **1402.5**

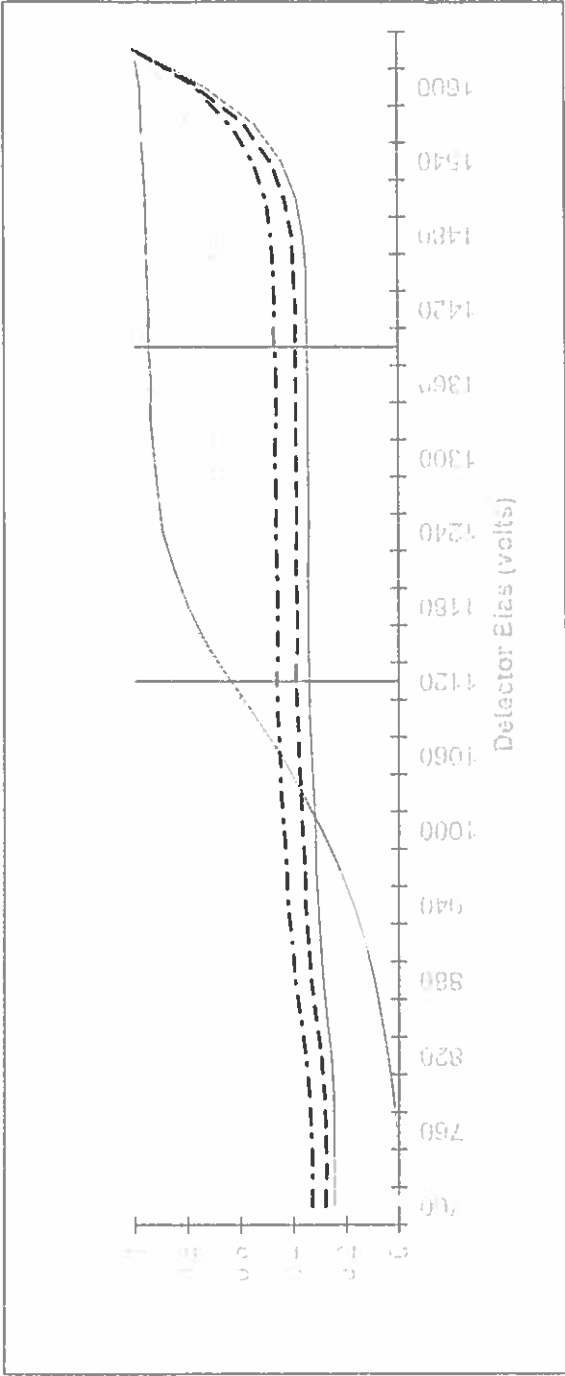
Optimum alpha only operating voltage: **1120**

	C1	C2	C3	C4
Beta slope at beta voltage	1.94%	1.64%	1.29%	1.87%
Alpha slope at beta voltage	0.69%	0.89%	0.80%	1.37%
Alpha slope at alpha voltage	3.36%	2.27%	2.34%	1.89%

*OK 7/6/15/RS*

Unit Type: LB4100/W  
Date Performed: 6/4/15 13:33  
FileName: PTC0604D  
Batch ID: DRAWER D PLATEAU

Unit Id: Magenta  
Application Revision: 2  
Application Version: Standard



Optimum alpha beta simultaneous operating voltage: 1402.5

Optimum alpha only operating voltage: 1120

	D1	D2	D3	D4
Beta slope at beta voltage	1.37%	0.31%	1.04%	2.34%
Alpha slope at beta voltage	1.21%	1.40%	0.81%	1.80%
Alpha slope at alpha voltage	2.81%	2.19%	2.37%	1.86%

OK TPC/5/15

3/12/15  
Cs-137 / Gross Beta Mass Attenuation

Benchsheet: AB150310-1

Sources: 1515002-1 to 24 File Name ACS0312

Det	8:53	9:03	9:21	9:38	9:50	10:00	10:12	10:22	10:36	10:49	11:04	11:18	11:26	11:38	11:48	12:00	12:10	12:22	12:33	12:43	12:59	13:11	13:21	13:31
A1	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
A2	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3
A3	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4
A4	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5
B1	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6
B2	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7
B3	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8
B4	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
C1	9	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
C2	10	9	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12	11
C3	11	10	9	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13	12
C4	12	11	10	9	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14	13
D1	13	12	11	10	9	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15	14
D2	14	13	12	11	10	9	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16	15
D3	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17	16
D4	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	24	23	22	21	20	19	18	17

6/04/2015

Plateau for Drawers A-D

Source Used	Detectors
410 Am-241	A1 B1 C1 D1
411 17,800 DPM	H2 B2 C2 D2
412 2-16.95	A3 B3 C3 D3
413	A4 B4 C4 D4

B Source Used

406	5,900/490
407	29,600 dpm
408	9-15-92
409	

Parameters

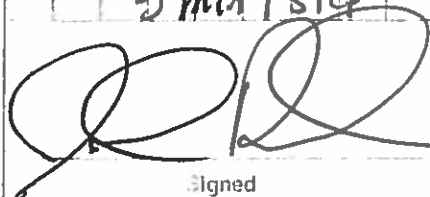
Starting Voltage 700  
End Voltage 1650  
30V / Step  
5 min / Step

Count Preset 40,000  
Time Between Steps 0.1  
Weak Check Times 0.1  
Weak Check Limits 20

File Name  
PTC0604A-D

Continued on Page

Read and Understood By

 03/13/15

Signed

Date

Signed

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Date 6/4/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12						(LB)			OLB
13						P			P
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKC0520W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	500	Dr A	0.1
		Dr B	
Tank 2	350	Dr C	
		Dr D	

Comments:

Date 6/4/15SOP 724r 11ALS  
Low Background Gas Flow Proportional Counter Log  
Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Daily EFF	==	=	30	6:02	JP	EFFC0604	JP
1-16	Daily Bkg	==	=	60	6:10	JP	BK C0604	JP
1-4	Alpha Beta	Drawer A Plateau	Plateau	5 Min / step	7:19	JP	PTC0604A	JP
5-8	Beta Alpha	Drawer B Plateau					B	
9-12	Alpha Beta				13:33	JP	C	
13-16	Beta Alpha						D	
JP 6/5/15								

Comments:

Page No.: 453998 **B**  
(cont. from page IVA **B**)

Form 780r8.doc (6/23/06)

Reviewed By / Date JP 6/5/15

# **Instrument ROIs**

Batch Specific:

Magenta	Event	Recycle
1	1	0.01

Drawer Specific:

	Date/Time	Official	Bias	Step
A	6-4-15 7:19	TRUE	1402.5	0
B	6-4-15 7:19	TRUE	1402.5	0
C	6-4-15 13:32	TRUE	1402.5	0
D	6-4-15 13:33	TRUE	1402.5	0

Detector Specific:

	Date/Time	Official	Thres	bLL	bUL	aLL	aUL	Time	bCntPsi	bPsiTm	aCntPsi	aPsiTm	bWkCnt	bWkTm	aWkCnt
A1	6-5-15 0:00	TRUE	0.1	0	43.71	80.56	100	35	10000	0	10000	0	0	0	0
A2	6-5-15 0:00	TRUE	0.1	0	42.85	80.21	100	35	10000	0	10000	0	0	0	0
A3	6-5-15 0:00	TRUE	0.1	0	41.59	79.82	100	35	10000	0	10000	0	0	0	0
A4	6-5-15 0:00	TRUE	0.1	0	42	76.8	100	35	10000	0	10000	0	0	0	0
B1	6-5-15 0:00	TRUE	0.1	0	44.51	86.44	100	35	10000	0	10000	0	0	0	0
B2	6-5-15 0:00	TRUE	0.1	0	42.53	77.46	100	35	10000	0	10000	0	0	0	0
B3	6-5-15 0:00	TRUE	0.1	0	41.48	76.5	100	35	10000	0	10000	0	0	0	0
B4	6-5-15 0:00	TRUE	0.1	0	41.44	77.5	100	35	10000	0	10000	0	0	0	0
C1	6-5-15 0:00	TRUE	0.1	0	40.92	77.99	100	35	10000	0	10000	0	0	0	0
C2	6-5-15 0:00	TRUE	0.1	0	41.36	77.09	100	35	10000	0	10000	0	0	0	0
C3	6-5-15 0:00	TRUE	0.1	0	37.28	71.47	100	35	10000	0	10000	0	0	0	0
C4	6-5-15 0:00	TRUE	0.1	0	42.34	78.09	100	35	10000	0	10000	0	0	0	0
D1	6-5-15 0:00	TRUE	0.1	0	39.19	71.47	100	35	10000	0	10000	0	0	0	0
D2	6-5-15 0:00	TRUE	0.1	0	39.56	73.84	100	35	10000	0	10000	0	0	0	0
D3	6-5-15 0:00	TRUE	0.1	0	38.24	72.82	100	35	10000	0	10000	0	0	0	0
D4	6-5-15 0:00	TRUE	0.1	0	40.92	77.82	100	35	10000	0	10000	0	0	0	0

ROI's

OK JP 6/5/15

6/5/2015

ROI's Set for All Drawers using Sr/Y-90 sources

Sources  $\rightarrow$  406, 407, 408, 409: Over 50,000 counts achieved for each detector $\alpha$  Lower Limit +  $\beta$  Upper limit set to 50% to startBoth  $\alpha$  lower limit +  $\beta$  upper limit moved to achieve  $\beta$   $\alpha$  Talk of 2.50%  $\alpha$   $\beta$  Talk of 0.10%  $\alpha$   $\beta$  Talk of 0.10%  $\alpha$   $\beta$  Talk of 0.10%

All ROI's Archived

6/5/15

After ROI's set, Interim Daily Efficiency control limits established for All 16 Detectors based on 5 individual counts

Files EFC0605A  $\rightarrow$  E. Interim limits for alpha + beta set at  $\pm 10\%$  of the mean of the 5 individual counts.

Historical control limits will be established upon acquisition of 30 Data Points.

6/5/151000 minute background count run. Interim long background calibration limits set to  $\pm 99\%$  for alpha,  $\pm 25\%$  for beta based on 6/5/15 1000 minute count.

Historical limits will be established following the acquisition of 10 data points.

6/6/15

Gross Alpha

Am241 Eff Calibration

Benchmark: ABIZ1109-1 Source ID  $\rightarrow$  1062 JPC6/6/15Logfile: Am241R  $\rightarrow$  06/15

Sources

Detectors

File names

1223001-20

A1 B1 C1 D1

EAM0606A

-22

A2 B2 C2 D2

B

-23

A3 B3 C3 D3

C

-24

A4 B4 C4 D4

D

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Date

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# **Calibration Efficiencies**

**Source Database for OSUM**

Number of sources in table: 127

Application Revision:

Control ID	Isotope	Type	Half-Life	DPM	Std dev	Date	Status	Alpha/Beta Archive File
1064	Cs-137	Beta	10990	3937.1	70.87	42044	ALS	Cs-137-06/15

**Source Database for OSUM**

Number of sources in table: 127

Application Revision:

Control ID	Isotope	Type	Half-Life	DPM	Std dev	Date	Status	Alpha/Beta Archive File
1067	Th-230	ALPHA	28124250	5831.907	116.63814	6-Nov-07	ALS	Th230-06/15

Th-230 Ringed Planchet Efficiency Calibration  
LB4100-C

Date: 6/9/2015

Source ID: 1067

Det ID	A1	A2	A3	A4	B1	B2	B3	B4
File Name	ETH0609A	ETH0609A	ETH0609A	ETH0609A	ETH0609B	ETH0609B	ETH0609B	ETH0609B
Cnt Time	7.32	7.53	7.43	7.24	7.61	7.81	7.56	7.83
Tot Cnts	10013	10011	10007	10005	10003	10004	10002	10010
Bkg CPM	0.124	0.157	0.112	0.110	0.114	0.122	0.134	0.145
CPM	1367.772	1329.325	1346.725	1381.796	1314.341	1280.800	1322.882	1278.271
Alpha Efficiency	0.234549	0.227956	0.230939	0.236953	0.225386	0.219634	0.226851	0.219201
Beta Efficiency	0.067309	0.066043	0.066819	0.069430	0.066602	0.064027	0.065035	0.065317
Efficiency	0.2345	0.2280	0.2309	0.2370	0.2254	0.2196	0.2269	0.2192

Det ID	C1	C2	C3	C4	D1	D2	D3	D4
File Name	ETH0609C	ETH0609C	ETH0609C	ETH0609C	ETH0609D	ETH0609D	ETH0609D	ETH0609D
Cnt Time	7.29	7.49	7.49	7.53	7.45	7.52	7.36	7.36
Tot Cnts	10013	10012	10016	10007	10006	10004	10017	10004
Bkg CPM	0.102	0.112	0.108	0.119	0.097	0.093	0.090	0.087
CPM	1373.423	1336.604	1337.142	1328.832	1342.990	1330.226	1360.915	1359.152
Alpha Efficiency	0.235518	0.229204	0.229296	0.227871	0.230299	0.228110	0.233373	0.233070
Beta Efficiency	0.065306	0.065826	0.064325	0.065418	0.068105	0.066486	0.067247	0.069349
Efficiency	0.2355	0.2292	0.2293	0.2279	0.2303	0.2281	0.2334	0.2331

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4
offset	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NumRecs	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
total time	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Alpha	7.32	7.53	7.43	7.24	7.61	7.81	7.56	7.83	7.29	7.49	7.49	7.53	7.45	7.52	7.36	7.36
total count	10013	10011	10007	10005	10003	10004	10002	10010	10013	10012	10016	10007	10006	10004	10017	10004
reduced cf	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
chi-square	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CPM	1367.772	1329.325	1346.725	1381.796	1314.341	1280.8	1322.882	1278.271	1373.423	1336.604	1337.142	1328.832	1342.99	1330.226	1360.915	1359.152
CPM var	373.9852	353.3105	362.6673	381.8376	345.5065	328.0867	350.0393	326.7065	377.0696	357.1477	357.3618	353.0987	360.6686	353.8791	370.1529	369.4324
Efficiency	0.234549	0.227956	0.230939	0.236953	0.225386	0.219634	0.228851	0.219201	0.235518	0.229204	0.229296	0.227871	0.230299	0.22811	0.233373	0.23307
archived S	0.005745	0.005583	0.005657	0.005804	0.005521	0.00538	0.005557	0.005369	0.005769	0.005614	0.005616	0.005582	0.005641	0.005587	0.005716	0.005709
predicted S	0.002344	0.002278	0.002309	0.002369	0.002254	0.002196	0.002268	0.002191	0.002354	0.002291	0.002291	0.002278	0.002302	0.002281	0.002332	0.002333
actual STC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Beta	2884	2912	2907	2943	2968	2929	2881	2996	2790	2889	2825	2887	2980	2928	2898	2989
reduced cf	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
chi-square	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CPM	392.5131	385.1318	389.6567	404.8797	388.3901	373.375	379.2517	380.8989	380.832	383.8643	375.1096	381.4827	397.154	387.7157	392.15	404.4101
CPM var	69.34786	66.31402	67.96775	72.67043	66.46273	62.08602	64.93241	63.50967	67.14781	66.37664	64.58416	65.61775	69.69412	66.93872	69.00415	71.67312
Efficiency	0.067309	0.066043	0.066819	0.06943	0.066602	0.064027	0.065035	0.065317	0.065306	0.065826	0.064325	0.065418	0.068105	0.066486	0.067247	0.069349
archived S	0.001963	0.001922	0.001945	0.002016	0.001931	0.001862	0.001898	0.001891	0.001918	0.00192	0.001885	0.001908	0.001976	0.001933	0.001959	0.002008
predicted S	0.001256	0.001226	0.001242	0.001282	0.001225	0.001186	0.001215	0.001196	0.001239	0.001228	0.001214	0.001221	0.001252	0.001231	0.001252	0.001271
actual STC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Cs-137 Ringed Planchet Efficiency Calibration  
LB4100-C

Date: 6/6/2015

Source ID: 1064

Det ID	A1	A2	A3	A4	B1	B2	B3	B4
File Name	ECS0606A	ECS0606A	ECS0606A	ECS0606A	ECS0606B	ECS0606B	ECS0606B	ECS0606B
Cnt Time	6.21	6.12	6.24	6.26	6.32	6.28	6.4	6.24
Tot Cnts	10005	10014	10014	10012	10012	10008	10009	10008
Bkg CPM	1.476	1.588	1.595	1.612	1.623	1.657	1.833	1.732
CPM	1609.635	1634.687	1603.213	1597.749	1582.554	1591.974	1562.073	1602.114
Alpha Efficiency	0.000875	0.000796	0.000504	0.000953	0.000659	0.000987	0.001125	0.000537
Beta Efficiency	0.411876	0.418286	0.410233	0.408835	0.404947	0.407357	0.399706	0.409952
Efficiency	0.4119	0.4183	0.4102	0.4088	0.4049	0.4074	0.3997	0.4100

Det ID	C1	C2	C3	C4	D1	D2	D3	D4
File Name	ECS0606C	ECS0606C	ECS0606C	ECS0606C	ECS0606D	ECS0606D	ECS0606D	ECS0606D
Cnt Time	6.30	6.14	6.24	6.30	6.28	6.13	6.03	6.3
Tot Cnts	10013	10003	10014	10008	10005	10022	10010	10016
Bkg CPM	1.884	1.850	2.060	1.917	2.846	1.646	1.600	1.704
CPM	1587.481	1627.303	1602.748	1586.654	1590.307	1633.264	1658.433	1588.137
Alpha Efficiency	0.000908	0.000555	0.000669	0.000619	0.000586	0.000978	0.000953	0.000912
Beta Efficiency	0.406208	0.416397	0.410114	0.405996	0.406931	0.417923	0.424363	0.406376
Efficiency	0.4062	0.4164	0.4101	0.4060	0.4069	0.4179	0.4244	0.4064

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4
offset	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NumRecs	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
total time	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
total count	6.21	6.12	6.24	6.26	6.32	6.28	6.4	6.24	6.3	6.14	6.24	6.3	6.28	6.13	6.03	6.3
reduced ci	22	20	13	24	17	25	29	14	23	14	17	16	15	24	23	23
chi-square	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CPM	3.418673	3.110974	1.971333	3.723866	2.575873	3.858892	4.39725	2.09859	3.548794	2.16813	2.616359	2.420683	2.291535	3.822171	3.724262	3.563794
CPM var	0.571658	0.535208	0.334414	0.614018	0.42645	0.635607	0.710195	0.360188	0.580926	0.371989	0.437446	0.403888	0.381007	0.640316	0.634092	0.580911
Efficiency	0.000875	0.000796	0.000504	0.000953	0.000659	0.000987	0.001125	0.000537	0.000908	0.000555	0.000669	0.000619	0.000586	0.000978	0.000953	0.000912
archived S	0.000194	0.000188	0.000148	0.000201	0.000168	0.000205	0.000217	0.000154	0.000196	0.000156	0.00017	0.000163	0.000158	0.000206	0.000204	0.000196
predicted S	0.00019	0.000182	0.000144	0.000197	0.000163	0.000201	0.000212	0.000148	0.000192	0.000152	0.000166	0.000159	0.000155	0.000202	0.000201	0.000192
actual STC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
total count	10005	10014	10014	10012	10012	10008	10009	10008	10013	10003	10014	10008	10005	10022	10010	10016
reduced ci	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
chi-square	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CPM	1609.635	1634.687	1603.213	1597.749	1582.554	1591.974	1562.073	1602.114	1587.481	1627.303	1602.748	1586.654	1590.307	1633.264	1658.433	1588.137
CPM var	519.0076	535.1061	514.7231	511.2862	501.6243	507.7303	488.9425	514.2606	504.8902	530.7502	514.7236	504.512	507.5032	534.0012	550.8683	505.117
Efficiency	0.411876	0.418286	0.410233	0.408835	0.404947	0.407357	0.399706	0.408952	0.406208	0.416397	0.410114	0.405996	0.408931	0.417923	0.424363	0.406376
archived S	0.009431	0.009577	0.009393	0.009361	0.009272	0.009328	0.009153	0.009388	0.009302	0.009536	0.009391	0.009297	0.009321	0.009569	0.009717	0.009305
predicted S	0.00412	0.004182	0.004101	0.004088	0.004049	0.004074	0.003988	0.0041	0.004062	0.004166	0.004101	0.004061	0.004072	0.004177	0.004244	0.004063
actual STC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

6/6/15

Sr90 Ring Eff Calibration (Gross Beta)

Benchsheet: AB110616-3

Source ID: 1051

1063

JP 6/6/15

Log File: Sr90R-06/15

Sources

Detectors

Filenames

JP 6/6/15

118005-2

A1 B1 C1 D1

ESR0606A

ESR0606A

-3

A2 B2 C2 D2

ESR0606B

-4

A3 B3 C3 D3

C

-5

A4 B4 C4 D4

D

6/6/15

Cs137 Eff Calibration (Gross Beta)

Benchsheet: AB150310-2

Source ID: 1061

1064

JP 6/6/15

Log File: Cs137-06/15

Sources

Detectors

Filenames

JP 6/6/15

1515003-1

A1 B1 C1 D1

ECS0606A

-3

A2 B2 C2 D2

B

-4

A3 B3 C3 D3

C

-5

A4 B4 C4 D4

D

6/6/15

6/8/2015

Ra228 Efficiency Calibration

Benchsheet: RA150603-1

Source ID: 1065

Log File: Ra228-06/15

Sources

Detectors

Filenames

1518001-1

A1 B1 C1 D1

ERA0608A

-2

A2 B2 C2 D2

B

-3

A3 B3 C3 D3

C

-5

A4 B4 C4 D4

D

Continued on Page

Read and Understood By

Signed

Date

6/6/15

Signed

D216 of 348

6/9/2015

Gross Alpha  $\rightarrow$  Th230 Efficiency CalibrationBenchsheet: AB1506035 Source ID  $\rightarrow$  1067

Log File: Th230-06/15

Sources

1518003-1

-2

-3

-4

Detectors

A1 B1 C1 D1

A2 B2 C2 D2

A3 B3 C3 D3

A4 B4 C4 D4

File names

ETH0609A

B

C

D

6/9/2015

Th230 (Gross Alpha) Mass Attenuation Curve

Benchsheet: AB1506036 Sources: 1518004-1  $\rightarrow$  16Calibration Range: 12.4  $\rightarrow$  100 mg

Filename:

ATH0609

ATH0610

Det	11:01	11:30	11:58	12:24	12:49	13:15	13:41	14:11	14:38	15:05	15:33	7:56	8:24	8:52	9:28	9:55
A1	1	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
A2	2	1	16	15	14	13	12	11	10	9	8	7	6	5	4	3
A3	3	2	1	16	15	14	13	12	11	10	9	8	7	6	5	4
A4	4	3	2	1	16	15	14	13	12	11	10	9	8	7	6	5
B1	5	4	3	2	1	16	15	14	13	12	11	10	9	8	7	6
B2	6	5	4	3	2	1	16	15	14	13	12	11	10	9	8	7
B3	7	6	5	4	3	2	1	16	15	14	13	12	11	10	9	8
B4	8	7	6	5	4	3	2	1	16	15	14	13	12	11	10	9
C1	9	8	7	6	5	4	3	2	1	16	15	14	13	12	11	10
C2	10	9	8	7	6	5	4	3	2	1	16	15	14	13	12	11
C3	11	10	9	8	7	6	5	4	3	2	1	16	15	14	13	12
C4	12	11	10	9	8	7	6	5	4	3	2	1	16	15	14	13
D1	13	12	11	10	9	8	7	6	5	4	3	2	1	16	15	14
D2	14	13	12	11	10	9	8	7	6	5	4	3	2	1	16	15
D3	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	16
D4	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Continued on Page

Read and Understood By

Signed

Date

Signed

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Date 6/6/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			*				P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16	✓	✓			✓				✓

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK0605W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	400	Dr A	0.1
		Dr B	
Tank 2	1800	Dr C	
		Dr D	✓

Comments: \* Not necessary to run daily background checks following a 1000 Minute Background Calibration JP 6/6/15

Date 6/6/15SOP 724r 11ALS  
Low Background Gas Flow Proportional Counter Log  
Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Dq. Eff	AB121109-1	Gross	30	7:17	JP	EFC0606	JP
1-4	1050	AB121109-1	Cal	30	7:38	JP	EAM0606A	
5-8					7:47			B
9-12					7:58			C
13-16					8:07			D
1-4	1051	AB110616-3	Gross	30	7:58	JP	ESR0606A	JP
5-8			Cal		8:08			B
9-12					8:17			C
13-16					8:27			D
1-4	1061	AB150310-2	Gross	30	8:08	JP	ECS0606A	
5-8			Cal		8:17			B
9-12					8:25			C
13-16								D
1-16	1223001-13-14-15-16-17-18-19	AB121109-1	Mass	30		JP	AAM0606	
			Att. Line					
1-4	1062	AB121109-1	d. EFF	30	8:34	JP	EAM0606A	JP
5-8			Cal (An 24)		8:43	JP		B
9-12					8:53	JP		C
13-16					9:03			D
1-4	1063	AB110616-3	B EFF	30	9:44		ESR0606A	JP
5-8			Cal (SAD)		8:54			B
9-12					9:04			C
13-16					9:13			D
1-4	1064	AB150310-2	B EFF	30	9:07		ECS0606A	JP
5-8			Cal		9:17			B
9-12			Cal 37		9:29			C
13-16					9:36			D
1-16	1223001-13-14-15-16-17-18-19	AB121109-1	Mass	30	9:56	JP	AAM0606	JP
			Att. Line					

Comments:

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(cont. from page NA **B**)

Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 6/7/15

Date 6/7/15SOP 724r 1)

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	✓	P			✓	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16	✓	✓			✓	✓			✓

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK0605W			
Dr B				
Dr C				
Dr D	✓			

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	350	Dr A	0.1
		Dr B	
Tank 2	1450	Dr C	
		Dr D	✓

Comments:Page No.: 455202 **A**

Form 780r8.doc (6/23/06)

Reviewed By / Date DP 6/7/15

Date 6/9/15

SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK00605W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	1850	Dr A	0.1
	↓	Dr B	
Tank 2	1200	Dr C	
	↓	Dr D	

Comments:

Page No.: 455204 **A**

Form 780r8.doc (6/23/06)

Reviewed By / Date

J 6/9/15

Date 6/9/15SOP 724r 11

## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Daily EFP	—	—	30	7:13	JP	EFP0609	JP
1-16	Daily Bkg	—	—	60	7:22	JP	BKG0609	JP
1	1518003-1	AB150603-5	Th230	10	8:47	JP	AB0609	JP
1	-2	↓	outlier	↓	9:00	JP	A	↓
1	-3	↓	↓	↓	9:13	JP	B	↓
1	-4	↓	↓	↓	9:37	JP	C	↓
1	-5	↓	↓	↓	9:51	JP	D	↓
1-4	1067	AB150603-5	Th230	30	10:15	JP	ETH0609A	JP
5-8	↓	↓	Eff	↓	10:23	↓	B	↓
9-12	↓	↓	Eff	↓	10:37	↓	C	↓
13-16	↓	↓	Eff	↓	10:51	↓	D	↓
1-16	1518004-1-16	AB150603-6	Th230	30	11:01	JP	ATH0609	JP
1	1505092-1	SR150605-1	Sr90	180	16:03	JP	SRC0609	JP
2	-3	↓	↓	↓	↓	↓	↓	↓
3	-30	↓	↓	↓	↓	↓	↓	↓
4	1505234-1	↓	↓	↓	↓	↓	↓	↓
5	-3	↓	↓	↓	↓	↓	↓	↓
6	-5	↓	↓	↓	↓	↓	↓	↓
7	-7	↓	↓	↓	↓	↓	↓	↓
8	-9	↓	↓	↓	↓	↓	↓	↓
9	-11	↓	↓	↓	↓	↓	↓	↓
10	-13	↓	↓	↓	↓	↓	↓	↓
11	-130	↓	↓	↓	↓	↓	↓	↓
12	1505235-1	↓	↓	↓	↓	↓	↓	↓
14	-3	↓	↓	↓	↓	↓	↓	↓
15	-30	↓	↓	↓	↓	↓	↓	↓
16	1505249-1	↓	↓	↓	↓	↓	↓	↓
1	-2	SR150605-1	Sr90	180	22:12	JP	SRC0609A	↓
2	1505344-1	↓	↓	↓	↓	↓	↓	↓
3	427-1	↓	↓	↓	↓	↓	↓	↓
4	-3	↓	↓	↓	↓	↓	↓	↓
5	SR1506051ms	↓	↓	↓	↓	↓	↓	↓
6	101	↓	↓	↓	↓	↓	↓	↓
7	1505379-8	AB150605-1	α117	120	22:13	JP	AB0609	↓
8	-80	↓	↓	↓	↓	↓	↓	↓
9	-10	↓	↓	↓	↓	↓	↓	↓
10	AB150605-116	↓	↓	↓	↓	↓	↓	↓
11	1505341-1	AB150605-2	↓	480	22:15	↓	AB0609A	↓
12	-10	↓	↓	↓	↓	↓	↓	↓
14	1505448-1	↓	↓	↓	↓	↓	↓	↓
15	-4	↓	↓	↓	↓	↓	↓	↓
JP 6/10/15								

Comments:

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(cont. from page NA **B**)

Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 6/10/15

Date 6/10/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	P	P			P	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKC 060512			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	500	Dr A	0
		Dr B	
Tank 2	1200	Dr C	
		Dr D	

Comments:Page No.: 455205 **A**

Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 6/10/15

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-5

Prep Procedure: GROSS\_ALPH Base Efficiency

Analytical QASS / NCR? Y *N*

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes
1	1518003-1	SMP	200	200	ml	pCi/l	See Logbook 3710 p 75									
1	1518003-2	SMP	200	200	ml	pCi/l										
1	1518003-3	SMP	200	200	ml	pCi/l										
1	1518003-4	SMP	200	200	ml	pCi/l										
1	1518003-5	SMP	200	200	ml	pCi/l										

*JP Collins*  
*Gutierrez*

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPN/ml	06/03/15	5 ml RS-027

## Sample Barcodes

1518003-1 AB150603-5PS1		1518003-2 AB150603-5PS2		1518003-3 AB150603-5PS3	
1518003-4 AB150603-5PS4		1518003-5 AB150603-5PS5			

## Reporting Units

LabID:	TstGrpName:	RptUnits:
1518003-1	GrossAlpha_DW	pCi/l
1518003-2	GrossAlpha_DW	pCi/l
1518003-3	GrossAlpha_DW	pCi/l
1518003-4	GrossAlpha_DW	pCi/l
1518003-5	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-5

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb *3/10/15* Review Date: 6/8/2015

Non-Routine Pre-Treatment? Y *(N)* Batch: *NA*

Prep QASS / NCR? Y *(N)* *NA*

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 6/3/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1518003-1	SMP	200	200	200	Unfiltered	S1	<i>7/27/15</i>
2	1	1518003-2	SMP	200	200	200	Unfiltered	S1	
3	1	1518003-3	SMP	200	200	200	Unfiltered	S1	
4	1	1518003-4	SMP	200	200	200	Unfiltered	S1	
5	1	1518003-5	SMP	200	200	200	Unfiltered	S1	

Comments

Zero Mass Efficiency for Th-230 USGS method

Spiked By: Jennie Kill-Bowden Date: 6/4/2015

Witnessed By: Dayna K. Lewis Date: 6/4/2015

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPM/ml	06/03/15	5	ml	RS-027

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# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-5

**Prep Batch Not Validated!!!**

Prep Procedure: GROSS\_ALPH

Reviewed By: Review Date:

Non-Routine Pre-Treatment? Y / N Batch:

Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden *JKB*

Prep Date: 6/3/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1518003-1	SMP		200	200	Unfiltered	S1	
2	1	1518003-2	SMP		200	200	Unfiltered	S1	
3	1	1518003-3	SMP		200	200	Unfiltered	S1	
4	1	1518003-4	SMP		200	200	Unfiltered	S1	
5	1	1518003-5	SMP		200	200	Unfiltered	S1	

Comments

Zero Mass Efficiency for Th-230 USGS method

Spiked By: *JKB* Date: *6/4/15*

Witnessed By: *[Signature]* Date: *6/4/15*

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Pipet ID
S1	Th-230	853.3020.89	1.166	300 DPM/ml	06/03/15	RS-027

*ra/13/15*

# Radiochemistry Instrument Worksheet

Prep Batch: AB150310-2

ALS Environmental -- FC JP 3/10/15

Prep Procedure: GROSS ~~ALPHA~~ BETA BASE EFFICIENCY

Analytical QASS / NCR? Y N

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 InstIDet	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 InstIDet	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 InstIDet	Cnt 3 Pos Chk By	Notes
1	1515003-1	SMP	200	200	ml	pCi/l	0	See Run Log 3710 p371									Outlier
1	1515003-2	SMP	200	200	ml	pCi/l	0										
1	1515003-3	SMP	200	200	ml	pCi/l	5.111/10.5										
1	1515003-4	SMP	200	200	ml	pCi/l	-90.6										
1	1515003-5	SMP	200	200	ml	pCi/l	-90.9										

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot Units	Pipet ID
S1	Cs-137	1019.4095	83	DPM/ml	03/10/15	1 ml	RS-005

## Sample Barcodes

1515003-1  
AB150310-2PS1

1515003-2  
AB150310-2PS2

1515003-4  
AB150310-2PS4

1515003-5  
AB150310-2PS5

## Reporting Units

LabID: 1515003-1 GrossAlpha\_DW pCi/l

1515003-1 GrossAlpha\_DW pCi/l

1515003-2 GrossAlpha\_DW pCi/l

1515003-3 GrossAlpha\_DW pCi/l

1515003-4 GrossAlpha\_DW pCi/l

1515003-5 GrossAlpha\_DW pCi/l

# Radiochemistry Prep Worksheet

Prep Batch: AB150310-2

ALS Environmental -- FC

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb Review Date: 3/10/2015

Non-Routine Pre-Treatment? Y ☒ N

Batch: AA

Re-Prep? Y ☒ N

Batch:

Prep QASS / NCR? Y ☒ N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Balance:

Balance:

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1515003-1	SMP		200	200	As Received	S1	
2	1	1515003-2	SMP		200	200	As Received	S1	
3	1	1515003-3	SMP		200	200	As Received	S1	
4	1	1515003-4	SMP		200	200	As Received	S1	
5	1	1515003-5	SMP		200	200	As Received	S1	

Comments

Cs-137 efficiencies

Spiked By: Jennie Kill-Bowden Date: 3/10/2015

Witnessed By: Dayna K Lewis Date: 3/10/2015

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Cs-137	1019.4095.83	3.929.815	DPM/ml	03/10/15
				1 ml	RS-005

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-2

**Prep Batch Not Validated!!!**

Prep Procedure: GROSS\_ALPHA

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch:

Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1515003-1	SMP	200	200	200	As Received	S1	
2	1	1515003-2	SMP	200	200	200	As Received	S1	
3	1	1515003-3	SMP	200	200	200	As Received	S1	
4	1	1515003-4	SMP	200	200	200	As Received	S1	
5	1	1515003-5	SMP	200	200	200	As Received	S1	

Comments

Cs-137 efficiencies

Spiked By: SKS Date: 3/10/15

Witnessed By: [Signature] Date: 3/10/15

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Pipet ID
S1	Cs-137	1019 4095.83	3.929.815	DPW/ml	03/10/15	RS-005

exp: 3/5/16

**OUTLIER TEST**

FILE	DET	SAMPLE ID	Alpha CPM	Relative % diff. from mean	Within acceptability range	Outlier?
ABC0609	A1(1)	1518003-1	1379.300	3.75%	YES	NO
ABC0609A	A1(1)	1518003-2	1319.7	0.74%	YES	NO
ABC0609B	A1(1)	1518003-3	1333	0.26%	YES	NO
ABC0609C	A1(1)	1518003-4	1348.5	1.43%	YES	NO
ABC0609D	A1(1)	1518003-5	1266.9	4.71%	REJECT	OUTLIER!

<b>Mean of all five plachnets:</b>					<u>Acceptability range</u>	<u>Relative range</u>
Average= 1329.48				Upper	1412.35	+/- 6.23%
Std dev= 41.437				Lower	1246.61	
2 Std Dev= 82.87						

**Sample 1518003-5 rejected as outlier.**

Criteria: Potential outliers fall outside acceptability range; which is the mean of all five measurements +/- 2 std dev per the Grubbs statistical test.

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-5

Prep Procedure: GROSS\_ALPHA

Analytical QASS / NCR? Y / N

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Ins/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Ins/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Ins/Det	Cnt 3 Pos Chk By	Notes
1	1518003-1	SMP	200	200	ml	pCi/l	AB00609	1	JP								
1	1518003-2	SMP	200	200	ml	pCi/l		A	1								
1	1518003-3	SMP	200	200	ml	pCi/l		B	1								
1	1518003-4	SMP	200	200	ml	pCi/l		C	1								
1	1518003-5	SMP	200	200	ml	pCi/l		D	1								Other

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot Units	Pipet ID
S1	Th-230	853.3020.89	1,166,300	DPM/ml	06/03/15	5 ml	RS-027

## Sample Barcodes

1518003-1  
AB150603-SPS1

1518003-2  
AB150603-SPS2

1518003-3  
AB150603-SPS3

1518003-4  
AB150603-SPS4

1518003-5  
AB150603-SPS5

## Reporting Units

LabID	TstGrpName	RptUnits
1518003-1	GrossAlpha_DW	pCi/l
1518003-2	GrossAlpha_DW	pCi/l
1518003-3	GrossAlpha_DW	pCi/l
1518003-4	GrossAlpha_DW	pCi/l
1518003-5	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-5

Prep Procedure: GROSS\_ALPH

Reviewed By: jkb *3/6/15* Review Date: 6/8/2015

Non-Routine Pre-Treatment? Y *(N)* Batch: *NA*

Re-Prep? Y *(N)* Batch: *NA*

Prep QASS / NCR? Y *(N)* *NA*

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 6/3/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1518003-1	SMP		200	200	Unfiltered	S1	
2	1	1518003-2	SMP		200	200	Unfiltered	S1	
3	1	1518003-3	SMP		200	200	Unfiltered	S1	
4	1	1518003-4	SMP		200	200	Unfiltered	S1	
5	1	1518003-5	SMP		200	200	Unfiltered	S1	

Comments

Zero Mass Efficiency for Th-230 USGS method

Spiked By: Jennie Kill-Bowden Date: 6/4/2015

Witnessed By: Dayna K. Lewis Date: 6/4/2015

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Th-230	853.3020.89	1,166,300	DPM/ml	05/03/15	5	ml	RS-027

# Radiochemistry Prep Worksheet

Prep Batch: AB150603-5

ALS Environmental -- FC

Prep Procedure: GROSS\_ALPH

Prep Batch Not Validated!!!

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch:

Prep QASS / NCR? Y / N

Re-Prep? Y / N Batch:

Prep SOP: PAI 702 Rev: 20

Prep Analyst: Jennie Kill-Bowden *JKB*

Balance:

Prep Date: 6/3/2015

Balance:

Prep SOP: NONE

Matrix Class: liquid

Prep Dept: RS

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1518003-1	SMP		200	200	Unfiltered	S1	
2	1	1518003-2	SMP		200	200	Unfiltered	S1	
3	1	1518003-3	SMP		200	200	Unfiltered	S1	
4	1	1518003-4	SMP		200	200	Unfiltered	S1	
5	1	1518003-5	SMP		200	200	Unfiltered	S1	

Comments

Zero Mass Efficiency for Th-230 USGS method

Spiked By: *JKB* Date: *6/4/15*

Witnessed By: *[Signature]* Date: *6/4/15*

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot Units
S1	Th-230	853.3020.89	1.166	300 DPM/ml	06/03/15	5 ml
						RS-027

*12/13/15*

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev: 120/08 JCP

Data file name: ABC0609  
Batch ID: TH230 OUTLIER  
Count Preset (m): 10  
2 Batch Ended: 6/9/2015 8:58

Background logfile: BKGABW  
Date of Bkg. Cal: 6/6/2015  
Alpha efficiency logfile: TH230-06/13  
Alpha attenuation calibration: ATH0615\_0620  
Beta efficiency logfile: Cs-137-03/15  
Beta attenuation calibration: ACS0312

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^a (e^{(mass \cdot c)})$		$y = b \cdot m^a (e^{(mass \cdot c)})$	
Alpha b=	0.833740	Beta b=	0.8484
m=	0.99090	m=	0.9993
a=	0.9208	a=	1.0464
c=	0.0000	c=	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b \cdot m^a \cdot c^{mass}$		$y = b \cdot m^a \cdot c^{mass}$	
a->b xtalk b=	0.2327	b->a xtalk b=	-3.54E-06
a->b xtalk m=	0.9978	b->a xtalk m=	0.0032

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity			
					Gross CPM	Bkg. CPM	b>a xtalk CPM	Base Cor.Fact	Progeny Eff	Base Cor.Fact	Progeny Eff	Cor.Fact.
A1	1518003-1	6/9/2015 8:58	10.00	0.0	1376.300	0.124	1.223	0.2366	0.937	0.4155	0.949	n/a
							348.5178					n/a
												n/a
												n/a

JP 6/9/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision:  
Application Version: Standard  
Rev: 12/01/08 JCP

Data file name: ABC0609A  
Batch ID: TH230 OUTLIER  
Count Preset (m): 10  
Batch Ended: 6/9/2015 9:10

Background logfile: BKGABW  
Data of Bkg. Cal: 6/6/2015  
Alpha efficiency logfile: TH230-0613  
Alpha attenuation calibration: ATH0618\_0620  
Beta efficiency logfile: Cs-137-Q315  
Beta attenuation calibration: ACS0312

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^a (a \cdot (\text{mass} \rightarrow 0))$		$y = b \cdot m^a (a \cdot (\text{mass} \rightarrow 0))$	
Alpha b=	0.33710	Beta b=	0.3434
m=	0.99090	m=	0.9983
a=	0.9206	a=	1.0468
x0=	0.0000	x0=	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b \cdot m^a \cdot \text{mass}$		$y = b \cdot m^a \cdot m$	
a -> b stalk b=	0.2527	b -> a stalk b=	-3.54E-06
a -> b stalk m=	0.9978	b -> a stalk m=	0.0052

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity						Beta Activity							
					Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Eff	Base Cor.Fact	Progeny Eff	Progeny Cor.Fact	Gross CPM	Bkg. CPM	a>b xtlk CPM	Base Eff	Base Cor.Fact	Progeny Eff	Progeny Cor.Fact
A1	1518003-2	6/9/2015 9:10	10.00	0.0	1319.700	0.124	1.210	0.2366	0.937	n/a	n/a	379.700	1.476	333.4589	0.4155	0.949	n/a	n/a

TH 6/9/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision:  
Rev:1201/03 JCP

Data file name: ABC0609B  
Batch ID: TH230 OUTLIER  
Count Preset (m): 10  
Batch Ended: 6/9/2015 9:24

2

Background logfile: BKGABW  
Data of Bkg. Cal: 6/6/2015  
Alpha efficiency logfile: TH230-06/13  
Alpha attenuation calibration: AT10619\_0620  
Beta efficiency logfile: Cs-137-03/15  
Beta attenuation calibration: ACS0312

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity						Beta Activity							
					Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Eff	Base Cor.Fact	Progeny Eff	Progeny Cor.Fact	Gross CPM	Bkg. CPM	a>b xtlk CPM	Base Eff	Base Cor.Fact	Progeny Eff	Progeny Cor.Fact
A1	1518003-3	6/9/2015 9:24	10.00	0.0	1333.000	0.124	1.242	0.2366	0.937	n/a	n/a	389.500	1.476	336.8178	0.4155	0.949	n/a	n/a

TH 6/9/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^2 (a \cdot \text{mass} - c0)$		$y = b \cdot m^2 (a \cdot \text{mass} - c0)$	
Alpha b=	0.33740	Beta b=	0.2484
m=	0.99990	m=	0.9993
a=	0.9208	a=	1.0458
c0=	0.0000	c0=	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b \cdot m^2 \cdot \text{mass}$		$y = b \cdot \text{mass} \cdot m$	
a -> b stalk b=	0.2327	b -> a stalk b=	-3.54E-06
a -> b stalk m=	0.9978	b -> a stalk m=	0.0032

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity					Beta Activity						
					Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Cor.Fact	Progeny Eff	Gross CPM	Bkg. CPM	a>b xtlk CPM	Base Cor.Fact	Progeny Eff		
A1	1518003-4	6/9/2015 9:47	10.00	0.0	1348.500	0.124	1.279	0.2365	0.937	n/a	401.100	1.476	340.7346	0.4155	0.949	n/a

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev.1201/08 JCP

Data file name: ABC0609C  
Batch ID: TH230 OUTLIER  
Count Preset (m): 10  
Batch Ended: 6/9/2015 9:47

Background logfile: BKGABW  
Date of Bkg. Cal: 6/6/2015  
Alpha efficiency logfile: TH230-06/13  
Alpha attenuation calibration: ATH0619\_0630  
Beta efficiency logfile: Cs-137-03/15  
Beta attenuation calibration: ACS0312

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

TH 6/9/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev:12/01/08 JCP

Data file name: ABC0609D  
Batch ID: TH230 OUTLIER  
Count Preset (m): 10  
Batch Ended: 06/2015 10:01  
2

Background logfile: BKGABW  
Date of Bkg. Cal: 06/2015  
Alpha efficiency logfile: TH230-06/13  
Alpha attenuation calibration: ATH0619\_0620  
Beta efficiency logfile: Cs-137-03/15  
Beta attenuation calibration: ACS0312

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity						Beta Activity							
					Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Eff	Progeny Cor.Fact.	Gross CPM	Bkg. CPM	a>b xtlk CPM	Base Eff	Progeny Cor.Fact.				
A1	1518003-5	6/9/2015 10:01	10.00	0.0	1286.900	0.124	1.184	0.2366	0.937	n/a	n/a	374.500	1.476	320.1143	0.4155	0.949	n/a	n/a

206/9/15

**OUTLIER TEST**

FILE	DET	SAMPLE ID	Beta CPM	Relative % diff. from mean	Within acceptability range	Outlier?
ABC0312	A1(1)	1515003-1	1620.1	0.64%	YES	NO
ABC0312A	A1(1)	1515003-2	1587.29	1.41%	YES	OUTLIER!
ABC0312B	A1(1)	1515003-3	1625.29	0.95%	YES	NO
ABC0312C	A1(1)	1515003-4	1622.57	0.79%	YES	NO
ABC0312D	A1(1)	1515003-5	1594.29	0.97%	YES	NO

Mean of all five plachets:  
 Average= 1609.91  
 Std dev= 17.7299  
 2 Std Dev= 35.46

Acceptability range  
 1645.37  
 1574.45

Upper  
 Lower

Relative range  
 +/- 1.49%

2.20%

**Sample 1515003-2 rejected as outlier.**

Criteria: Potential outliers fall outside acceptability range; which is the mean of all five measurements +/- 2 std dev per the Grubbs statistical test.

# Radiochemistry Instrument Worksheet

Prep Batch: AB150310-2

ALS Environmental -- FC JP 3/10/15

Outlier

BASE EFFICIENCY

Prep Procedure: GROSS ALPHA BETA

Analytical QASS / NCR? Y NA

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Pos Chk By	Notes
1	1515003-1	SMP	200	200	ml	pCi/l	0	ABC031Z	1 JP					OUTLIER
1	1515003-2	SMP	200	200	ml	pCi/l	0	A	1 JP					
1	1515003-3	SMP	200	200	ml	pCi/l	0	B	1 JP					
1	1515003-4	SMP	200	200	ml	pCi/l	0	C	1 JP					
1	1515003-5	SMP	200	200	ml	pCi/l	0	D	1 JP					

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Prep ID
S1	Cs-137	1019.4095.83	3.929.815	DP4/ml	03/10/15	1	ml	RS-005

## Sample Barcodes

1515003-1 AB150310-2P51	1515003-2 AB150310-2P52	1515003-3 AB150310-2P53
1515003-4 AB150310-2P54	1515003-5 AB150310-2P55	

## Reporting Units

LabID	Sample Name	Units
1515003-1	GrossAlpha_DW	pCi/l
1515003-2	GrossAlpha_DW	pCi/l
1515003-3	GrossAlpha_DW	pCi/l
1515003-4	GrossAlpha_DW	pCi/l
1515003-5	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental - FC

Prep Batch: AB150310-2

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb Review Date: 3/10/2015

Non-Routine Pre-Treatment? Y ☒ Batch: AA Re-Prep? Y ☒ Prep QASS / NCR? Y ☒ NA

Prep SOP: PAI 702 Rev: 20  
Prep SOP: NONE  
Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden  
Prep Date: 3/10/2015  
Prep Dept: RS

Balance:  
Balance:

Sampl Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1515003-1	SMP		200	200	As Received	S1	
2	1	1515003-2	SMP		200	200	As Received	S1	
3	1	1515003-3	SMP		200	200	As Received	S1	
4	1	1515003-4	SMP		200	200	As Received	S1	
5	1	1515003-5	SMP		200	200	As Received	S1	

Comments

Cs-137 efficiencies

Spiked By: Jennie Kill-Bowden Date: 3/10/2015

Witnessed By: Dayna K. Lewis Date: 3/10/2015

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1019-4095-83	3,929.815	CPM/ml	03/10/15	1	ml	RS-005

# Radiochemistry Prep Worksheet

Prep Batch: AB150310-2

ALS Environmental -- FC

**Prep Batch Not Validated!!!**

Review Date:

Reviewed By:

Prep Procedure: GROSS\_ALPHA

Prep QASS / NCR? Y / N

Re-Prep? Y / N Batch:

Non-Routine Pre-Treatment? Y / N Batch:

Prep Analyst: Jennie Kill-Bowden

Balance:

Prep Date: 3/10/2015

Balance:

Prep Dept: RS

Prep SOP: PAI 702

Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1515003-1	SMP	200	200	200	As Received	S1	
2	1	1515003-2	SMP	200	200	200	As Received	S1	
3	1	1515003-3	SMP	200	200	200	As Received	S1	
4	1	1515003-4	SMP	200	200	200	As Received	S1	
5	1	1515003-5	SMP	200	200	200	As Received	S1	

Comments

Cs-137 efficiencies

Spiked By: SKB Date: 3/10/15  
 Witnessed By: SKB Date: 3/10/15

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date
S1	Cs-137	1018.4085.83	3.929.815	DPW/ml	03/10/15
				1 ml	RS-005

exp: 3/5/16

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100 -C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision:  
Application Version: Standard  
Rev.12/01/03 JCP

Data file name: ABC0312  
Batch ID: AB150310-2 OUTLIER  
Count Preset (m): 7  
Batch Endet: 3/12/2015 7:20  
2

Background logfile: BKGABW  
Date of Bkg. Cal: 3/12/2015  
Alpha efficiency logfile: AM041R-06/13  
Alpha attenuation calibration: AAM0610\_0611  
Beta efficiency logfile: SR0R-06/13  
Beta attenuation calibration: ASR0611

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^2 + a$ (mass-a0)		$y = b \cdot m^2 + a$ (mass-a0)	
Alpha b=	0.90570	Beta b=	0.9712
m=	0.89140	m=	0.9993
a=	0.8487	a=	1.0249
x0=	21.4875	x0=	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b \cdot m^2 + a$		$y = b \cdot m^2 + a$	
a -> b talk m=	0.2510	b -> a talk m=	-1.12E-05
a -> b talk m=	0.9987	b -> a talk m=	0.0032

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity				Progeny Eff	Progeny Cor.Fact	Progeny
					Gross CPM	Bkg. CPM	b>a xilk CPM	Base Eff	Base Cor.Fact	Progeny Eff	Progeny Cor.Fact	a>b xilk CPM	Base Eff	Base Cor.Fact	
A1	1515003-1	3/12/2015 7:20	7.00	0.0	3.000	0.109	5.180	0.2102	1.060	n/a	n/a	0.7256	0.4355	0.978	n/a

JP 3/12/15

# PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100 -C  
 Counting Unit ID: Magenta  
 High Voltage Mode: Simultaneous  
 Application Revision: Standard  
 Rev.12/01/08 JCP

Data file name: ABC0312A  
 Batch ID: AB150310-2 OUTLIER  
 Count Preset (m): 7  
 Batch Ended: 3/12/2015 7:33

Background logfile: BKGABW  
 Date of Bkg. Cal: 3/12/2015  
 Alpha efficiency logfile: Am241R-0613  
 Alpha attenuation calibration: AAM0610, 0611  
 Beta efficiency logfile: SR06-0613  
 Beta attenuation calibration: ASR0611

Alpha Attenuation Calibration	
$y = b \cdot m^a \cdot (a \cdot (mass - d))$	$y = b \cdot m^a \cdot (a \cdot (mass - d))$
Alpha b=	0.96570
m=	0.99140
a=	0.8487
d=	21.4875
Alpha to Beta X-talk	
$y = b \cdot m^a \cdot (a \cdot (mass - d))$	$y = b \cdot m^a \cdot (a \cdot (mass - d))$
a -> b talk b=	0.2510
b -> a talk m=	0.5987

Beta Attenuation Calibration	
$y = b \cdot m^a \cdot (a \cdot (mass - d))$	$y = b \cdot m^a \cdot (a \cdot (mass - d))$
Beta b=	0.9782
m=	0.9993
a=	1.0249
d=	0.0000
Beta to Alpha X-talk	
$y = b \cdot m^a \cdot (a \cdot (mass - d))$	$y = b \cdot m^a \cdot (a \cdot (mass - d))$
b -> a talk b=	-1.82E-06
b -> a talk m=	0.0032

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity				Progeny			
					Gross CPM	Bkg. CPM	b>a xtlk CPM	a>b xtlk CPM	Base Eff	Cor.Fact.	Base Eff	Cor.Fact.	Base Eff	Cor.Fact.	Base Eff	Cor.Fact.
A1	1515003-2	3/12/2015 7:33	7.00	0.0	2286	0.109	5.075	0.2102	1.060	n/a	n/a	n/a	1587.286	1.308	0.5464	n/a

JP 3/12/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision:  
Application Version: Standard  
Rev.12/01/08 JCP

Data file name: ABC0312B  
Batch ID: AB150310-2 OUTLIER  
Count Preset (m): 7  
Batch Ended: 3/12/2015 7:41

2

Background logfile: BKGABW  
Date of Bkg. Cal: 3/12/2015  
Alpha efficiency logfile: An241R-06/13  
Alpha attenuation calibration: AAM0810\_0611  
Beta efficiency logfile: SRR040613  
Beta attenuation calibration: A3R0611

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^2 (a \cdot \gamma_{mass} + c)$		$y = b \cdot m^2 (a \cdot \gamma_{mass} + c)$	
Alpha b <sup>a</sup>	0.90370	Beta b <sup>a</sup>	0.9762
m <sup>a</sup>	0.99140	m <sup>a</sup>	0.9993
a <sup>a</sup>	0.9487	a <sup>a</sup>	1.0248
d0 <sup>a</sup>	21.4875	d0 <sup>a</sup>	0.0000
Alpha to Beta X-talk		Beta to Alpha X-talk	
$y = b \cdot m^2$		$y = b \cdot m^2$	
a → b talk b <sup>a</sup>	0.2310	b → a talk b <sup>a</sup>	-1.82E-05
a → b talk m <sup>a</sup>	0.9387	b → a talk m <sup>a</sup>	0.0012

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity				Progeny					
					Gross CPM	Bkg. CPM	b>a xtlk CPM	Base Eff	Base Cor.Fact	Progeny Eff	Progeny Cor.Fact	Gross CPM	Bkg. CPM	a>b xtlk CPM	Base Eff	Base Cor.Fact	Progeny Eff	Progeny Cor.Fact
A1	1515003-3	3/12/2015 7:41	7.00	0.0	4.286	0.109	5.196	0.2102	1.060	n/a	n/a	1635.286	1.399	1.0484	0.4355	0.978	n/a	n/a

JP 3/12/15

# PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100 -C  
 Counting Unit ID: Magenta  
 High Voltage Mode: Simultaneous  
 Application Revision: Standard  
 Rev.120108 JCP

Background logfile: BKGABW  
 Date of Bkg Cal: 3/12/2015  
 Alpha efficiency logfile: Am241R-06/13  
 Alpha attenuation calibration: A440610.0611  
 Beta efficiency logfile: SR0R-06/13  
 Beta attenuation calibration: ASR0611

Alpha prog. logfile: n/a  
 Alpha prog. attenuation: n/a  
 Beta prog. logfile: n/a  
 Beta prog. attenuation: n/a

Alpha Attenuation Calibration		Beta Attenuation Calibration	
y = b * m <sup>1/a</sup> (mass=10)		y = b * m <sup>1/a</sup> (mass=10)	
Alpha b=	0.95570	Beta b=	0.9762
m=	0.99140	m=	0.9993
a=	0.6487	a=	1.0248
sd=	21.4975	sd=	0.0009
Alpha to Beta X-talk		Beta to Alpha X-talk	
y = b * m <sup>1/a</sup> - mass		y = b * m <sup>1/a</sup> - mass	
a -> b stalk b=	0.2510	b -> a stalk b=	-1.82E-05
a -> b stalk m=	0.9987	b -> a stalk m=	0.0032

Det. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity				Progeny			
					Gross CPM	b>a xtlk CPM	Bkg. CPM	Base Eff	Base Cor.Fact.	Gross CPM	a>b xtlk CPM	Base Eff	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.	
A1	1515003-4	3/12/2015 7:51	7.00	0.0	3.571	0.109	5.188	0.2102	1.060	1622.571	0.6691	0.4355	0.978	n/a	n/a	

JP 3/12/15

PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100-C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev.12/2010 JCP

Data file name: ABC0312D  
Batch ID: AB150310-2 OUTLIER  
Count Preset (m): 7  
Batch Ended: 3/12/2015 8:06

Background logfile: BKGABW  
Date of Bkg. Cal: 3/12/2015  
Alpha efficiency logfiles: AAM0610, 0611  
Alpha attenuation calibration: AAM0610, 0611  
Beta efficiency logfiles: S200R-0610, 0611  
Beta attenuation calibration: ASR0611

Alpha prog. logfiles: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfiles: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration		Beta Attenuation Calibration	
$y = b \cdot m^2 / (a \cdot (\text{mass} \cdot a0))$		$y = b \cdot m^2 / (a \cdot (\text{mass} \cdot a0))$	
Alpha b=	0.90570	Beta b=	0.9742
m=	0.99140	m=	0.9993
a=	0.8487	a=	1.0249
a0=	21.4875	a0=	0.0000
Alpha to Beta X-fact		Beta to Alpha X-fact	
$y = b \cdot m^2 \cdot \text{mass}$		$y = b \cdot \text{mass} \cdot m$	
a -> b xfact b=	0.2510	b -> a xfact b=	-1.82E-05
a -> b xfact m=	0.9987	b -> a xfact m=	0.0032

Det. ID	Sample ID	Count		Resid.		Alpha Activity				Beta Activity			
		End	Dur.	Mass		Gross CPM	Bkg. CPM	a>b xilk CPM	Base Eff	Progeny Cor.Fact.	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.
A1	1515003-5	3/12/2015 8:06	7.00	0.0		3.571	0.109	5.097	0.2102	1.060	0.4355	0.978	n/a

DP 3/12/15

Date 3/12/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP				P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK0311W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	2100	Dr A	0.1
		Dr B	
Tank 2	1900	Dr C	
		Dr D	

Comments: \* It is not necessary to run daily background checks on the morning following a weekly background calibration.

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Form 780r8.doc (6/23/06)

Reviewed By / Date JP 3/12/15

Date 3/12/15SOP 724r 11ALS  
Low Background Gas Flow Proportional Counter Log  
Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
F-16	Det. EFL			30	6:52	JP	EFC0312	JP
1	1515003-1	AB150310-2	B-Q/HM	7	7:13	JP	ABC0312	JP
1	-2				7:26	JP	A	JP
1	-3				7:34	JP	B	JP
1	-4				7:44	JP	C	JP
1	-5				7:59	JP	D	JP
1-4	1061		(313)EFL	30	8:20	JP	ECS0312A	JP
5-8			Cal		8:28	JP	B	
9-12					8:36	JP	C	
13-16					8:43	JP	D	
1-16	1515002-1-24	AB150310-1	ATTN/Qual	30	8:53	JP	ACS0312	JP
1	1503144-1	AB150311-1	α1B	240	15:42	JP	ABC0312E	JP
2	-10							JP 3/12/15
3	AB150311-140							
4	LCJ							
5	1503192-1	AB150312-4		300	15:43	JP	ABC03124F	JP 3/12/15
6	-10							
7	-2							
8	AB150312-4MB							
9	LCJ							
10	15031160-1	AB150311-3		1000	15:44	JP	ABC0312G	
11	-7							
12	-2D							
13	-3			120	15:45		H	
14	AB150311-3MB			1000	15:44		G	
15	LCJ			120	15:45		H	

Comments:

Page No.: 450690 **B**  
(cont. from page NA **B**)

Form 780r8 doc (6/23/06)

Reviewed By / Date

JP 3/13/15

Date 3/13/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKCO311W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	1850	Dr A	0.1
		Dr B	
Tank 2	1900	Dr C	
		Dr D	

Comments:

JP 3/13/15

Prepare a working dilution of RSO#1019

12/3/15

1. Density of 0.1M HCl, lot # 0000094396

Mass of 100mL vol. flask:

56.4421 g

Balance # 12

Mass of flask &amp; 100mL acid:

156.2152 g

Balance # 12

Net Mass:

99.7731 g

Density:

0.9977 g/mL

2. Mass of RSO#1019 transferred:

Mass of empty nalgene:

74.1899 g

Balance # 12

Mass of nalgene &amp; standard

79.0859 g

Balance # 12

Net mass of standard transferred:

4.8960 g

3. Dilute to final volume:

Mass of nalgene, standard, &amp; diluent:

629.3 g

Balance # 26

Mass of empty nalgene:

74.1899 g

Balance # 12

Net mass of new dilution:

555.1101 g

4. Final activity calculation:

$$3,727 \text{ Bq} \left( \frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left( \frac{4.8960 \text{ g}}{4.99800 \text{ g}} \right) \left( \frac{0.9977 \text{ g/mL}}{555.1101 \text{ g}} \right) = 39,37.10 \text{ dpm/mL}$$

Std ID: 1019.4095.83

Description: Cs-137

Expiration: 3/6/2016

Activity: 3937.10 dpm/mL

2s Uncertainty: 70.87 dpm/mL

Ref. Date: 2/9/2015

Ref Time: N/A

Prep Date: 3/5/2015 Prep by: TE

Matrix/Comp. 0.1 MHCl

Half Life (y): 3.01E+01

## Reverification Log

Analysis Date Initials Expiration Date


JP 2/4/2/15

JP 4/2/15

Continued on Page

Signed

Date

Read and Understood By

Signed

Date



Eckert & Ziegler

Analytics

RSO#  
1019

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.ezag.com

**CERTIFICATE OF CALIBRATION**  
Standard Reference Source

99575

Cs-137 5 mL Liquid in Flame Sealed Vial

**Customer:** ALS Laboratory Group  
**P.O. No.:** FC000610, Item 3 **Product Code:** 8137

This standard radionuclide source was prepared gravimetrically from a master solution calibrated with an ionization chamber. The ionization chamber was calibrated by the National Physical Laboratory, Teddington, U.K., and is traceable to national standards. Radionuclide calibration and purity were checked by germanium gamma-ray spectrometry, liquid scintillation counting, and/or alpha spectrometry, as applicable. The nuclear decay rate and reference date for this source are given below. Eckert & Ziegler Analytics (EZA) maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Revision 2, July 2007, and compliance with ANSI N42.22-1995, "Traceability of Radioactive Sources to NIST."

Isotope	Half-Life, Days	Activity (Bq)	Uncertainty*, %			Reference Date (12:00 PM EST)
			$u_A$	$u_B$	U	
Cs-137	1.099E+04	3.727E+04	0.1	0.9	1.8	02/09/2015

\*Uncertainty: U - Relative expanded uncertainty,  $k = 2$ . See NIST Technical Note 1297, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results."

**Comments:**

Impurities:  $\gamma$ -impurities < 0.1%.

4.99800 g 0.1M HCl solution with approximately 30  $\mu\text{g/g}$  Cs carrier.

Source Prepared by:

  
K. Eardley, Radiochemist

QC Approved:

  
A. Chen, Spectroscopist

Date: 7 Feb 15

Prepare an intermediate dilution of TH-230 P50# 853 of approximately 1200 dpm/ml

1) Prepare 0.5M  $\text{HNO}_3$ , 31 ml  $\text{HNO}_3$  and 969 ml DI water.  
lot # 073602

2) Determine density of 0.5M  $\text{HNO}_3$ .

Mass of 100 ml vol. flask:

Mass of flask + 100 ml 0.5M  $\text{HNO}_3$ :

Net mass of 0.5M  $\text{HNO}_3$ :

Bal. 12

68.0999 g

169.9509 g

101.851 g

$$\rho = 1.015 \text{ g/ml}$$

3) Transfer contents of vial to 1000 ml Nalgene.

Mass of full standard vial:

Mass of empty standard vial:

Net mass of standard transferred:

8.2827

3.2327

5.05 g

4) Dilute with 0.5 M  $\text{HNO}_3$

Mass of Nalgene w/o lid (empty):

Mass of Nalgene with standard:

Mass of Nalgene, standard, and diluent:

Net mass of standard:

73.66 g

73.70 g

78.71 g

1085.2

1011.54 g

Bal. 12

Bal. 36

5) Final activity calculation

$$(1.983 \times 10^4 \text{ Bq}) / (5.15119 \text{ g}) = 3849.60 \text{ Bq/g} \times \left( \frac{60 \text{ s}}{1 \text{ min}} \right) = 230,975.755 \text{ dpm}$$

$$(3849.60 \text{ Bq/g}) \cdot \left( \frac{5.05 \text{ g}}{1011.54 \text{ g}} \right) \cdot (1.015 \text{ g/ml}) = 1166.38 \text{ dpm/ml}$$

Std ID: 853.3020.89

Description: Th-230

Expiration: 2/5/2009

Activity: 1166.38 dpm/mL

2s Uncertainty: 23.33 dpm/mL

Ref. Date: 11/6/2007

Ref Time: N/A

Prep Date: 12/12/2007 Prep by: DC

Matrix/Comp. 0.5 M  $\text{HNO}_3$

Half Life (y): 7.70E+04

#### Reverification Log

Analysis Date	Initials	Expiration Date
5/5/09	RG	5/5/2010
11/19/10	RG	11/19/2011
12/13/14	JP	12/13/2015

Continued on Page

Signature:

Sign:

12/12/07

Date:

Read and Understood By

Signature:

Sign:

2/13/08



1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.analyticinc.com

## CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

76253-307

Th-230 5 mL Liquid in Flame Sealed Vial

Customer: Paragon Analytics / Fort Collins, CO  
P.O. No.: 72905-REL 10-30-07, Item 1

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.18, Revision 1.

Isotope:	Th-230
Activity (Bq):	1.983 E4
Half-Life:	7.538 E4 years
Calibration Date:	November 6, 2007 12:00 EST
Relative Expanded Uncertainty (k=2):	2.0%

### Comments:

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%.  
5.15119 grams 0.8M HNO<sub>3</sub> solution.

Source Prepared By: N. E. Klesman  
N. E. Klesman, Radiochemist

QA Approved: D. M. Montgomery  
D. M. Montgomery, QA Manager

Date: 11-19-07

End of Certificate

Corporate Office  
24937 Avenue Tibbitts Valencia, California 91355

Laboratory  
1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

# Mass Attenuation Curves

# LB4100C Alpha Attenuation Curve -- Th-230

WO # 1518004	
Mass Range	12.4 mg
Low	100.0 mg
High	100.0 mg

Spike Information	
Std. ID	853.3020.69
Ref. Date	11/6/2007
Half-life	77000
Activity	1166.38 dpm/mL
Vol.	5.0 mL
Act. Added	5931.50 dpm

Attenuation Equation	
b =	0.8148
m =	0.9902
a =	0.8822
% Diff Max. = 12.2%	

Cross-Talk Equation	
b =	0.2652
m =	0.9981
% Diff Max. = 9.3%	

File ID	Detector ID	Sample ID	Mass (mg)	Count Date	Alpha Counts	Beta Counts	Time	Alpha CPM	Beta CPM	Base Alpha Eff.	Decay Corr. Act added dpm/L	Alpha Att. Eff Actual	Alpha Att. Fitted	AcquisFitted Ratio	Obs. Atten Fact.	Fitted Atten Fact.	% Diff.	$\alpha > 0.5 \times \text{Th-230} > \beta \times \text{Th-230}$	% Diff.	
ATH0610	A1	1518004-2	12.4	6/10/15 10:05	10021	2748	9.64	1039.40	283.59	0.2345	5831.50	0.1782	0.1715	0.9620	0.7601	0.7312	3.8%	0.2728	0.2714	0.5%
ATH0609	A2	1518004-2	12.4	6/9/15 11:12	10014	2946	9.75	1026.92	300.57	0.2280	5831.50	0.1761	0.1667	0.9467	0.7724	0.7312	5.3%	0.2927	0.2714	7.3%
ATH0609	A3	1518004-2	12.4	6/9/15 11:40	10007	2843	9.86	1014.80	286.74	0.2309	5831.50	0.1740	0.1688	0.9702	0.7537	0.7312	3.0%	0.2826	0.2714	4.0%
ATH0609	A4	1518004-2	12.4	6/9/15 12:08	10005	2876	9.32	1073.39	306.97	0.2370	5831.50	0.1841	0.1733	0.9414	0.7767	0.7312	5.9%	0.2860	0.2714	5.1%
ATH0609	B1	1518004-2	12.4	6/9/15 12:34	10004	2763	9.87	1013.46	278.32	0.2250	5831.50	0.1738	0.1645	0.9466	0.7774	0.7312	5.3%	0.2746	0.2714	1.2%
ATH0609	B2	1518004-2	12.4	6/9/15 13:00	10010	2719	10.06	994.91	268.62	0.2166	5831.50	0.1706	0.1606	0.9411	0.7769	0.7312	5.9%	0.2700	0.2714	-0.5%
ATH0609	B3	1518004-2	12.4	6/9/15 13:25	10013	2801	10.13	988.32	274.67	0.2269	5831.50	0.1695	0.1659	0.9411	0.7769	0.7312	2.1%	0.2779	0.2714	2.4%
ATH0609	B4	1518004-2	12.4	6/9/15 13:51	10011	2876	10.24	978.52	279.13	0.2182	5831.50	0.1675	0.1603	0.9571	0.7639	0.7312	4.3%	0.2658	0.2714	5.1%
ATH0609	C1	1518004-2	12.4	6/9/15 14:21	10011	2719	9.57	1045.98	282.23	0.2355	5831.50	0.1794	0.1722	0.9600	0.7616	0.7312	4.0%	0.2698	0.2714	-0.6%
ATH0609	C2	1518004-2	12.4	6/9/15 14:48	10006	2870	9.70	1031.43	294.03	0.2292	5831.50	0.1769	0.1676	0.9475	0.7717	0.7312	5.3%	0.2851	0.2714	4.8%
ATH0609	C3	1518004-2	12.4	6/9/15 15:15	10005	2781	9.84	1016.66	281.58	0.2293	5831.50	0.1743	0.1743	0.9617	0.7603	0.7312	3.8%	0.2770	0.2714	2.0%
ATH0609	C4	1518004-2	12.4	6/9/15 15:43	10002	2875	9.89	1011.21	288.78	0.2279	5831.50	0.1734	0.1666	0.9609	0.7609	0.7312	3.9%	0.2656	0.2714	5.0%
ATH0610	D1	1518004-2	12.4	6/10/15 8:07	10006	2805	10.11	989.62	274.60	0.2303	5831.50	0.1697	0.1684	0.9623	0.7369	0.7312	0.8%	0.2775	0.2714	2.2%
ATH0610	D2	1518004-2	12.4	6/10/15 8:35	10018	2737	9.92	1009.79	274.26	0.2281	5831.50	0.1732	0.1668	0.9631	0.7591	0.7312	3.7%	0.2716	0.2714	0.1%
ATH0610	D3	1518004-2	12.4	6/10/15 9:02	10017	2804	9.39	1066.68	297.02	0.2334	5831.50	0.1829	0.1707	0.9330	0.7837	0.7312	6.7%	0.2784	0.2714	2.5%
ATH0610	D4	1518004-2	12.4	6/10/15 9:38	10008	2929	9.67	1034.87	301.19	0.2331	5831.50	0.1775	0.1704	0.9604	0.7613	0.7312	4.0%	0.2910	0.2714	6.8%
ATH0609	A1	1518004-1	13.2	6/9/15 11:12	10005	2803	9.85	1005.40	280.23	0.2345	5831.50	0.1724	0.1703	0.9676	0.7352	0.7261	1.2%	0.2787	0.2718	2.5%
ATH0609	A2	1518004-1	13.2	6/9/15 11:40	10015	2792	9.84	1017.63	282.15	0.2280	5831.50	0.1745	0.1655	0.9487	0.7654	0.7261	5.1%	0.2773	0.2718	2.0%
ATH0609	A3	1518004-1	13.2	6/9/15 12:08	10005	2802	9.81	1019.77	284.03	0.2309	5831.50	0.1749	0.1677	0.9587	0.7573	0.7261	4.1%	0.2785	0.2718	2.4%
ATH0609	A4	1518004-1	13.2	6/9/15 12:34	10012	2912	9.46	1058.24	306.21	0.2370	5831.50	0.1815	0.1721	0.9463	0.7657	0.7261	5.2%	0.2894	0.2718	6.1%
ATH0609	B1	1518004-1	13.2	6/9/15 13:00	10012	3017	10.21	980.49	293.87	0.2250	5831.50	0.1681	0.1634	0.9473	0.7473	0.7261	2.8%	0.2907	0.2718	9.3%
ATH0609	B2	1518004-1	13.2	6/9/15 13:25	10007	2807	10.21	980.00	273.27	0.2196	5831.50	0.1681	0.1594	0.9488	0.7653	0.7261	5.1%	0.2768	0.2718	2.5%
ATH0609	B3	1518004-1	13.2	6/9/15 13:51	10018	2790	10.20	982.02	271.70	0.2269	5831.50	0.1684	0.1647	0.9783	0.7422	0.7261	2.2%	0.2767	0.2718	1.8%
ATH0609	B4	1518004-1	13.2	6/9/15 14:21	10004	2848	10.16	984.50	278.58	0.2192	5831.50	0.1684	0.1592	0.9427	0.7702	0.7261	5.7%	0.2830	0.2718	-0.8%
ATH0609	C1	1518004-1	13.2	6/9/15 14:48	10008	2863	9.78	1023.21	270.41	0.2282	5831.50	0.1755	0.1710	0.9745	0.7451	0.7261	2.5%	0.2643	0.2718	-2.8%
ATH0609	C2	1518004-1	13.2	6/9/15 15:15	10001	2728	9.53	1049.31	284.40	0.2293	5831.50	0.1723	0.1665	0.9662	0.7515	0.7261	3.4%	0.2810	0.2718	-0.3%
ATH0609	C3	1518004-1	13.2	6/9/15 15:43	10009	2827	9.96	1004.81	281.78	0.2279	5831.50	0.1745	0.1655	0.9481	0.7515	0.7261	5.2%	0.2767	0.2718	1.8%
ATH0610	C4	1518004-1	13.2	6/10/15 8:08	10006	2787	9.83	1017.79	281.60	0.2303	5831.50	0.1699	0.1672	0.9841	0.7378	0.7261	1.6%	0.2848	0.2718	4.6%
ATH0610	D1	1518004-1	13.2	6/10/15 8:35	10009	2879	10.10	990.89	282.20	0.2281	5831.50	0.1701	0.1656	0.9737	0.7457	0.7261	2.6%	0.2843	0.2718	4.4%
ATH0610	D2	1518004-1	13.2	6/10/15 9:02	10019	2865	10.10	991.89	282.02	0.2281	5831.50	0.1701	0.1656	0.9737	0.7457	0.7261	2.6%	0.2843	0.2718	4.4%
ATH0610	D3	1518004-1	13.2	6/10/15 9:38	10011	2740	9.59	1043.81	284.11	0.2334	5831.50	0.1790	0.1695	0.9468	0.7669	0.7261	5.3%	0.2722	0.2718	0.2%
ATH0610	D4	1518004-1	13.2	6/10/15 9:38	10015	2943	9.89	1012.55	295.87	0.2331	5831.50	0.1736	0.1692	0.9747	0.7449	0.7261	2.5%	0.2922	0.2718	7.0%
ATH0610	A1	1518004-6	36.8	6/10/15 8:09	10006	2844	12.83	778.77	220.19	0.2345	5831.50	0.1337	0.1366	1.0362	0.5702	0.5909	-3.6%	0.2824	0.2840	-0.6%
ATH0610	A2	1518004-6	36.8	6/10/15 8:37	10008	2847	12.58	795.39	224.72	0.2280	5831.50	0.1364	0.1347	0.9877	0.5822	0.5909	1.2%	0.2825	0.2840	-0.5%
ATH0610	A3	1518004-6	36.8	6/10/15 9:05	10010	2873	12.81	781.31	222.68	0.2309	5831.50	0.1340	0.1364	1.0183	0.5803	0.5909	-1.8%	0.2850	0.2840	0.4%
ATH0610	A4	1518004-6	36.8	6/10/15 9:41	10001	2875	12.20	819.64	234.04	0.2370	5831.50	0.1406	0.1406	0.9963	0.5931	0.5909	0.4%	0.2855	0.2840	0.6%
ATH0610	B1	1518004-6	36.8	6/10/15 10:09	10009	2922	12.91	775.18	224.71	0.2250	5831.50	0.1329	0.1329	1.0001	0.5908	0.5909	0.0%	0.2850	0.2840	0.4%
ATH0609	B2	1518004-6	36.8	6/9/15 11:16	10006	2874	13.51	740.51	211.07	0.2196	5831.50	0.1270	0.1298	1.0218	0.5783	0.5909	-2.2%	0.2850	0.2840	0.4%
ATH0609	B3	1518004-6	36.8	6/9/15 11:43	10001	3010	13.44	743.59	222.13	0.2269	5831.50	0.1276	0.1341	1.0509	0.5623	0.5909	-5.3%	0.2986	0.2840	4.9%
ATH0609	B4	1518004-6	36.8	6/9/15 12:12	10016	2861	13.22	757.48	214.68	0.2182	5831.50	0.1299	0.1392	0.9971	0.5926	0.5909	0.3%	0.2834	0.2840	-0.2%
ATH0609	C1	1518004-6	36.8	6/9/15 12:37	10013	2908	12.71	767.70	226.91	0.2292	5831.50	0.1351	0.1392	1.0302	0.5736	0.5909	-3.0%	0.2881	0.2840	1.4%
ATH0609	C2	1518004-6	36.8	6/9/15 13:02	10006	2839	12.55	797.18	224.37	0.2283	5831.50	0.1367	0.1354	0.9907	0.5865	0.5909	0.9%	0.2814	0.2840	-0.9%
ATH0609	C3	1518004-6	36.8	6/9/15 13:28	10005	2828	13.16	760.15	220.43	0.2279	5831.50	0.1360	0.1347	1.0360	0.5885	0.5909	1.0%	0.2869	0.2840	1.0%
ATH0609	C4	1518004-6	36.8	6/9/15 13:54	10002	2893	12.61	793.06	227.50	0.2279	5831.50	0.1360	0.1347	1.0360	0.5885	0.5909	-3.9%	0.2900	0.2840	2.1%
ATH0609	D1	1518004-6	36.8	6/9/15 14:24	10011	2869	13.01	762.36	215.66	0.2303	5831.50	0.1307	0.1361	1.0409	0.5677	0.5909	-4.1%	0.2829	0.2840	-0.4%
ATH0609	D2	1518004-6	36.8	6/9/15 14:51	10001	2798	13.13	768.82	213.42	0.2281	5831.50	0.1318	0.1348	1.0226	0.5778	0.5909	-2.3%	0.2777	0.2840	-3.9%
ATH0609	D3	1518004-6	36.8	6/9/15 15:18	10009	2754	12.45	803.95	219.60	0.2334	5831.50	0.1378	0.1377	1.0095	0.5906	0.5909	0.0%	0.2732	0.2840	-3.9%
ATH0609	D4	1518004-6	36.8	6/9/15 15:46	10003	2996	12.69	788.17	234.39	0.2331	5831.50	0.1352	0.1377	1.0191	0.5798	0.5909	-1.9%	0.2974	0.2840	4.5%
ATH0610	A1	151801																		

LB4100C Alpha Attenuation Curve - Th-230

WO # 1518004		Mass Range 12.4 mg 100.0 mg		Spike Information		Attenuation Equation		y=B*ln(x <sup>2</sup> ) b = 0.8148 m = 0.9602 a = 0.8622		Cross-Talk Equation y=B*ln(x <sup>2</sup> ) b = 0.2652 m = 0.9981			
				Std. ID 853.3020.89	Ref. Date 11/6/2007							yr's 1166.38	Activity 5.0
		Act. Added	Vol.	5.0	1000	14.99	667.10	190.27	0.2162	5831.50	% Diff Max. = 12.2%	0.2972	% Diff Max. = 9.3%
AT-H0609	B4	69/15 12:39	43.9	5831.50	10002	2998	667.10	190.27	0.2162	5831.50	1.0641	0.2972	0.2877
AT-H0609	C1	69/15 13:04	43.9	5831.50	10000	2859	707.11	200.31	0.2355	5831.50	1.0144	0.2972	0.2877
AT-H0609	C2	69/15 13:30	43.9	5831.50	10014	2936	703.61	204.47	0.2355	5831.50	1.0144	0.2972	0.2877
AT-H0609	C3	69/15 13:55	43.9	5831.50	10007	2823	690.98	192.90	0.2292	5831.50	1.0144	0.2972	0.2877
AT-H0609	C4	69/15 14:25	43.9	5831.50	10003	2974	694.53	204.61	0.2292	5831.50	1.0144	0.2972	0.2877
AT-H0609	D1	69/15 14:53	43.9	5831.50	10009	3115	684.80	204.27	0.2303	5831.50	1.0144	0.2972	0.2877
AT-H0609	D2	69/15 15:20	43.9	5831.50	10008	2957	668.71	202.14	0.2281	5831.50	1.0144	0.2972	0.2877
AT-H0609	D3	69/15 15:47	43.9	5831.50	10009	2823	727.24	210.83	0.2334	5831.50	1.0144	0.2972	0.2877
AT-H0610	D4	69/15 15:11	43.9	5831.50	10008	2861	705.63	200.99	0.2331	5831.50	1.0144	0.2972	0.2877
AT-H0609	A1	69/15 15:20	43.9	5831.50	10007	2976	707.58	200.99	0.2345	5831.50	1.0221	0.2972	0.2877
AT-H0609	A2	69/15 15:48	49.5	69/15 15:48	10008	2881	711.14	201.75	0.2280	5831.50	1.0219	0.2972	0.2877
AT-H0610	A3	69/15 16:11	49.5	69/15 16:11	10017	2930	707.30	205.33	0.2309	5831.50	1.0219	0.2972	0.2877
AT-H0610	A4	69/15 16:38	49.5	69/15 16:38	10011	2930	743.65	216.07	0.2370	5831.50	1.0219	0.2972	0.2877
AT-H0610	B1	69/15 16:06	49.5	69/15 16:06	10004	2810	717.53	199.96	0.2270	5831.50	1.0219	0.2972	0.2877
AT-H0610	B2	69/15 16:06	49.5	69/15 16:06	10005	2853	687.98	184.56	0.2168	5831.50	1.0219	0.2972	0.2877
AT-H0610	B3	69/15 16:11	49.5	69/15 16:11	10007	2929	665.67	193.04	0.2269	5831.50	1.0219	0.2972	0.2877
AT-H0609	B4	69/15 16:11	49.5	69/15 16:11	10006	3076	679.61	207.24	0.2192	5831.50	1.0219	0.2972	0.2877
AT-H0609	C1	69/15 11:44	49.5	69/15 11:44	10001	2861	721.89	201.46	0.2355	5831.50	1.0219	0.2972	0.2877
AT-H0609	C2	69/15 12:12	49.5	69/15 12:12	10007	2924	710.79	209.12	0.2295	5831.50	1.0219	0.2972	0.2877
AT-H0609	C3	69/15 12:38	49.5	69/15 12:38	10009	2924	701.79	195.70	0.2279	5831.50	1.0219	0.2972	0.2877
AT-H0609	C4	69/15 13:04	49.5	69/15 13:04	10002	2957	684.48	200.48	0.2279	5831.50	1.0219	0.2972	0.2877
AT-H0609	D1	69/15 13:30	49.5	69/15 13:30	10002	3005	689.70	204.40	0.2303	5831.50	1.0219	0.2972	0.2877
AT-H0609	D2	69/15 13:55	49.5	69/15 13:55	10009	2865	710.27	201.69	0.2281	5831.50	1.0219	0.2972	0.2877
AT-H0609	D3	69/15 14:24	48.5	69/15 14:24	10003	2836	743.07	209.10	0.2334	5831.50	1.0219	0.2972	0.2877
AT-H0609	D4	69/15 14:52	49.5	69/15 14:52	10006	2850	726.57	205.27	0.2331	5831.50	1.0219	0.2972	0.2877
AT-H0609	A1	69/15 15:47	49.5	69/15 15:47	10013	2789	717.29	213.39	0.2345	5831.50	1.0219	0.2972	0.2877
AT-H0610	A2	69/15 16:09	49.9	69/15 16:09	10002	2841	777.00	219.16	0.2280	5831.50	1.0219	0.2972	0.2877
AT-H0610	A3	69/15 16:38	49.9	69/15 16:38	10007	2791	763.20	211.30	0.2309	5831.50	1.0219	0.2972	0.2877
AT-H0610	A4	69/15 16:06	49.9	69/15 16:06	10008	2822	797.34	223.25	0.2370	5831.50	1.0219	0.2972	0.2877
AT-H0610	B1	69/15 16:06	49.9	69/15 16:06	10001	2727	773.36	209.28	0.2250	5831.50	1.0219	0.2972	0.2877
AT-H0610	B2	69/15 16:06	49.9	69/15 16:06	10004	2792	742.01	205.46	0.2186	5831.50	1.0219	0.2972	0.2877
AT-H0609	B3	69/15 11:46	49.9	69/15 11:46	10002	2932	736.45	214.17	0.2192	5831.50	1.0219	0.2972	0.2877
AT-H0609	B4	69/15 12:11	49.9	69/15 12:11	10003	2858	765.83	208.54	0.2292	5831.50	1.0219	0.2972	0.2877
AT-H0609	C1	69/15 12:37	49.9	69/15 12:37	10005	2724	765.03	205.60	0.2293	5831.50	1.0219	0.2972	0.2877
AT-H0609	C3	69/15 13:03	49.9	69/15 13:03	10008	2728	778.78	216.00	0.2279	5831.50	1.0219	0.2972	0.2877
AT-H0609	D1	69/15 13:28	49.9	69/15 13:28	10001	2788	778.78	216.00	0.2279	5831.50	1.0219	0.2972	0.2877
AT-H0609	D4	69/15 14:24	49.9	69/15 14:24	10003	2828	778.78	216.00	0.2279	5831.50	1.0219	0.2972	0.2877
AT-H0609	D2	69/15 14:51	49.9	69/15 14:51	10002	2821	778.78	216.00	0.2279	5831.50	1.0219	0.2972	0.2877
AT-H0609	D3	69/15 15:18	49.9	69/15 15:18	10005	2747	782.16	213.07	0.2331	5831.50	1.0219	0.2972	0.2877
AT-H0609	A1	69/15 15:45	67.8	69/15 15:45	10005	2802	649.97	180.59	0.2345	5831.50	1.0115	0.2972	0.2877
AT-H0609	A2	69/15 16:21	67.8	69/15 16:21	10019	2919	682.97	188.70	0.2280	5831.50	1.0115	0.2972	0.2877
AT-H0609	A3	69/15 16:49	67.8	69/15 16:49	10005	3047	658.74	192.36	0.2309	5831.50	1.0115	0.2972	0.2877
AT-H0610	A4	69/15 16:11	67.8	69/15 16:11	10001	3101	682.65	203.69	0.2370	5831.50	1.0115	0.2972	0.2877
AT-H0610	B1	69/15 16:06	67.8	69/15 16:06	10003	2899	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	B2	69/15 16:06	67.8	69/15 16:06	10004	3078	689.14	185.80	0.2186	5831.50	1.0145	0.2972	0.2877
AT-H0610	B3	69/15 16:06	67.8	69/15 16:06	10001	3049	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	B4	69/15 16:11	67.8	69/15 16:11	10003	3012	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	C1	69/15 16:11	67.8	69/15 16:11	10009	2961	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	C2	69/15 16:11	67.8	69/15 16:11	10007	2935	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	C3	69/15 16:11	67.8	69/15 16:11	10009	3007	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D1	69/15 16:11	67.8	69/15 16:11	10010	3125	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D4	69/15 16:11	67.8	69/15 16:11	10010	3013	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D2	69/15 16:11	67.8	69/15 16:11	10002	2944	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D3	69/15 16:11	67.8	69/15 16:11	10002	2946	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D4	69/15 16:11	67.8	69/15 16:11	10002	3001	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	A1	69/15 16:11	67.8	69/15 16:11	10005	2933	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	A2	69/15 16:11	67.8	69/15 16:11	10019	2919	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	A3	69/15 16:11	67.8	69/15 16:11	10005	3047	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	A4	69/15 16:11	67.8	69/15 16:11	10001	3101	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	B1	69/15 16:11	67.8	69/15 16:11	10003	2899	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	B2	69/15 16:11	67.8	69/15 16:11	10004	3078	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	B3	69/15 16:11	67.8	69/15 16:11	10001	3049	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	B4	69/15 16:11	67.8	69/15 16:11	10003	3012	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	C1	69/15 16:11	67.8	69/15 16:11	10009	2961	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	C2	69/15 16:11	67.8	69/15 16:11	10007	2935	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	C3	69/15 16:11	67.8	69/15 16:11	10009	3007	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D1	69/15 16:11	67.8	69/15 16:11	10010	3125	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D4	69/15 16:11	67.8	69/15 16:11	10010	3013	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D2	69/15 16:11	67.8	69/15 16:11	10002	2944	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D3	69/15 16:11	67.8	69/15 16:11	10002	2946	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	D4	69/15 16:11	67.8	69/15 16:11	10002	3001	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	A1	69/15 16:11	67.8	69/15 16:11	10005	2933	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	A2	69/15 16:11	67.8	69/15 16:11	10019	2919	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0609	A3	69/15 16:11	67.8	69/15 16:11	10005	3047	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	A4	69/15 16:11	67.8	69/15 16:11	10001	3101	682.65	181.51	0.2250	5831.50	1.0145	0.2972	0.2877
AT-H0610	B1	69/15 16:11	67.8	69/15 16:11	10003	2899	682.65	181.51					

LB4100C Alpha Attenuation Curve -- Th-230

WO # 1518004		Spike Information				Std. ID 853.3020.89				Ref. Date 11/06/2007				yrs				Cross-Talk Equation				y=5*ln(a/z)							
Mass Range		Vol.		Act. Added		5831.50		95m		1166.38		5.0		1166.38		5.0		b = 0.8148		b = 0.9902		m = 0.9981		b = 0.8148		b = 0.9902		m = 0.9981	
Low		12.4		mg		1166.38		5.0		1166.38		5.0		1166.38		5.0		a = 0.8822		a = 0.8822		a = 0.8822		a = 0.8822		a = 0.8822		a = 0.8822	
High		100.0		mg																									

**LB4100C Alpha Attenuation Curve – Th-230**

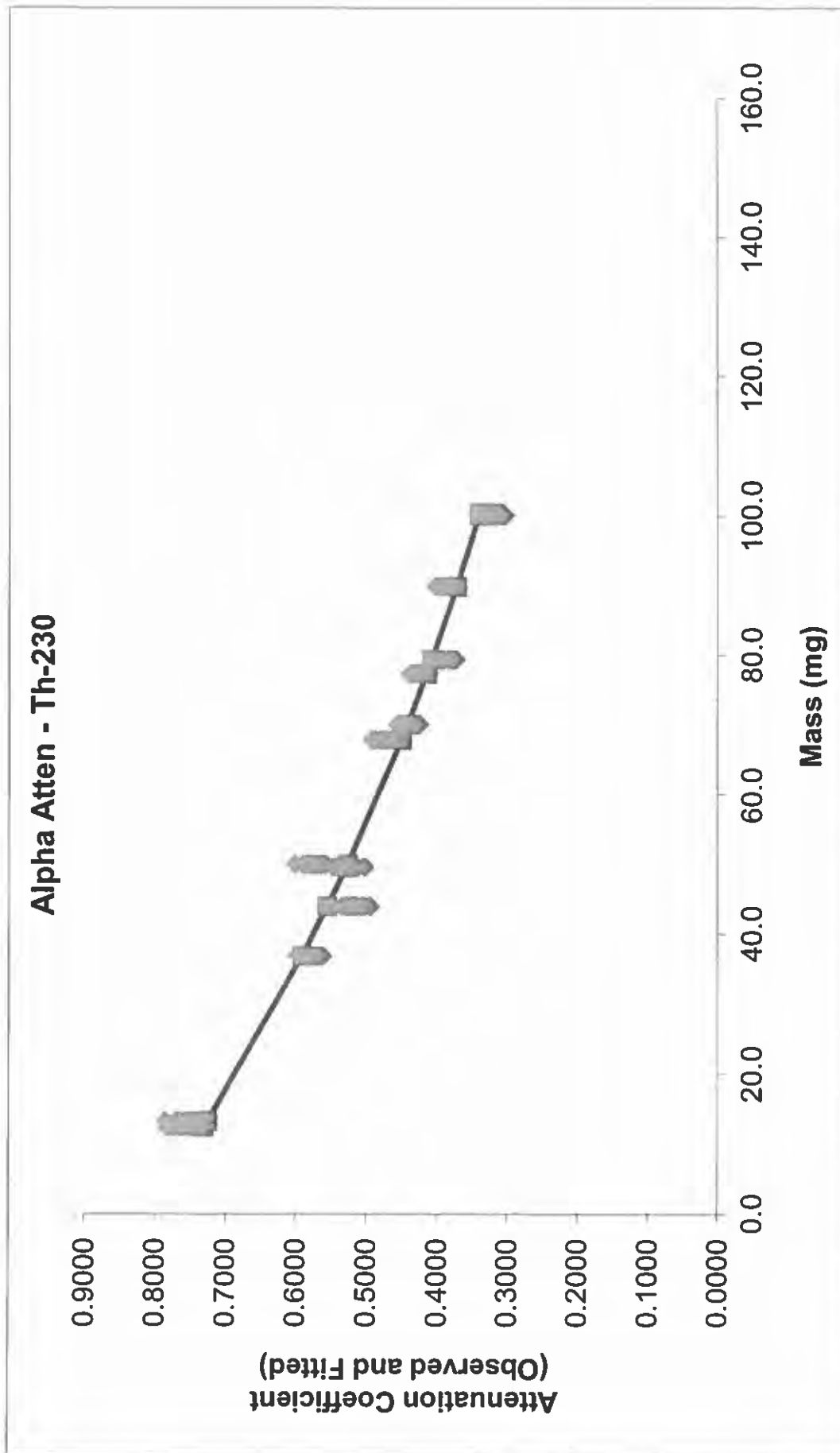
[illegible]

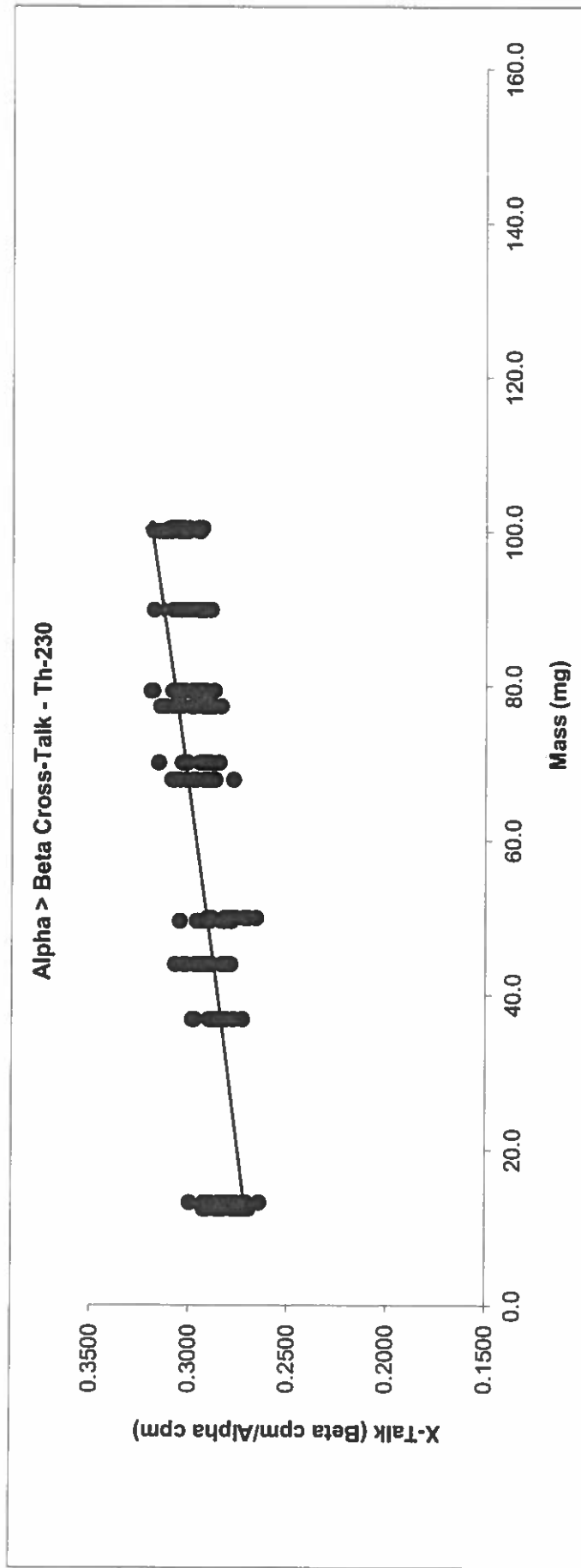
## OUTLIERS

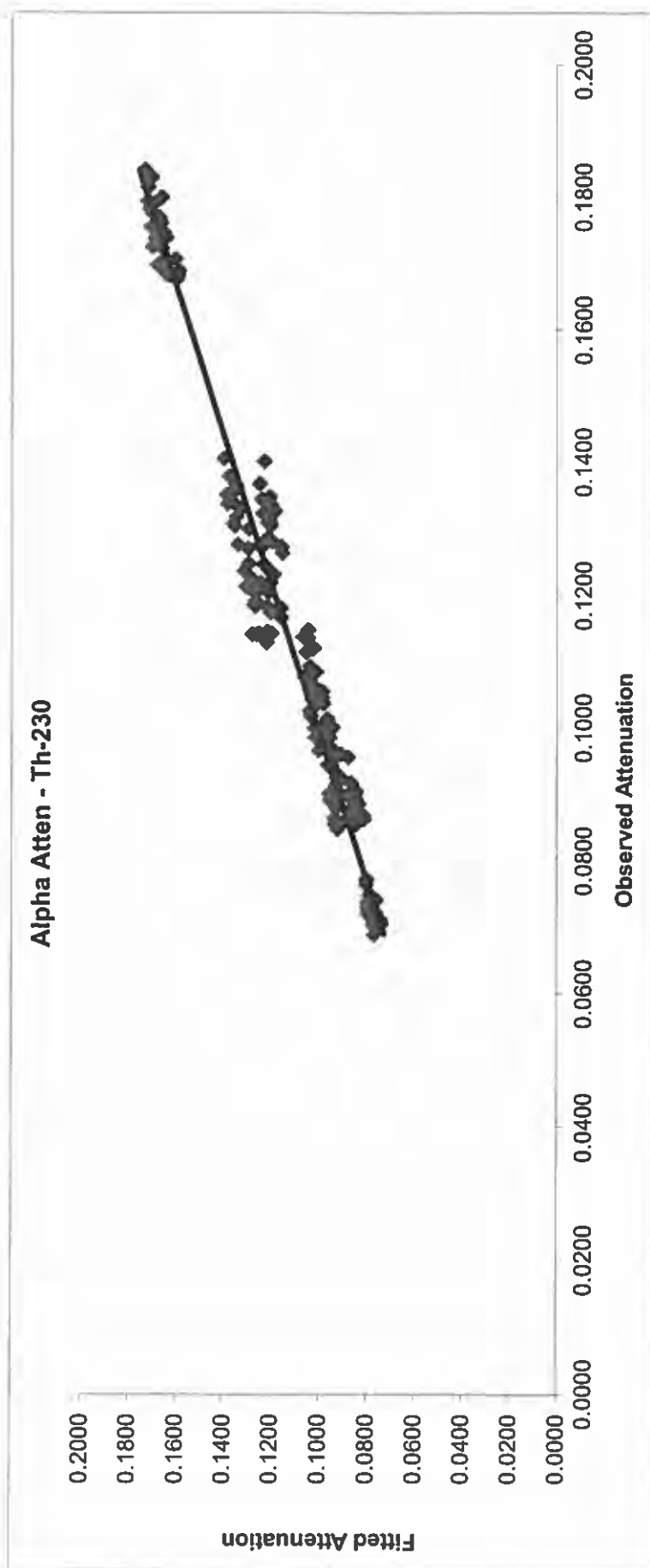
ATH0610	A1	1518004-3	25.8	6/10/15 9:39	10003	2777	9.92	1008.24	278.46	0.2345	5831.50	0.1728	0.1525	0.8822	0.7373	0.6504	11.8%	0.2762	-0.7%
ATH0610	A2	1518004-3	25.8	6/10/15 10:05	10016	2622	9.73	1029.24	267.89	0.2280	5831.50	0.1765	0.1463	0.8402	0.7741	0.6504	16.0%	0.2603	-6.9%
ATH0609	A3	1518004-3	25.8	6/9/15 11:12	10000	2752	9.85	1015.12	277.80	0.2309	5831.50	0.1741	0.1502	0.8628	0.7539	0.6504	13.7%	0.2737	-1.7%
ATH0609	A4	1518004-3	25.8	6/9/15 11:39	10008	2600	9.47	1036.70	294.06	0.2376	5831.50	0.1812	0.1542	0.8507	0.7646	0.6504	14.9%	0.2783	0.0%
ATH0609	B1	1518004-3	25.8	6/9/15 12:08	10001	2802	9.88	1012.13	281.98	0.2250	5831.50	0.1736	0.1463	0.8432	0.7714	0.6504	15.7%	0.2788	0.1%
ATH0609	B2	1518004-3	25.8	6/9/15 12:35	10008	2749	10.22	979.13	267.33	0.2196	5831.50	0.1679	0.1428	0.8507	0.7380	0.6504	14.9%	0.2730	-1.9%
ATH0609	B3	1518004-3	25.8	6/9/15 13:00	10021	2708	10.24	976.53	262.62	0.2267	5831.50	0.1675	0.1476	0.8813	0.7380	0.6504	11.9%	0.2689	-3.4%
ATH0609	B4	1518004-3	25.8	6/9/15 13:25	10003	2706	10.12	990.27	274.55	0.2192	5831.50	0.1698	0.1426	0.8396	0.7747	0.6504	16.0%	0.2773	-0.3%
ATH0609	C1	1518004-3	25.8	6/9/15 13:51	10004	2702	9.89	1011.42	271.32	0.2355	5831.50	0.1734	0.1532	0.8832	0.7365	0.6504	11.7%	0.2663	-3.7%
ATH0609	C2	1518004-3	25.8	6/9/15 14:21	10008	2776	9.71	1030.58	284.04	0.2293	5831.50	0.1767	0.1491	0.8436	0.7711	0.6504	15.6%	0.2756	-0.9%
ATH0609	C3	1518004-3	25.8	6/9/15 14:48	10007	2790	10.05	995.61	275.55	0.2282	5831.50	0.1707	0.1491	0.8738	0.7446	0.6504	12.6%	0.2768	-0.5%
ATH0609	D1	1518004-3	25.8	6/9/15 15:13	10017	2725	9.90	1022.02	276.14	0.2279	5831.50	0.1753	0.1462	0.8458	0.7690	0.6504	15.4%	0.2702	-3.0%
ATH0609	D4	1518004-3	25.8	6/9/15 15:43	10012	2730	10.19	982.43	265.06	0.2303	5831.50	0.1685	0.1498	0.8891	0.7315	0.6504	11.1%	0.2698	-3.1%
ATH0610	D2	1518004-3	25.8	6/10/15 8:07	10006	2822	10.1	990.60	277.76	0.2281	5831.50	0.1769	0.1484	0.8734	0.7447	0.6504	12.7%	0.2782	0.8%
ATH0610	D3	1518004-3	25.8	6/10/15 8:34	10018	2655	9.67	1035.90	272.96	0.2334	5831.50	0.1776	0.1518	0.8546	0.7611	0.6504	14.5%	0.2635	-5.8%

LB4100C Alpha Attenuation Curve - Th-230

WO # 1518004		Spike Information				Attenuation Equation		Cross-Talk Equation	
Mass Range	mg	Std. ID	853.3020 89	Ref. Date	11/02/2007	b =	0.8148	b =	0.2652
Low	12.4	Half-life	77000	Activity	1166.36	m =	0.9902	m =	0.9981
High	100.0	Vol.	5.0	dpm/mL		a =	0.8822		
		Act. Added	5831.90	dpm		% Diff Max =		% Diff Max =	
ATH0610	D4	25.8	6/10/15 9:02	10005	2843	5831.50	0.1761	0.2825	0.2782
ATH0609	A1	83.5	6/9/15 13:07	10004	3020	5831.50	0.1007	0.2894	0.3097
ATH0610	A2	83.5	6/9/15 13:32	10004	2923	5831.50	0.1029	0.2896	0.3097
ATH0609	A3	83.5	6/9/15 13:58	10006	2983	5831.50	0.1011	0.2955	0.3097
ATH0609	A4	83.5	6/9/15 14:27	10000	2898	5831.50	0.1074	0.2873	0.3097
ATH0609	B1	83.5	6/9/15 14:55	10002	2885	5831.50	0.1029	0.2859	0.3097
ATH0609	B2	83.5	6/9/15 15:23	10002	2806	5831.50	0.0983	0.2877	0.3097
ATH0609	B3	83.5	6/9/15 15:51	10003	2728	5831.50	0.0998	0.2894	0.3097
ATH0610	B4	83.5	6/10/15 8:14	10005	2920	5831.50	0.0985	0.2869	0.3097
ATH0610	C1	83.5	6/10/15 8:41	10005	2950	5831.50	0.1030	0.2918	0.3097
ATH0610	C2	83.5	6/10/15 9:09	10002	2917	5831.50	0.1028	0.2886	0.3097
ATH0610	C3	83.5	6/10/15 9:46	10006	2904	5831.50	0.1004	0.2868	0.3097
ATH0610	C4	83.5	6/10/15 10:12	10003	3018	5831.50	0.1016	0.2985	0.3097
ATH0609	D1	83.5	6/9/15 11:20	10003	3039	5831.50	0.0976	0.2989	0.3097
ATH0609	D2	83.5	6/9/15 11:47	10004	2867	5831.50	0.0986	0.2838	0.3097
ATH0609	D3	83.5	6/9/15 12:15	10013	2942	5831.50	0.1030	0.2912	0.3097
ATH0609	D4	83.5	6/9/15 12:41	10002	2984	5831.50	0.1049	0.2956	0.3097
ATH0610	A1	26.1	6/10/15 9:06	10002	2987	5831.50	0.1320	0.2851	0.2794
ATH0610	A2	26.1	6/10/15 9:42	10004	3046	5831.50	0.1270	0.3024	0.2794
ATH0610	A3	26.1	6/10/15 10:09	10003	2980	5831.50	0.1267	0.2958	0.2794
ATH0609	A4	26.1	6/9/15 11:15	10004	2902	5831.50	0.1363	0.2681	0.2794
ATH0609	B1	26.1	6/9/15 11:44	10004	3022	5831.50	0.1257	0.2988	0.2794
ATH0609	B2	26.1	6/9/15 12:12	10008	2965	5831.50	0.1237	0.2940	0.2794
ATH0609	B3	26.1	6/9/15 12:38	10008	2954	5831.50	0.1232	0.2920	0.2794
ATH0609	B4	26.1	6/9/15 13:04	10003	3014	5831.50	0.1232	0.2990	0.2794
ATH0609	C1	26.1	6/9/15 13:28	10006	2785	5831.50	0.1316	0.2759	0.2794
ATH0609	C2	26.1	6/9/15 13:54	10004	2816	5831.50	0.1320	0.2791	0.2794
ATH0609	C3	26.1	6/9/15 14:24	10004	2795	5831.50	0.1317	0.2767	0.2794
ATH0609	C4	26.1	6/9/15 14:51	10006	2881	5831.50	0.1306	0.2855	0.2794
ATH0609	D1	26.1	6/9/15 15:18	10006	2860	5831.50	0.1294	0.2821	0.2794
ATH0609	D2	26.1	6/9/15 15:47	10004	3018	5831.50	0.1269	0.2955	0.2794
ATH0610	D3	26.1	6/10/15 8:10	10006	2944	5831.50	0.1314	0.2922	0.2794
ATH0610	D4	26.1	6/10/15 8:38	10002	2909	5831.50	0.1330	0.2787	0.2794







LB4100C Beta Attenuation Curve -- Cs137

<b>WO #</b> 1515002 <b>Mass Range</b> Low 11.3 mg High 305.7 mg		<b>Spike Information</b> Std. ID 1019.408583 Ref. Date 2/9/2015 Half-life 30.1 yrs Activity 3937.10 dpm/mL Vol. 1.0 mL Act. Added -3937.10 dpm				<b>Attenuation Equation</b> $y = b \cdot m^a$ b = 0.9764 m = 0.9988 a = 0.9758 % Diff Max. = 8.6%				<b>Cross-Talk Equation</b> $y = b' \cdot x^{m'}$ b = -1.07E-07 m = 0.0004 % Diff Max. = 84.6%			
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File ID	Detector ID	Sample ID	Mass (mg)	Count Date	Alpha Counts	Beta Counts	Count Time	Alpha CPM	Beta CPM	Base Beta Eff.	Decay Corr. Act. added dpm/mL	Beta Att. Eff. Actual	Beta Att. Fitted	Actual/Fit Ratio	Obs. Atten Fact.	Fitted Atten Fact.	% Diff.	$\beta > \alpha$ X Tlk Actual	$\beta > \alpha$ X Tlk Fitted	% Diff.
ACS0608	A1	1515002-2	11.3	6/8/15 7:41	20	10017	6.57	2.92	1523.18	0.4119	3907.59	0.3959	0.3957	0.9827	0.9463	0.9630	-1.7%	0.0019	0.0004	-76.6%
ACS0608A	A1	1515002-4	27.4	6/8/15 14:12	16	10017	6.55	2.32	1527.84	0.4119	3907.53	0.3910	0.3890	1.0052	0.9493	0.9443	0.5%	0.0015	0.0004	-70.6%
ACS0608A	A1	1515002-6	43.7	6/8/15 13:52	14	10017	7.15	1.83	1399.50	0.4119	3907.53	0.3582	0.3813	0.9392	0.8695	0.9258	-6.1%	0.0013	0.0004	-66.0%
ACS0608A	A1	1515002-8	57.5	6/8/15 13:40	23	10018	7.02	3.15	1425.59	0.4119	3907.53	0.3648	0.3750	0.9729	0.8857	0.9104	-2.7%	0.0022	0.0004	-79.9%
ACS0608A	A1	1515002-10	76.1	6/8/15 13:22	25	10016	7.15	3.37	1399.36	0.4119	3907.53	0.3581	0.3666	0.9769	0.8694	0.8900	-2.3%	0.0024	0.0004	-81.7%
ACS0608A	A1	1518002-12	89.1	6/8/15 13:08	15	10015	6.7	2.11	1493.30	0.4119	3907.54	0.3822	0.3608	1.0591	0.9278	0.8760	5.9%	0.0014	0.0004	-68.9%
ACS0608	A1	1515002-14	105.6	6/8/15 9:47	13	10002	7.6	1.59	1314.58	0.4119	3907.57	0.3364	0.3537	0.9512	0.8167	0.8586	-4.9%	0.0012	0.0004	-63.7%
ACS0608	A1	1515002-16	118.3	6/8/15 9:34	13	10020	7.04	1.72	1421.82	0.4119	3907.57	0.3539	0.3482	1.0449	0.8834	0.8455	4.5%	0.0012	0.0004	-63.9%
ACS0608	A1	1515002-18	133.3	6/8/15 9:22	11	10011	7.25	1.39	1379.35	0.4119	3907.58	0.3530	0.3419	1.0323	0.8570	0.8302	3.2%	0.0010	0.0004	-56.9%
ACS0608	A1	1515002-20	156.4	6/8/15 9:10	21	10008	7.56	2.65	1322.33	0.4119	3907.58	0.3394	0.3325	1.0179	0.8216	0.8071	1.8%	0.0020	0.0004	-78.4%
ACS0608	A1	1515002-22	175.7	6/8/15 8:58	20	10010	7.65	2.49	1307.02	0.4119	3907.58	0.3345	0.3247	1.0300	0.8121	0.7884	3.0%	0.0019	0.0004	-77.4%
ACS0608	A1	1515002-24	188.6	6/8/15 8:45	19	10019	7.69	2.35	1301.38	0.4119	3907.58	0.3330	0.3197	1.0418	0.8085	0.7761	4.2%	0.0018	0.0004	-76.2%
ACS0608	A1	1515002-26	226.6	6/8/15 8:31	18	10020	8.05	2.11	1243.24	0.4119	3907.58	0.3182	0.3052	1.0423	0.7724	0.7411	4.2%	0.0017	0.0004	-75.0%
ACS0608	A1	1515002-28	245.8	6/8/15 8:20	18	10007	8.63	1.96	1158.08	0.4119	3907.59	0.2964	0.2982	0.9939	0.7195	0.7239	-0.6%	0.0017	0.0004	-75.0%
ACS0608	A1	1515002-30	266.7	6/8/15 8:09	17	10007	9.33	1.70	1071.09	0.4119	3907.59	0.2741	0.2837	0.9661	0.6655	0.6888	-3.4%	0.0016	0.0004	-73.6%
ACS0608	A1	1515002-32	300.4	6/8/15 7:57	13	10005	9	1.32	1110.19	0.4119	3907.59	0.2841	0.2790	1.0182	0.6899	0.6774	1.8%	0.0012	0.0004	-64.5%
ACS0608	A2	1515002-2	11.3	6/8/15 7:55	11	10019	6.39	1.56	1566.33	0.4183	3907.59	0.4008	0.4028	0.9951	0.9593	0.9630	-0.5%	0.0010	0.0004	-55.1%
ACS0608	A2	1515002-4	27.4	6/8/15 7:41	11	10022	6.49	1.54	1542.63	0.4183	3907.59	0.3948	0.3950	0.9994	0.9438	0.9443	-0.1%	0.0010	0.0004	-55.2%
ACS0608A	A2	1515002-6	43.7	6/8/15 14:13	18	10007	7.11	2.37	1405.87	0.4183	3907.53	0.3598	0.3873	0.9290	0.8601	0.9258	-7.1%	0.0017	0.0004	-73.7%
ACS0608A	A2	1515002-8	57.5	6/8/15 13:52	19	10005	6.96	2.57	1435.91	0.4183	3907.53	0.3675	0.3808	0.9650	0.8785	0.9104	-3.5%	0.0018	0.0004	-75.2%
ACS0608A	A2	1515002-10	76.1	6/8/15 13:40	6	10010	7.11	0.69	1406.29	0.4183	3907.53	0.3699	0.3723	0.9667	0.8604	0.8900	-3.3%	0.0005	0.0004	-9.6%
ACS0608A	A2	1515002-12	89.1	6/8/15 13:21	10	10023	6.74	1.33	1485.50	0.4183	3907.53	0.3802	0.3664	1.0374	0.9088	0.8760	3.7%	0.0009	0.0004	-50.7%
ACS0608A	A2	1515002-14	105.6	6/8/15 13:09	14	10002	7.52	1.70	1328.47	0.4183	3907.54	0.3400	0.3592	0.9466	0.8128	0.8586	-4.3%	0.0013	0.0004	-65.8%
ACS0608	A2	1515002-16	118.3	6/8/15 9:47	8	10019	7.13	0.97	1403.60	0.4183	3907.57	0.3592	0.3537	1.0157	0.8597	0.8455	1.6%	0.0007	0.0004	-36.4%
ACS0608	A2	1515002-18	133.3	6/8/15 9:34	13	10014	7.33	1.62	1364.58	0.4183	3907.57	0.3492	0.3476	1.0056	0.8348	0.8302	0.6%	0.0012	0.0004	-63.2%
ACS0608	A2	1515002-20	156.4	6/8/15 9:22	14	10022	7.63	1.68	1311.91	0.4183	3907.58	0.3357	0.3376	0.9944	0.8026	0.8071	-0.6%	0.0013	0.0004	-66.2%
ACS0608	A2	1515002-22	175.7	6/8/15 9:10	11	10022	7.6	1.29	1317.10	0.4183	3907.58	0.3371	0.3298	1.0220	0.8058	0.7884	2.2%	0.0010	0.0004	-56.0%
ACS0608	A2	1515002-24	188.6	6/8/15 8:58	13	10012	7.72	1.53	1295.30	0.4183	3907.58	0.3315	0.3247	1.0210	0.7925	0.7761	2.1%	0.0012	0.0004	-63.6%
ACS0608	A2	1515002-26	226.6	6/8/15 8:46	13	10010	8.06	1.46	1240.35	0.4183	3907.58	0.3174	0.3100	1.0240	0.7588	0.7411	2.4%	0.0012	0.0004	-63.8%
ACS0608	A2	1515002-28	245.8	6/8/15 8:31	12	10004	8.35	1.28	1186.50	0.4183	3907.58	0.3062	0.3028	1.0111	0.7320	0.7239	1.1%	0.0011	0.0004	-60.3%
ACS0608	A2	1515002-30	266.7	6/8/15 8:21	10	10008	9.22	0.93	1083.88	0.4183	3907.58	0.2774	0.2881	0.9627	0.6631	0.6888	-3.7%	0.0009	0.0004	-51.0%
ACS0608	A3	1515002-2	11.3	6/8/15 8:09	12	10011	8.9	1.19	1123.24	0.4102	3907.59	0.2875	0.2834	1.0144	0.6872	0.6774	1.4%	0.0011	0.0004	-60.6%
ACS0608	A3	1515002-4	27.4	6/8/15 7:55	14	10013	6.41	2.07	1560.50	0.4102	3907.59	0.3994	0.3950	1.0109	0.9735	0.9630	1.1%	0.0013	0.0004	-66.2%
ACS0608	A3	1515002-6	43.7	6/8/15 7:42	10	10009	6.43	1.44	1555.01	0.4102	3907.59	0.3979	0.3874	1.0273	0.9701	0.9443	2.7%	0.0009	0.0004	-51.9%
ACS0608	A3	1515002-8	57.5	6/8/15 14:12	12	10019	6.74	1.67	1484.90	0.4102	3907.53	0.3704	0.3798	0.9753	0.9029	0.9258	-2.5%	0.0012	0.0004	-63.5%
ACS0608A	A3	1515002-10	76.1	6/8/15 13:52	8	10019	6.74	1.67	1484.90	0.4102	3907.53	0.3600	0.3734	0.9763	0.9264	0.9104	1.8%	0.0011	0.0004	-60.5%
ACS0608A	A3	1515002-12	89.1	6/8/15 13:40	8	10015	6.64	1.09	1416.65	0.4102	3907.53	0.3625	0.3651	0.9931	0.8838	0.8900	-0.7%	0.0009	0.0004	-52.0%
ACS0608A	A3	1515002-14	105.6	6/8/15 13:22	5	10011	7.31	0.57	1506.69	0.4102	3907.53	0.3856	0.3593	1.0730	0.9400	0.8760	7.3%	0.0007	0.0004	-39.3%
ACS0608A	A3	1515002-16	118.3	6/8/15 13:08	6	10014	7.1	0.73	1367.90	0.4102	3907.54	0.3501	0.3522	0.9938	0.8534	0.8586	-0.6%	0.0004	0.0004	-4.8%
ACS0608	A3	1515002-18	133.3	6/8/15 9:47	11	10012	7.27	1.40	1408.83	0.4102	3907.57	0.3520	0.3405	1.0338	0.8582	0.8302	3.4%	0.0010	0.0004	-57.3%
ACS0608	A3	1515002-20	156.4	6/8/15 9:34	8	10012	7.55	0.95	1375.57	0.4102	3907.57	0.3390	0.3311	1.0238	0.8263	0.8071	2.4%	0.0007	0.0004	-39.5%
ACS0608	A3	1515002-22	175.7	6/8/15 9:22	11	10026	7.56	1.34	1324.60	0.4102	3907.58	0.3390	0.3234	1.0482	0.8264	0.7884	4.8%	0.0010	0.0004	-57.5%
ACS0608	A3	1515002-24	188.6	6/8/15 9:10	11	10005	7.61	1.33	1313.12	0.4102	3907.58	0.3360	0.3184	1.0555	0.8192	0.7761	5.6%	0.0010	0.0004	-57.7%
ACS0608	A3	1515002-26	226.6	6/8/15 8:59	8	10013	8.04	0.88	1243.80	0.4102	3907.58	0.3183	0.3040	1.0471	0.7760	0.7411	4.7%	0.0007	0.0004	-40.1%
ACS0608	A3	1515002-28	245.8	6/8/15 8:46	13	10001	8.35	1.44	1196.13	0.4102	3907.58	0.3061	0.2970	1.0308	0.7462	0.7239	3.1%	0.0012	0.0004	-65.0%
ACS0608	A3	1515002-30	266.7	6/8/15 8:32	10	10003	9.34	0.96	1059.39	0.4102	3907.58	0.2737	0.2825	0.9686	0.6672	0.6888	-3.1%	0.0009	0.0004	-53.3%
ACS0608	A3	1515002-32	300.4	6/8/15 8:20	6	10009	8.88	0.56	1125.54	0.4102	3907.59	0.2880	0.2779	1.0366	0.7022	0.6774	3.7%	0.0005	0.0004	-16.6%
ACS0608	A4	1515002-2	11.3	6/8/15 8:18	14	10025	6.32	2.11	1594.62	0.4088	3907.59									

**LB4100C Beta Attenuation Curve -- Cs137**

WO #		Mass Range		Spoke Information				Attenuation Equation				Cross-Tail Equation				y-b <sup>2</sup> x-m							
				Std. ID	Ref. Date	Half-life	Activity	Vol	Act. Added	Std. ID	Ref. Date	Half-life	Activity	Vol	Act. Added			Std. ID	Ref. Date	Half-life	Activity	Vol	Act. Added
				1019.4085.83	2/9/2015	30.1	3937.10	1.0	3937.10	16	7.21	2.11	1387.43	0.4088	3907.53	0.3551	0.3510	8.6%	0.9764	0.9988	0.9758	b = -1.07E-07	m = 0.0004
ACS06008A	A4	1515002-14	105.6	6/8/15 13:40	16	10015	7.21	2.11	1387.43	0.4088	3907.53	0.3551	0.3510	1.0116	0.9586	0.9630	0.9630	0.4%	0.0010	0.0004	0.0004	84.6%	
	A4	1515002-16	113.3	6/8/15 13:22	13	10011	6.91	1.77	1447.16	0.4088	3907.53	0.3704	0.3456	1.0716	0.9059	0.9455	0.9455	7.2%	0.0012	0.0004	0.0004	-71.2%	
ACS06008A	A4	1515002-18	138.3	6/8/15 13:09	5	10019	7.26	1.58	1378.42	0.4088	3907.54	0.3528	0.3434	1.0395	0.9629	0.9352	0.9352	3.9%	0.0004	0.0004	0.0004	3.7%	
	A4	1515002-20	156.4	6/8/15 9:47	19	10016	7.44	2.44	1345.03	0.4088	3907.57	0.3442	0.3300	1.0432	0.8420	0.9071	0.9071	4.3%	0.0018	0.0004	0.0004	-76.2%	
ACS06008A	A4	1515002-22	175.7	6/8/15 9:34	7	10006	7.58	0.81	1318.44	0.4088	3907.57	0.3374	0.3223	1.0469	0.8254	0.7884	0.7884	4.7%	0.0006	0.0004	0.0004	-30.2%	
	A4	1515002-24	188.6	6/8/15 9:22	15	10003	7.7	1.84	1297.48	0.4088	3907.58	0.3320	0.3173	1.0465	0.8122	0.7761	0.7761	4.7%	0.0014	0.0004	0.0004	-60.2%	
ACS06008A	A4	1515002-26	226.6	6/8/15 9:10	19	10011	7.78	2.33	1285.15	0.4088	3907.58	0.3289	0.3029	1.0856	0.8045	0.7411	0.7411	8.6%	0.0018	0.0004	0.0004	-76.6%	
	A4	1515002-28	245.8	6/8/15 8:59	16	10014	8.27	1.82	1209.27	0.4088	3907.58	0.3095	0.2959	1.0457	0.7570	0.7239	0.7239	4.6%	0.0015	0.0004	0.0004	-71.9%	
ACS06008A	A4	1515002-30	286.7	6/8/15 8:47	11	10011	8.87	1.13	1127.02	0.4088	3907.58	0.2884	0.2816	1.0243	0.7055	0.6888	0.6888	2.4%	0.0010	0.0004	0.0004	-58.2%	
	A4	1515002-32	300.4	6/8/15 8:37	7	10001	8.71	0.69	1146.61	0.4088	3907.58	0.2769	0.2769	1.0596	0.7178	0.6774	0.6774	6.0%	0.0006	0.0004	0.0004	-31.0%	
ACS06008A	B1	1515002-2	11.3	6/8/15 8:29	8	10024	6.60	1.10	1517.16	0.4049	3907.58	0.3803	0.3809	0.9957	0.9569	0.9630	0.9630	-0.4%	0.0010	0.0004	0.0004	-38.0%	
	B1	1515002-4	27.4	6/8/15 8:18	11	10011	6.68	1.53	1497.03	0.4049	3907.58	0.3831	0.3824	1.0019	0.9462	0.9443	0.9443	0.2%	0.0010	0.0004	0.0004	-56.4%	
ACS06008A	B1	1515002-6	43.7	6/8/15 8:07	10	10015	7.12	1.29	1404.98	0.4049	3907.58	0.3596	0.3749	0.9582	0.8860	0.9258	0.9258	-4.1%	0.0009	0.0004	0.0004	-51.6%	
	B1	1515002-8	57.5	6/8/15 7:55	7	10014	6.78	0.89	1437.17	0.4049	3907.59	0.3686	0.3686	0.9978	0.9063	0.9104	0.9104	-0.2%	0.0006	0.0004	0.0004	-28.5%	
ACS06008A	B1	1515002-10	76.1	6/8/15 7:42	11	10016	7.26	1.40	1374.20	0.4049	3907.59	0.3517	0.3604	0.9759	0.8685	0.8900	0.8900	-2.4%	0.0010	0.0004	0.0004	-46.4%	
	B1	1515002-12	89.1	6/8/15 14:13	9	10011	6.9	1.19	1450.41	0.4049	3907.53	0.3712	0.3547	1.0464	0.9167	0.8760	0.8760	4.6%	0.0008	0.0004	0.0004	-28.8%	
ACS06008A	B1	1515002-14	105.6	6/8/15 13:53	7	10011	7.39	0.83	1353.05	0.4049	3907.53	0.3463	0.3477	0.9960	0.8552	0.8586	0.8586	-0.4%	0.0006	0.0004	0.0004	-29.5%	
	B1	1515002-16	118.3	6/8/15 13:40	7	10009	7.05	0.88	1418.09	0.4049	3907.53	0.3629	0.3423	0.9963	0.8963	0.8455	0.8455	6.0%	0.0006	0.0004	0.0004	-29.5%	
ACS06008A	B1	1515002-18	133.3	6/8/15 13:22	8	10011	7.34	0.98	1362.27	0.4049	3907.53	0.3486	0.3361	1.0372	0.8610	0.8302	0.8302	3.7%	0.0007	0.0004	0.0004	-39.2%	
	B1	1515002-20	156.4	6/8/15 13:09	6	10015	7.56	0.68	1323.11	0.4049	3907.54	0.3386	0.3268	1.0361	0.8363	0.8071	0.8071	3.6%	0.0005	0.0004	0.0004	-15.7%	
ACS06008A	B1	1515002-22	175.7	6/8/15 9:48	10	10012	7.65	1.19	1307.14	0.4049	3907.57	0.3345	0.3192	1.0479	0.8262	0.7894	0.7894	4.8%	0.0009	0.0004	0.0004	-52.8%	
	B1	1515002-24	188.6	6/8/15 9:34	10	10018	7.6	1.20	1315.22	0.4049	3907.57	0.3366	0.3143	1.0710	0.8313	0.7761	0.7761	7.1%	0.0009	0.0004	0.0004	-53.0%	
ACS06008A	B1	1515002-26	226.6	6/8/15 9:23	8	10007	8.17	0.87	1223.22	0.4049	3907.58	0.3130	0.3049	1.0433	0.7731	0.7411	0.7411	4.3%	0.0007	0.0004	0.0004	-39.9%	
	B1	1515002-28	245.8	6/8/15 9:11	15	10012	8.44	1.66	1184.63	0.4049	3907.58	0.3032	0.2931	1.0342	0.7487	0.7239	0.7239	3.4%	0.0014	0.0004	0.0004	-68.8%	
ACS06008A	B1	1515002-30	286.7	6/8/15 9:00	12	10011	9.24	1.18	1091.82	0.4049	3907.58	0.2769	0.2769	0.9927	0.8938	0.8688	0.8688	-0.7%	0.0011	0.0004	0.0004	-61.7%	
	B1	1515002-32	300.4	6/8/15 8:47	14	10005	9.04	1.13	1105.12	0.4049	3907.58	0.2828	0.2743	1.0311	0.8985	0.8774	0.8774	3.1%	0.0013	0.0004	0.0004	-67.8%	
ACS06008A	B2	1515002-2	11.3	6/8/15 8:44	30	10005	6.67	4.36	1496.34	0.4074	3907.58	0.3834	0.3923	0.9773	0.9412	0.9630	0.9630	-2.3%	0.0029	0.0004	0.0004	-84.6%	
	B2	1515002-4	27.4	6/8/15 8:30	20	10014	6.82	2.81	1468.67	0.4074	3907.58	0.3753	0.3847	0.9756	0.9213	0.9443	0.9443	-2.4%	0.0019	0.0004	0.0004	-76.7%	
ACS06008A	B2	1515002-6	43.7	6/8/15 8:19	24	10021	7.16	3.23	1397.92	0.4074	3907.59	0.3577	0.3772	0.9485	0.8781	0.9258	0.9258	-5.1%	0.0023	0.0004	0.0004	-80.7%	
	B2	1515002-8	57.5	6/8/15 8:07	20	10023	7.15	2.68	1400.16	0.4074	3907.59	0.3583	0.3769	0.9661	0.8795	0.9104	0.9104	-3.4%	0.0019	0.0004	0.0004	-76.8%	
ACS06008A	B2	1515002-10	76.1	6/8/15 7:56	23	10016	7.43	2.97	1346.39	0.4074	3907.59	0.3446	0.3626	0.9503	0.8457	0.8900	0.8900	-5.0%	0.0022	0.0004	0.0004	-80.0%	
	B2	1515002-12	89.1	6/8/15 7:42	18	10016	6.98	2.46	1433.30	0.4074	3907.59	0.3668	0.3569	1.0277	0.9003	0.8760	0.8760	2.8%	0.0014	0.0004	0.0004	-74.3%	
ACS06008A	B2	1515002-14	105.6	6/8/15 7:31	15	10013	7.53	1.87	1326.76	0.4074	3907.53	0.3395	0.3498	0.9707	0.8334	0.8586	0.8586	-2.9%	0.0017	0.0004	0.0004	-68.9%	
	B2	1515002-16	118.3	6/8/15 13:53	15	10017	7.27	1.94	1376.20	0.4074	3907.53	0.3522	0.3444	1.0225	0.8645	0.8455	0.8455	2.3%	0.0014	0.0004	0.0004	-69.0%	
ACS06008A	B2	1515002-18	133.3	6/8/15 13:41	25	10010	7.63	3.15	1310.27	0.4074	3907.53	0.3353	0.3382	0.9915	0.8231	0.8302	0.8302	-0.9%	0.0024	0.0004	0.0004	-81.9%	
	B2	1515002-20	156.4	6/8/15 13:23	22	10010	7.78	2.71	1284.98	0.4074	3907.53	0.3288	0.3288	1.0000	0.8072	0.8071	0.8071	0.0%	0.0021	0.0004	0.0004	-79.4%	
ACS06008A	B2	1515002-22	175.7	6/8/15 13:09	16	10009	7.71	1.95	1296.51	0.4074	3907.54	0.3318	0.3212	1.0330	0.8144	0.7884	0.7884	3.3%	0.0015	0.0004	0.0004	-71.4%	
	B2	1515002-24	188.6	6/8/15 9:48	16	10006	7.99	1.88	1251.91	0.4074	3907.57	0.3204	0.3162	1.0132	0.7864	0.7761	0.7761	1.3%	0.0015	0.0004	0.0004	-71.4%	
ACS06008A	B2	1515002-26	226.6	6/8/15 9:35	18	10002	8.07	2.11	1237.75	0.4074	3907.57	0.3168	0.3168	1.0492	0.7775	0.7411	0.7411	4.9%	0.0017	0.0004	0.0004	-75.0%	
	B2	1515002-28	245.8	6/8/15 9:23	13	10012	8.57	1.39	1166.60	0.4074	3907.58	0.2985	0.2949	1.0123	0.7328	0.7239	0.7239	1.2%	0.0012	0.0004	0.0004	-64.6%	
ACS06008A	B2	1515002-30	286.7	6/8/15 9:12	19	10012	9.5	1.86	1052.24	0.4074	3907.58	0.2893	0.2893	0.9598	0.6610	0.6888	0.6888	-4.0%	0.0018	0.0004	0.0004	-76.5%	
	B2	1515002-32	300.4	6/8/15 9:00	10	10008	9.11	0.98	1056.92	0.4074	3907.58	0.2807	0.2760	1.0172	0.6950	0.6774	0.6774	1.7%	0.0009	0.0004	0.0004	-83.4%	
ACS06008A	B3	1515002-2	11.3	6/8/15 8:57	28	10019	6.71	4.04	1491.31	0.3997	3907.58	0.3816	0.3849	0.9915	0.9548	0.9630	0.9630	-0.9%	0.0027	0.0004	0.0004	-81.4%	
	B3	1515002-4	27.4	6/8/15 8:44	21	10020	6.72	2.99	1489.24	0.3997	3907.58	0.3811	0.3870	1.0097	0.9535	0.9443	0.9443	1.0%	0.0020	0.0004	0.0004	-77.8%	
ACS06008A	B3	1515002-6	43.7	6/8/15 8:30	16	10012	7.14	2.11	1400.41	0.3997	3907.58	0.3584	0.3700	0.9685	0.8966	0.9258	0.9258	-3.2%	0.0015	0.0004	0.0004	-70.4%	
	B3	1515002-8	57.5	6/8/15 8:18	20	10001	7.1	2.68	1406.76	0.3997	3907.59	0.3600	0.3639	0.9894	0.9007	0.9104	0.9104	-1.1%	0.0019	0.0004	0.0004	-76.7%	
ACS06008A	B3	1515002-10	76.1	6/8/15 8:07	18	10021	7.39	2.30	1354.19	0.3997	3907.59	0.3466	0.3557	0.9742	0.8670	0.8900	0.8900	-2.6%	0.0017	0.0004	0.0004	-74.0%	
	B3	1515002-12	89.1	6/8/15 7:55	19	10009	6.85	2.64	1459.33	0.3997	3907.59	0.3735	0.3502	1.0666	0.9344	0.8760	0.8760	6.7%	0.0018	0.0004	0.0004	-75.7%	
ACS06008A	B3	15																					

**LB4100C Beta Attenuation Curve -- Cs137**

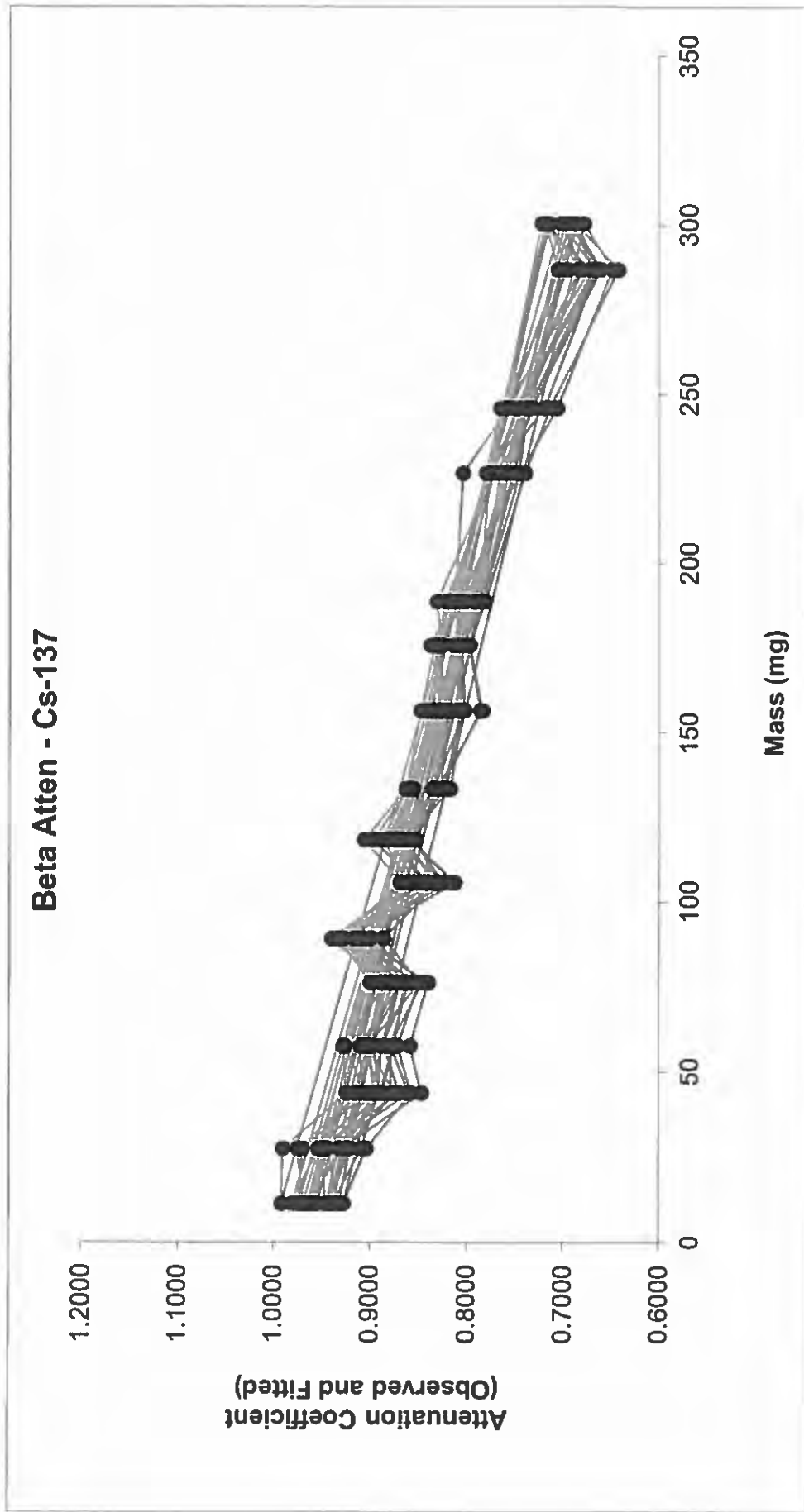
[illegible]

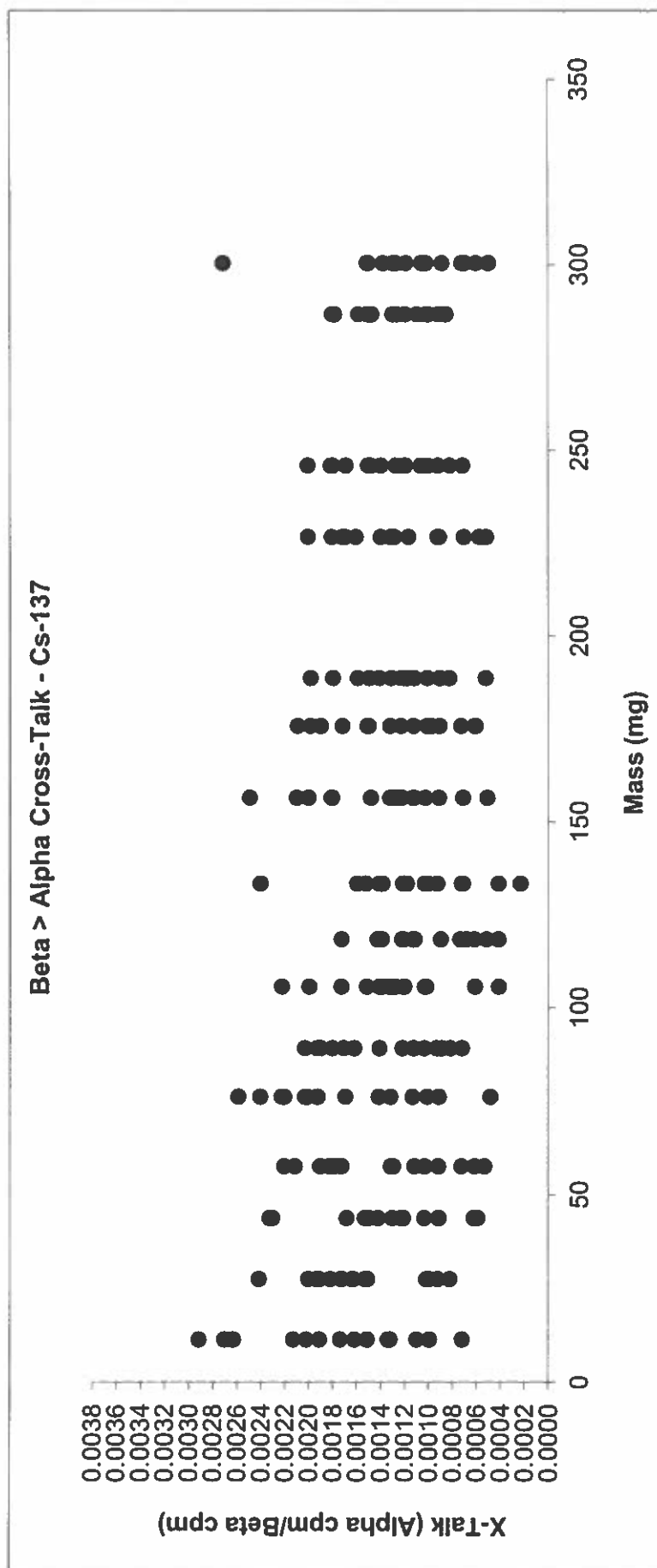
LB4100C Beta Attenuation Curve -- Cs137

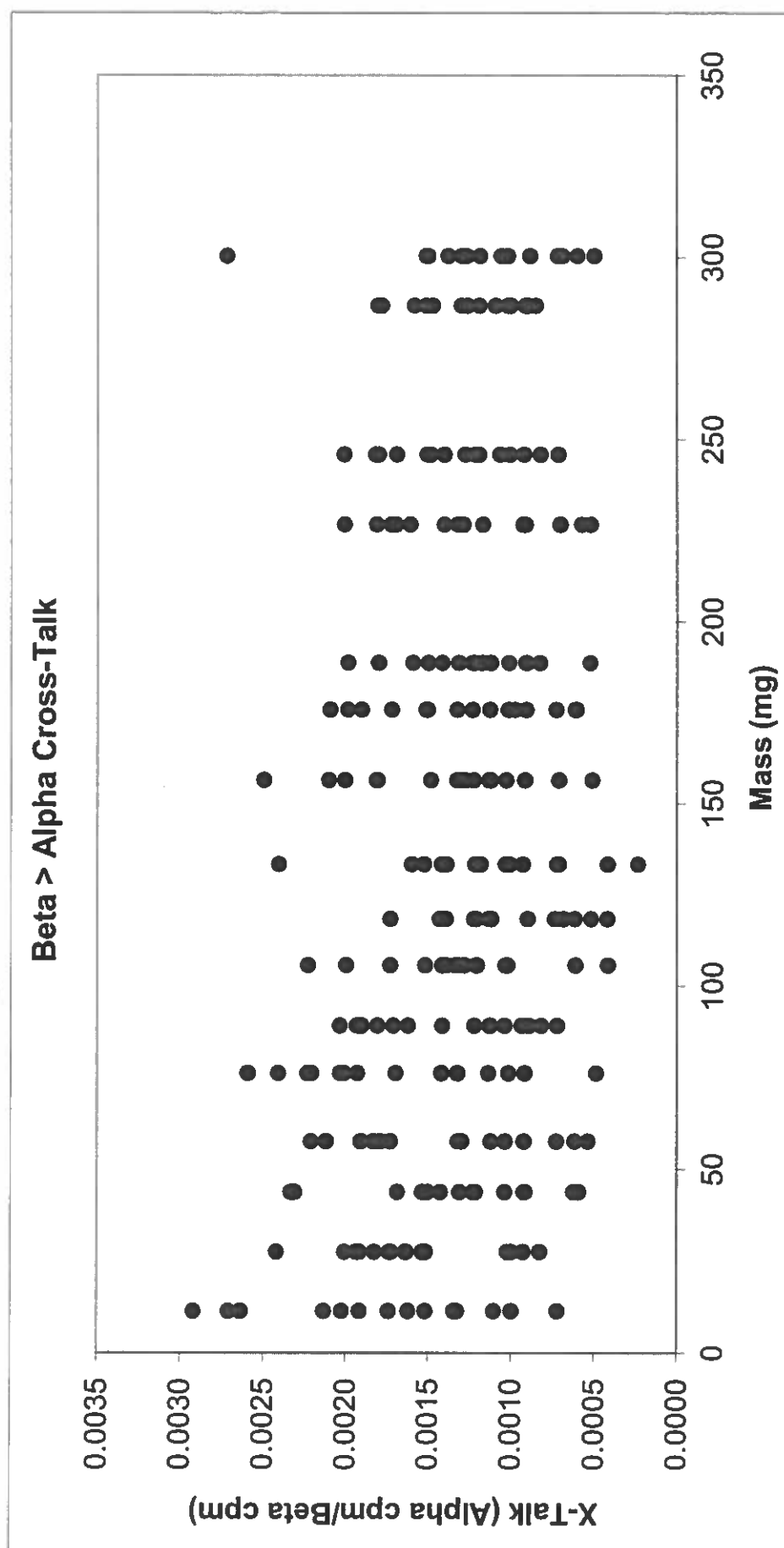
WG # 1515002		Spike Information				Attenuation Equation				Cross-Talk Equation				y=b*x+mm				
Mass Range Low 11.3 mg High 305.7 mg		Sid. ID 1019 4095 83 Ref. Date 2/9/2015 Half-life 30.1 yrs Activity 3937 10 dpm/mL Vol. 1.0 mL	Act. Added 3937 10 dpm	b = 0.9764 m = 0.9988 a = 0.9758		b = -1.07E-07 m = 0.0004												
				% Diff Max. = 8.6%	% Diff Max. =													
ACS0608	C3	1515002-18	133.3	6/8/15 8:07	15	10014	7.47	1.90	1338.50	0.4101	3907.59	0.3425	0.3404	1.0061	0.8353	0.8302	0.6%	84.6%
ACS0608	C3	1515002-20	156.4	6/8/15 7:56	10	10006	7.63	1.26	1309.34	0.4101	3907.59	0.3351	0.3310	1.0123	0.8171	0.8071	1.2%	-69.3%
ACS0608	C3	1515002-22	175.7	6/8/15 7:42	11	10021	7.49	1.36	1335.86	0.4101	3907.59	0.3419	0.3233	1.0573	0.8366	0.7884	5.7%	-52.9%
ACS0608A	C3	1515002-24	188.6	6/8/15 14:13	14	10006	7.77	1.69	1285.71	0.4101	3907.53	0.3290	0.3183	1.0338	0.8023	0.7761	3.4%	-67.4%
ACS0608A	C3	1515002-26	226.6	6/8/15 13:54	17	10006	8.3	1.94	1203.48	0.4101	3907.53	0.3080	0.3039	1.0134	0.7510	0.7411	1.3%	-73.6%
ACS0608A	C3	1515002-28	245.8	6/8/15 13:41	21	10005	8.34	2.41	1197.58	0.4101	3907.53	0.3065	0.2969	1.0323	0.7473	0.7239	3.2%	-79.0%
ACS0608A	C3	1515002-30	286.7	6/8/15 13:24	14	10002	9.36	1.39	1066.53	0.4101	3907.53	0.2729	0.2875	0.9653	0.6888	0.6888	-3.4%	-67.8%
ACS0608A	C3	1515002-32	300.4	6/8/15 13:10	6	10009	9.09	0.55	1059.04	0.4101	3907.54	0.2813	0.2778	1.0124	0.6858	0.6774	1.2%	-16.9%
ACS0608A	C4	1515002-2	11.3	6/8/15 13:08	16	10034	6.52	2.33	1537.04	0.4060	3907.54	0.3934	0.3910	1.0060	0.9688	0.9630	0.6%	0.0015
ACS0608A	C4	1515002-4	27.4	6/8/15 9:46	25	10021	6.47	3.74	1546.92	0.4060	3907.57	0.3959	0.3834	1.0325	0.9751	0.9443	3.3%	0.0024
ACS0608	C4	1515002-6	43.7	6/8/15 9:33	13	10020	6.94	1.75	1441.89	0.4060	3907.57	0.3690	0.3759	0.9817	0.9089	0.9258	-1.8%	0.0012
ACS0608	C4	1515002-8	57.5	6/8/15 9:21	22	10000	6.92	3.06	1443.17	0.4060	3907.58	0.3693	0.3696	0.9892	0.9087	0.9104	-0.1%	0.0021
ACS0608	C4	1515002-10	76.1	6/8/15 9:10	21	10017	7.22	2.79	1385.48	0.4060	3907.58	0.3546	0.3613	0.9812	0.8733	0.8900	-1.9%	0.0020
ACS0608	C4	1515002-12	89.1	6/8/15 8:57	20	10015	6.79	2.83	1473.05	0.4060	3907.58	0.3770	0.3557	1.0599	0.9285	0.8760	6.0%	0.0019
ACS0608	C4	1515002-14	105.6	6/8/15 8:45	13	10006	7.46	1.62	1339.37	0.4060	3907.58	0.3428	0.3466	0.9833	0.8442	0.8586	-1.7%	0.0012
ACS0608	C4	1515002-16	118.3	6/8/15 8:30	15	10016	7.23	1.96	1383.28	0.4060	3907.58	0.3540	0.3433	1.0313	0.8719	0.8455	3.1%	0.0014
ACS0608	C4	1515002-18	133.3	6/8/15 8:19	11	10015	7.37	1.37	1357.11	0.4060	3907.59	0.3473	0.3370	1.0304	0.8554	0.8302	3.0%	0.0010
ACS0608	C4	1515002-20	156.4	6/8/15 8:07	19	10007	7.61	2.38	1313.06	0.4060	3907.59	0.3360	0.3277	1.0254	0.8277	0.8071	2.5%	0.0018
ACS0608	C4	1515002-22	175.7	6/8/15 7:56	7	10007	7.52	0.81	1328.80	0.4060	3907.59	0.3401	0.3201	1.0624	0.8376	0.7884	6.2%	0.0006
ACS0608	C4	1515002-24	188.6	6/8/15 7:42	10	10013	7.72	1.18	1295.10	0.4060	3907.59	0.3314	0.3151	1.0518	0.8163	0.7761	5.2%	0.0009
ACS0608A	C4	1515002-26	226.6	6/8/15 14:14	15	10006	8.07	1.74	1237.98	0.4060	3907.53	0.3168	0.3069	1.0530	0.7803	0.7411	5.3%	0.0014
ACS0608A	C4	1515002-28	245.8	6/8/15 13:54	19	10007	8.23	2.19	1214.00	0.4060	3907.53	0.3107	0.2939	1.0570	0.7652	0.7239	5.7%	0.0018
ACS0608A	C4	1515002-30	286.7	6/8/15 13:42	13	10007	9.06	1.32	1102.61	0.4060	3907.53	0.2822	0.2796	1.0090	0.6950	0.6888	0.9%	0.0012
ACS0608A	C4	1515002-32	300.4	6/8/15 13:24	8	10007	8.82	0.79	1132.66	0.4060	3907.53	0.2899	0.2750	1.0540	0.7140	0.6774	5.4%	0.0007
ACS0608A	D1	1515002-2	11.3	6/8/15 13:21	22	10031	6.53	3.27	1533.29	0.4069	3907.53	0.3924	0.3919	1.0014	0.9644	0.9630	0.1%	0.0021
ACS0608A	D1	1515002-4	27.4	6/8/15 13:08	16	10003	6.77	2.27	1474.70	0.4069	3907.54	0.3774	0.3843	0.9822	0.9275	0.9443	-1.8%	0.0015
ACS0608A	D1	1515002-6	43.7	6/8/15 9:47	24	10013	7.08	3.29	1411.42	0.4069	3907.57	0.3612	0.3767	0.9588	0.8877	0.9258	-4.1%	0.0023
ACS0608	D1	1515002-8	57.5	6/8/15 9:34	18	10010	7.18	2.41	1391.30	0.4069	3907.57	0.3561	0.3704	0.9710	0.8750	0.9104	-3.9%	0.0017
ACS0608	D1	1515002-10	76.1	6/8/15 9:22	20	10010	7.27	2.65	1374.05	0.4069	3907.58	0.3516	0.3621	0.9612	0.8642	0.8900	-2.9%	0.0019
ACS0608	D1	1515002-12	89.1	6/8/15 9:09	20	10010	6.92	2.79	1443.69	0.4069	3907.58	0.3695	0.3565	1.0365	0.9080	0.8760	3.6%	0.0019
ACS0608	D1	1515002-14	105.6	6/8/15 8:58	23	10011	7.47	2.98	1337.31	0.4069	3907.58	0.3422	0.3494	0.9796	0.8411	0.8586	-2.0%	0.0022
ACS0608	D1	1515002-16	118.3	6/8/15 8:45	18	10009	7.16	2.42	1395.06	0.4069	3907.58	0.3570	0.3440	1.0378	0.8774	0.8455	3.8%	0.0017
ACS0608	D1	1515002-18	133.3	6/8/15 8:30	16	10014	7.6	2.01	1314.79	0.4069	3907.58	0.3365	0.3378	0.9961	0.8269	0.8302	-0.4%	0.0015
ACS0608	D1	1515002-20	156.4	6/8/15 8:19	13	10010	7.65	1.60	1305.65	0.4069	3907.59	0.3341	0.3284	1.0174	0.8212	0.8071	1.7%	0.0012
ACS0608	D1	1515002-22	175.7	6/8/15 8:07	14	10004	7.77	1.70	1284.67	0.4069	3907.59	0.3288	0.3208	1.0248	0.8080	0.7884	2.5%	0.0013
ACS0608	D1	1515002-24	188.6	6/8/15 7:56	12	10007	7.98	1.41	1251.54	0.4069	3907.59	0.3203	0.3158	1.0142	0.7871	0.7761	1.4%	0.0011
ACS0608	D1	1515002-26	226.6	6/8/15 7:43	14	10006	8.25	1.60	1210.00	0.4069	3907.59	0.3097	0.3015	1.0269	0.7610	0.7411	2.7%	0.0013
ACS0608A	D1	1515002-28	245.8	6/8/15 14:14	19	10005	8.53	2.13	1170.07	0.4069	3907.53	0.2994	0.2946	1.0165	0.7359	0.7239	1.7%	0.0018
ACS0608A	D1	1515002-30	286.7	6/8/15 13:55	10	10004	9.41	0.97	1060.28	0.4069	3907.53	0.2713	0.2803	0.9681	0.6669	0.6888	-3.2%	0.0009
ACS0608A	D1	1515002-32	300.4	6/8/15 13:42	16	10011	9.14	1.85	1092.45	0.4069	3907.53	0.2796	0.2796	1.0143	0.6871	0.6774	1.4%	0.0015
ACS0608A	D2	1515002-2	11.3	6/8/15 13:40	27	10024	6.53	4.04	1533.42	0.4179	3907.53	0.3924	0.4025	0.9751	0.9390	0.9630	-2.5%	0.0026
ACS0608A	D2	1515002-4	27.4	6/8/15 13:21	20	10010	6.59	2.94	1517.32	0.4179	3907.53	0.3883	0.3946	0.9839	0.9292	0.9443	-1.6%	0.0019
ACS0608A	D2	1515002-6	43.7	6/8/15 13:09	13	10020	7.24	1.70	1382.33	0.4179	3907.54	0.3538	0.3669	0.9144	0.8465	0.9258	-8.6%	0.0012
ACS0608	D2	1515002-8	57.5	6/8/15 9:47	19	10008	7.13	2.57	1402.00	0.4179	3907.57	0.3588	0.3804	0.9431	0.8595	0.9104	-5.7%	0.0018
ACS0608	D2	1515002-10	76.1	6/8/15 9:34	23	10010	7.29	3.06	1371.47	0.4179	3907.57	0.3510	0.3719	0.9437	0.8399	0.8900	-5.6%	0.0022
ACS0608	D2	1515002-12	89.1	6/8/15 9:21	10	10009	6.73	1.39	1485.58	0.4179	3907.58	0.3802	0.3661	1.0365	0.9097	0.8760	3.8%	0.0009
ACS0608	D2	1515002-14	105.6	6/8/15 9:10	18	10004	7.41	2.34	1348.42	0.4179	3907.58	0.3451	0.3588	0.9617	0.8257	0.8586	-3.8%	0.0017
ACS0608	D2	1515002-16	118.3	6/8/15 8:58	15	10011	7.18	2.00	1392.64	0.4179	3907.58	0.3564	0.3533	1.0087	0.8528	0.8455	0.9%	0.0014
ACS0608	D2	1515002-18	133.3	6/8/15 8:45	10	10004	7.4	1.26	1350.25	0.4179	39							

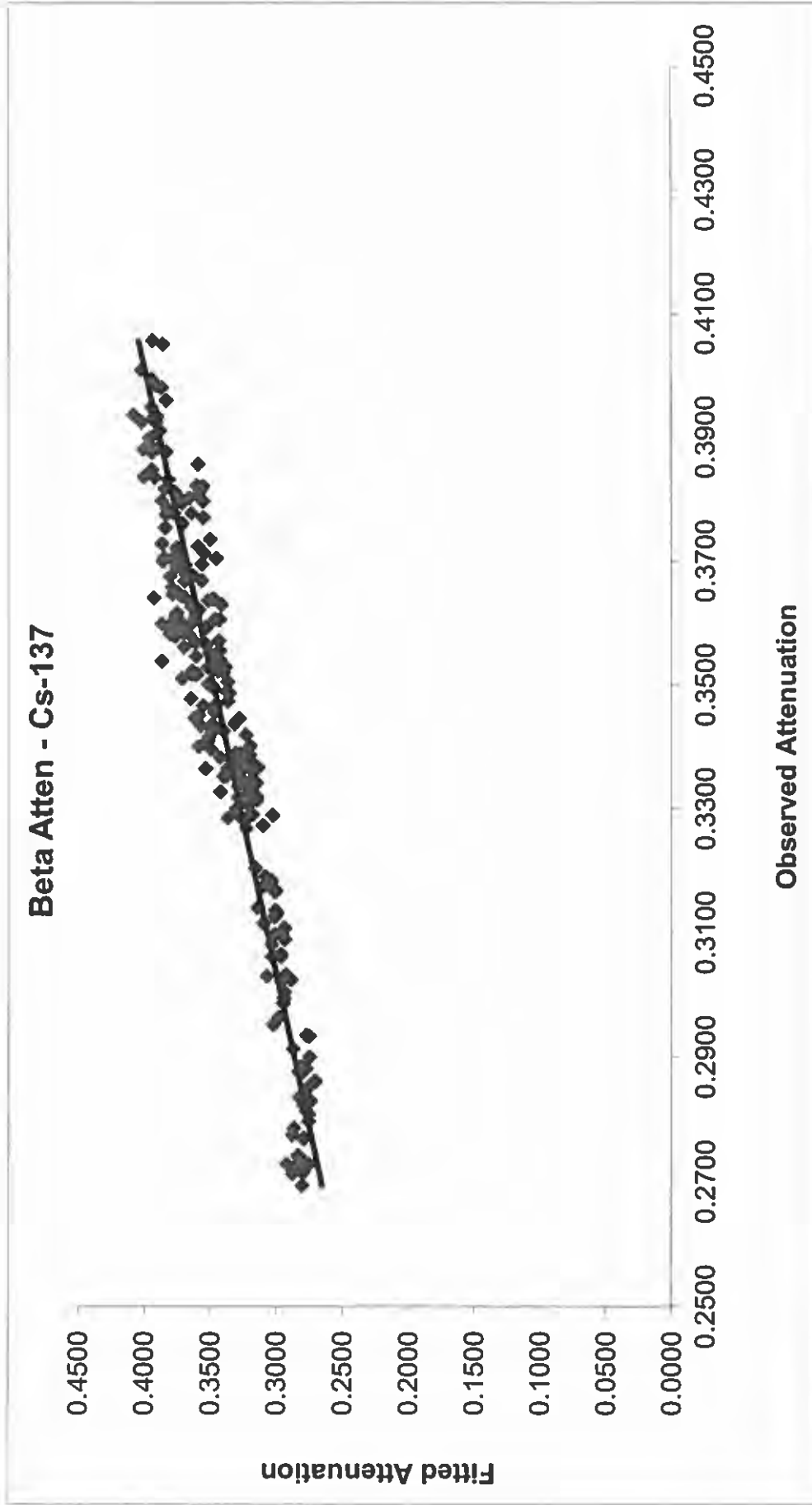
**LB4100C Beta Attenuation Curve -- Cs137**

WO #		1515002		Mass Range		11.3 mg		305.7 mg		Scale Information				Std. ID		1019.4095.85		Ref. Date		2/9/2015		yrs		30.1		Halflife		Activity		3937.10		dpn/mL		mL		den		Act. Added		3937.10		1.0		b = 0.9764		m = 0.9988		a = 0.9758		y-b* <sup>2</sup> *m/(a <sup>2</sup> *x)		Attenuation Equation		% Diff Max. =		8.6%		b = 0.9764		m = 0.9988		a = 0.9758		y-b* <sup>2</sup> *m/(a <sup>2</sup> *x)		Cross-Talk Equation		b = -1.07E-07		m = 0.0004		y-b* <sup>2</sup> *m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											









6/8/2015

Cs 137 (Gross Beta) Mass Attenuation Curve

Benchsheets: AB150310-1 AB150423-3 Sources: 1515002-1 → 32 (Even #s Only)

Calibration Curve Range: 11.3 → 300.4

Det	7:34	7:48	7:59	8:11	8:22	8:37	8:50	9:02	9:14	9:26	9:39	13:01	13:14	13:33	13:45	14:05
A1	2	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4
A2	4	2	32	30	28	26	24	22	20	18	16	14	12	10	8	6
A3	6	4	2	32	30	28	26	24	22	20	18	16	14	12	10	8
A4	8	6	4	2	32	30	28	26	24	22	20	18	16	14	12	10
B1	10	8	6	4	2	32	30	28	26	24	22	20	18	16	14	12
B2	12	10	8	6	4	2	32	30	28	26	24	22	20	18	16	14
B3	14	12	10	8	6	4	2	32	30	28	26	24	22	20	18	16
B4	16	14	12	10	8	6	4	2	32	30	28	26	24	22	20	18
C1	18	16	14	12	10	8	6	4	2	32	30	28	26	24	22	20
C2	20	18	16	14	12	10	8	6	4	2	32	30	28	26	24	22
C3	22	20	18	16	14	12	10	8	6	4	2	32	30	28	26	24
C4	24	22	20	18	16	14	12	10	8	6	4	2	32	30	28	26
D1	26	24	22	20	18	16	14	12	10	8	6	4	2	32	30	28
D2	28	26	24	22	20	18	16	14	12	10	8	6	4	2	32	30
D3	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	32
D4	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2

File names:

ACS0608

ACS0608A

ACS0608

ACS0608A

6/8/2015

Sr90 Flat Efficiency Calibration

Benchsheet: SR110623-2 Source ID → 1066

Log file → SR90F-06/15

Sources

1118013-1  
-2  
-4  
-5


Detectors

A1 B1 C1 D1  
A2 B2 C2 D2  
A3 B3 C3 D3  
A4 B4 C4 D4

File names

ESF0608A  
B  
C  
D

Continued on Page

 6/8/15

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Date

6/9/2015

Gross Alpha  $\rightarrow$  Th230 Efficiency Calibration  
Benchsheet: AB1506035 Source ID  $\rightarrow$  1067  
Log File: Th230-06/15

Sources	Detectors	File names
1518003-1	A1 B1 C1 D1	ETH0609A
-2	A2 B2 C2 D2	B
-3	A3 B3 C3 D3	C
-4	A4 B4 C4 D4	D

6/9/2015


Th230 (Gross Alpha) Mass Attenuation Curve  
Benchsheet: AB1506036 Sources: 1518004-1  $\rightarrow$  16  
Calibration Range: 12.4  $\rightarrow$  100 mg

Filename:  
ATH0609  
ATH0610

Det	11:01	11:30	11:58	12:24	12:49	13:15	13:41	14:11	14:38	15:05	15:33	7:56	8:24	8:52	9:28	9:55
A1	1	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
A2	2	1	16	15	14	13	12	11	10	9	8	7	6	5	4	3
A3	3	2	1	16	15	14	13	12	11	10	9	8	7	6	5	4
A4	4	3	2	1	16	15	14	13	12	11	10	9	8	7	6	5
B1	5	4	3	2	1	16	15	14	13	12	11	10	9	8	7	6
B2	6	5	4	3	2	1	16	15	14	13	12	11	10	9	8	7
B3	7	6	5	4	3	2	1	16	15	14	13	12	11	10	9	8
B4	8	7	6	5	4	3	2	1	16	15	14	13	12	11	10	9
C1	9	8	7	6	5	4	3	2	1	16	15	14	13	12	11	10
C2	10	9	8	7	6	5	4	3	2	1	16	15	14	13	12	11
C3	11	10	9	8	7	6	5	4	3	2	1	16	15	14	13	12
C4	12	11	10	9	8	7	6	5	4	3	2	1	16	15	14	13
D1	13	12	11	10	9	8	7	6	5	4	3	2	1	16	15	14
D2	14	13	12	11	10	9	8	7	6	5	4	3	2	1	16	15
D3	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	16
D4	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Continued on Page

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6/9/15

Signed

Date

Signed

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Date 6/8/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	W	P			W	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKCOU0SL			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

	P-10 Supply	P-10 Flow	
Tank 1	2700	Dr A	0.1
		Dr B	
Tank 2	1200	Dr C	
		Dr D	

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Reviewed By / Date OP 6/8/15

Date

6/8/15

SOP 724r 11

## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File-ID	Output Initials
1-16	Daily Eff	—	—	30	6:25	JP	EFF0608	JP
1-16	Daily Bkg	—	—	60	6:33	JP	BKCG0608	JP
1-16	1515002-1332	AB150310-1	(S13) Map	30	7:34	JP	ACSG0608	JP
1	(Even #s Only)	AB150423-3	Attn	1				
1-4	1065	RA150603-1	Ra228	30	9:58	JP	RERA0608A	JP
5-8			Eff		10:02	JP	ERA0608B	
9-12			Cal		10:11	JP	ERA0608C	
13-16					10:18	JP	ERA0608D	
1-4	1066	SR110623-2	Sr90	30	10:13	JP	ESF0608A	
5-8			Eff		10:19	JP	ESF0608B	
9-12			Cal		10:24	JP	ESF0608C	
13-16					10:30	JP	ESF0608D	
1	1118012-1	SR110623-1	Sr90	120	10:39	JP	SRC0608	JP
6	-2		ICV					
9	-3		ICV					
15	-4		ICV					
4	SR110623-1MB1							
7	MB2							
10	MB3							
16	MB4							
1-16	1515002-1332	AB150310-1	(S13)	30	13:01	JP	ACSG0608A	JP
	(Even #s Only)	AB150423-3	Marathon					
1	1505234-1	AB150605-1	α/B	120	15:50	JP	ABCG0608A	JP
2	-3							
3	-3MS							
4	-5							
5	-7							
6	-9							
7	-11							
8	-11D							
9	-13							
10	15052756							
11	-6D							
12	-6MS							
14	15053792							
15	-4							
16	-6							

Comments:

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 (cont. from page NA B)

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Reviewed By / Date

JP 6/9/15

Date 6/9/15

SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JD	P			JD	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK00605W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

	P-10 Supply		P-10 Flow
Tank 1	1850	Dr A	0.1
	↓	Dr B	↓
Tank 2	1200	Dr C	↓
	↓	Dr D	↓

Comments:

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Form 780r8.doc (6/23/06)

Reviewed By / Date J. Galis

Date 6/9/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JD	P			JD	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK00605W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	1850	Dr A	0.1
	↓	Dr B	
Tank 2	1200	Dr C	
	↓	Dr D	

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Form 780r8.doc (6/23/06)

Reviewed By / Date J 6/9/15

Date

6/9/15

SOP 724r/11

ALS

Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Daily Eff	—	—	30	7:13	JP	ETH0609	JP
1-16	Daily Bkg	—	—	60	7:22	JP	BK0609	JP
1	1518003-1	AB150603-5	Th230	10	8:47	JP	AB0609	JP
1	-2	↓	Outlier	↓	9:00	JP	A	↓
1	-3	↓	↓	↓	9:13	JP	B	↓
1	-4	↓	↓	↓	9:37	JP	C	↓
1	-5	↓	↓	↓	9:51	JP	D	↓
1-4	1067	AB150603-5	Th230	30	10:15	JP	ETH0609A	JP
5-8	↓	↓	Th230	↓	10:23	↓	B	↓
9-12	↓	↓	Eff	↓	10:37	↓	C	↓
13-16	↓	↓	Cal	↓	10:51	↓	D	↓
1-16	1518004-1-16	AB150603-6	Th230	30	11:01	JP	ATH0609	JP
1	1505092-1	SR150605-1	Sr90	180	16:03	JP	SRC0609	JP
2	↓ -3	↓	↓	↓	↓	↓	↓	↓
3	↓ -30	↓	↓	↓	↓	↓	↓	↓
4	1505234-1	↓	↓	↓	↓	↓	↓	↓
5	↓ -3	↓	↓	↓	↓	↓	↓	↓
6	↓ -5	↓	↓	↓	↓	↓	↓	↓
7	↓ -7	↓	↓	↓	↓	↓	↓	↓
8	↓ -9	↓	↓	↓	↓	↓	↓	↓
9	↓ -11	↓	↓	↓	↓	↓	↓	↓
10	↓ -13	↓	↓	↓	↓	↓	↓	↓
11	↓ -130	↓	↓	↓	↓	↓	↓	↓
12	1505235-1	↓	↓	↓	↓	↓	↓	↓
14	↓ -3	↓	↓	↓	↓	↓	↓	↓
15	↓ -30	↓	↓	↓	↓	↓	↓	↓
16	1505249-1	↓	↓	↓	↓	↓	↓	↓
1	↓ -2	SR150605-1	Sr90	180	22:12	JP	SRC0609A	↓
2	1505344-1	↓	↓	↓	↓	↓	↓	↓
3	↓ 427-1	↓	↓	↓	↓	↓	↓	↓
4	↓ -3	↓	↓	↓	↓	↓	↓	↓
5	SR1506051MB	↓	↓	↓	↓	↓	↓	↓
6	↓ 1C1	↓	↓	↓	↓	↓	↓	↓
7	1505379-8	AB150605-1	α15	120	22:13	JP	AB0609	↓
8	↓ -80	↓	↓	↓	↓	↓	↓	↓
9	↓ -10	↓	↓	↓	↓	↓	↓	↓
10	AB150605-1C9	↓	↓	↓	↓	↓	↓	↓
11	1505341-1	AB150605-2	↓	480	22:15	↓	AB0609A	↓
12	↓ -10	↓	↓	↓	↓	↓	↓	↓
14	1505448-1	↓	↓	↓	↓	↓	↓	↓
15	↓ -4	↓	↓	↓	↓	↓	↓	↓
JP 6/10/15								

Comments:

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Reviewed By / Date

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(cont. from page

NA

B)

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Date

6/10/15

SOP 724r

11

## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

## Instrument Daily Response and Background Checks

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	P	P			P	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

## Weekly Background Calibration

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKC 0605W			
Dr B				
Dr C				
Dr D				

Dr = Drawer

## Gas Supply

	P-10 Supply		P-10 Flow
Tank 1	1500	Dr A	0.1
		Dr B	
Tank 2	1200	Dr C	
		Dr D	

Comments:

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Form 780r8.doc (6/23/06)

Reviewed By / Date

JP 6/10/15

Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

Prep Procedure: GROSS\_ALPH

Mass Attenuation Curve

Analytical QASS / NCR? Y NA

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Ins/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Ins/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Ins/Det	Cnt 3 Pos Chk By	Notes
1	1518004-1	SMP	200	200	ml	pCi/l	13.2										
1	1518004-2	SMP	200	200	ml	pCi/l	12.4										
1	1518004-3	SMP	200	200	ml	pCi/l	25.8										
1	1518004-4	SMP	200	200	ml	pCi/l	28.1										
1	1518004-5	SMP	200	200	ml	pCi/l	43.9										
1	1518004-6	SMP	200	200	ml	pCi/l	36.8										
1	1518004-7	SMP	200	200	ml	pCi/l	49.9										
1	1518004-8	SMP	200	200	ml	pCi/l	49.5										
1	1518004-9	SMP	200	200	ml	pCi/l	67.8										
1	1518004-10	SMP	200	200	ml	pCi/l	70										
1	1518004-11	SMP	200	200	ml	pCi/l	79.3										
1	1518004-12	SMP	200	200	ml	pCi/l	77.3										
1	1518004-13	SMP	200	200	ml	pCi/l	83.5										
1	1518004-14	SMP	200	200	ml	pCi/l	89.8										
1	1518004-15	SMP	200	200	ml	pCi/l	100.4										
1	1518004-16	SMP	200	200	ml	pCi/l	100										

See Entry 3710 pg 75

Mc/23/11

Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot Units	Pipet ID
S1	Th-230	853.3020.89	1.166.300	DPM/ml	06/03/15	5 ml	RS-027

Sample Barcodes

1518004-1 AB150603-6PS1		1518004-2 AB150603-6PS2		1518004-3 AB150603-6PS3	
1518004-4 AB150603-6PS4		1518004-5 AB150603-6PS5		1518004-6 AB150603-6PS6	
1518004-7 AB150603-6PS7		1518004-8 AB150603-6PS8		1518004-9 AB150603-6PS9	
1518004-10 AB150603-6PS10		1518004-11 AB150603-6PS11		1518004-12 AB150603-6PS12	

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# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

Prep Procedure: GROSS\_ALPHA

Analytical QASS / NCR? Y / N

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Ins/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Ins/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Ins/Det	Cnt 3 Pos Chk By	Notes
1518004-13	AB150603-6PS13							1518004-14	AB150603-6PS14					1518004-15	AB150603-6PS15		
1518004-16	AB150603-6PS16																

## Reporting Units

LabID:	TstGrpName:	RptUnits:
1518004-1	GrossAlpha_DW	pCi/l
1518004-2	GrossAlpha_DW	pCi/l
1518004-3	GrossAlpha_DW	pCi/l
1518004-4	GrossAlpha_DW	pCi/l
1518004-5	GrossAlpha_DW	pCi/l
1518004-6	GrossAlpha_DW	pCi/l
1518004-7	GrossAlpha_DW	pCi/l
1518004-8	GrossAlpha_DW	pCi/l
1518004-9	GrossAlpha_DW	pCi/l
1518004-10	GrossAlpha_DW	pCi/l
1518004-11	GrossAlpha_DW	pCi/l
1518004-12	GrossAlpha_DW	pCi/l
1518004-13	GrossAlpha_DW	pCi/l
1518004-14	GrossAlpha_DW	pCi/l
1518004-15	GrossAlpha_DW	pCi/l
1518004-16	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb *JKB* Review Date: 6/8/2015

Non-Routine Pre-Treatment? Y / ☒ Batch: NA

Prep QASS / NCR? Y ☒ *NA*

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 6/3/2015

Prep Dept: RS

Balance:

Balance:

Sampl Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1518004-1	SMP	200	200	200		S1	Salt added based on 51mg/mL -->0.23ml
2	1	1518004-2	SMP	200	200	200		S1	0.23 mL salt
3	1	1518004-3	SMP	200	200	200		S1	0.5 mL salt
4	1	1518004-4	SMP	200	200	200		S1	0.5 mL salt
5	1	1518004-5	SMP	200	200	200		S1	0.78 mL salt
6	1	1518004-6	SMP	200	200	200		S1	0.78 mL salt
7	1	1518004-7	SMP	200	200	200		S1	1.08 mL salt
8	1	1518004-8	SMP	200	200	200		S1	1.08 mL salt
9	1	1518004-9	SMP	200	200	200		S1	1.37 mL salt
10	1	1518004-10	SMP	200	200	200		S1	1.37 mL salt
11	1	1518004-11	SMP	200	200	200		S1	1.57 mL salt
12	1	1518004-12	SMP	200	200	200		S1	1.57 mL salt
13	1	1518004-13	SMP	200	200	200		S1	1.76 mL salt
14	1	1518004-14	SMP	200	200	200		S1	1.76 mL salt
15	1	1518004-15	SMP	200	200	200		S1	2.02 mL salt
16	1	1518004-16	SMP	200	200	200		S1	2.02 mL salt

## Comments

Th-230 mass attenuation curve USGS method (approximately 200 mL DI H2O + 20 mL conc HNO3 cooked down in a glass beaker and transferred to a planchet) Salt added based on weight per mL of salt solution, additional salt added as needed.

Spiked By: Jennie Kill-Bowden Date: 6/3/2015

Witnessed By: Peter Workman Date: 6/3/2015

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Th-230	853.3020.89	1,166.300	DPM/ml	06/03/15	5	ml	RS-027

# Radiochemistry Prep Worksheet

Prep Batch: AB150603-6

ALS Environmental -- FC

Prep Procedure: GROSS\_ALPHA

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch:

Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden *JKB*

Prep Date: 6/3/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1518004-1	SMP	200	200	200		S1	
2	1518004-2	SMP	200	200	200		S1	
3	1518004-3	SMP	200	200	200		S1	
4	1518004-4	SMP	200	200	200		S1	
5	1518004-5	SMP	200	200	200		S1	
6	1518004-6	SMP	200	200	200		S1	
7	1518004-7	SMP	200	200	200		S1	
8	1518004-8	SMP	200	200	200		S1	
9	1518004-9	SMP	200	200	200		S1	
10	1518004-10	SMP	200	200	200		S1	
11	1518004-11	SMP	200	200	200		S1	
12	1518004-12	SMP	200	200	200		S1	
13	1518004-13	SMP	200	200	200		S1	
14	1518004-14	SMP	200	200	200		S1	
15	1518004-15	SMP	200	200	200		S1	
16	1518004-16	SMP	200	200	200		S1	

Comments

Th-230 mass attenuation curve USGS method

Spiked By: *JKB* Date: *6/3/15*  
 Witnessed By: *[Signature]* Date: *6/3/15*

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Pipet ID
S1	Th-230	853.3020 89	1.166 300	DPW/ml	06/03/15	RS-027

# Radiochemistry Gravimetric Worksheet

ALS Environmental -- FC

Prep Batch: AB150603-6

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb *jk* Review Date: 6/8/2015

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Gross Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1518004-1	SMP	10	9.1569	0.0000	0	0	0	200	9.1701	13.2	0.23	
1	2	1518004-2	SMP	10	9.1115	0.0000	0	0	0	200	9.1239	12.4	0.23	
1	3	1518004-3	SMP	10	9.1509	0.0000	0	0	0	200	9.1767	25.8	0.5	
1	4	1518004-4	SMP	10	9.1834	0.0000	0	0	0	200	9.2115	28.1	0.5	
1	5	1518004-5	SMP	10	9.1505	0.0000	0	0	0	200	9.1944	43.9	0.78	
1	6	1518004-6	SMP	10	9.1176	0.0000	0	0	0	200	9.1544	36.8	0.78	
1	7	1518004-7	SMP	10	9.1596	0.0000	0	0	0	200	9.2095	49.9	1.08	
1	8	1518004-8	SMP	10	9.1459	0.0000	0	0	0	200	9.1954	49.5	1.08	
1	9	1518004-9	SMP	10	9.1503	0.0000	0	0	0	200	9.2181	67.8	1.37	
1	10	1518004-10	SMP	10	9.0442	0.0000	0	0	0	200	9.1142	70	1.37	
1	11	1518004-11	SMP	10	9.0531	0.0000	0	0	0	200	9.1324	79.3	1.57	
1	12	1518004-12	SMP	10	9.0094	0.0000	0	0	0	200	9.0867	77.3	1.57	
1	13	1518004-13	SMP	10	9.0334	0.0000	0	0	0	200	9.1169	83.5	1.76	
1	14	1518004-14	SMP	10	9.4305	0.0000	0	0	0	200	9.5203	89.8	1.76	
1	15	1518004-15	SMP	10	9.3886	0.0000	0	0	0	200	9.4890	100.4	2.02	
1	16	1518004-16	SMP	10	9.3856	0.0000	0	0	0	200	9.4856	100	2.02	

*Nx*

# Radiochemistry Instrument Worksheet

Prep Batch: AB150310-1

ALS Environmental -- FC *Palis*

Prep Procedure: GROSS ~~ALPHA~~ BETA

*MASS ATTENUATION*

Analytical QASS / NCR? Y *N* *NN*

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Ins/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Ins/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Ins/Det	Cnt 3 Pos Chk By	Notes
1	1515002-1	SMP	200	200	ml	pCi/l	11.3	<i>See Runlog 3710 p. 74</i>								
1	1515002-2	SMP	200	200	ml	pCi/l	11.3									
1	1515002-3	SMP	200	200	ml	pCi/l	25.9									
1	1515002-4	SMP	200	200	ml	pCi/l	27.4									
1	1515002-5	SMP	200	200	ml	pCi/l	43.2									
1	1515002-6	SMP	200	200	ml	pCi/l	43.7									
1	1515002-7	SMP	200	200	ml	pCi/l	58.3									
1	1515002-8	SMP	200	200	ml	pCi/l	57.5									
1	1515002-9	SMP	200	200	ml	pCi/l	75.9									
1	1515002-10	SMP	200	200	ml	pCi/l	76.1									
1	1515002-11	SMP	200	200	ml	pCi/l	90.2									
1	1515002-12	SMP	200	200	ml	pCi/l	89.1									
1	1515002-13	SMP	200	200	ml	pCi/l	103.4									
1	1515002-14	SMP	200	200	ml	pCi/l	105.6									
1	1515002-15	SMP	200	200	ml	pCi/l	121									
1	1515002-16	SMP	200	200	ml	pCi/l	118.3									
1	1515002-17	SMP	200	200	ml	pCi/l	136.1									
1	1515002-18	SMP	200	200	ml	pCi/l	133.3									
1	1515002-19	SMP	200	200	ml	pCi/l	152									
1	1515002-20	SMP	200	200	ml	pCi/l	156.4									
1	1515002-21	SMP	200	200	ml	pCi/l	178.3									
1	1515002-22	SMP	200	200	ml	pCi/l	175.7									
1	1515002-23	SMP	200	200	ml	pCi/l	189.1									
1	1515002-24	SMP	200	200	ml	pCi/l	188.6									

*Dr G/19/16*

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Pipet ID
S1	Cs-137	1019.4095	83	DPM/ml	03/10/15	RS-005

# Radiochemistry Instrument Worksheet

Prep Batch: AB150310-1

ALS Environmental -- FC

Prep Procedure: GROSS\_ALPH

Analytical QASS / NCR? Y (N) NA

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Ins/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Ins/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Ins/Det	Cnt 3 Pos Chk By	Notes
1515002-1 AB150310-1PS1								1515002-2 AB150310-1PS2						1515002-3 AB150310-1PS3			
1515002-4 AB150310-1PS4								1515002-5 AB150310-1PS5						1515002-6 AB150310-1PS6			
1515002-7 AB150310-1PS7								1515002-8 AB150310-1PS8						1515002-9 AB150310-1PS9			
1515002-10 AB150310-1PS10								1515002-11 AB150310-1PS11						1515002-12 AB150310-1PS12			
1515002-13 AB150310-1PS13								1515002-14 AB150310-1PS14						1515002-15 AB150310-1PS15			
1515002-16 AB150310-1PS16								1515002-17 AB150310-1PS17						1515002-18 AB150310-1PS18			
1515002-19 AB150310-1PS19								1515002-20 AB150310-1PS20						1515002-21 AB150310-1PS21			
1515002-22 AB150310-1PS22								1515002-23 AB150310-1PS23						1515002-24 AB150310-1PS24			

## Sample Barcodes

NA

# Radiochemistry Instrument Worksheet

Prep Batch: AB150310-1

ALS Environmental -- FC

## Reporting Units

LabID	IsotopeName	RptUnits
1515002-1	GrossAlpha_DW	pCi/l
1515002-2	GrossAlpha_DW	pCi/l
1515002-3	GrossAlpha_DW	pCi/l
1515002-4	GrossAlpha_DW	pCi/l
1515002-5	GrossAlpha_DW	pCi/l
1515002-6	GrossAlpha_DW	pCi/l
1515002-7	GrossAlpha_DW	pCi/l
1515002-8	GrossAlpha_DW	pCi/l
1515002-9	GrossAlpha_DW	pCi/l
1515002-10	GrossAlpha_DW	pCi/l
1515002-11	GrossAlpha_DW	pCi/l
1515002-12	GrossAlpha_DW	pCi/l
1515002-13	GrossAlpha_DW	pCi/l
1515002-14	GrossAlpha_DW	pCi/l
1515002-15	GrossAlpha_DW	pCi/l
1515002-16	GrossAlpha_DW	pCi/l
1515002-17	GrossAlpha_DW	pCi/l
1515002-18	GrossAlpha_DW	pCi/l
1515002-19	GrossAlpha_DW	pCi/l
1515002-20	GrossAlpha_DW	pCi/l
1515002-21	GrossAlpha_DW	pCi/l
1515002-22	GrossAlpha_DW	pCi/l
1515002-23	GrossAlpha_DW	pCi/l
1515002-24	GrossAlpha_DW	pCi/l

NA

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-1

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb JCB Review Date: 3/10/2015

Non-Routine Pre-Treatment? Y ☒ Batch: AA Re-Prep? Y ☒ Batch: AA

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Balance: 13

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1515002-1	SMP	200	200	200	As Received	S1	<del>3/10/15 ASR</del>
2	1	1515002-2	SMP	200	200	200	As Received	S1	
3	1	1515002-3	SMP	200	200	200	As Received	S1	
4	1	1515002-4	SMP	200	200	200	As Received	S1	
5	1	1515002-5	SMP	200	200	200	As Received	S1	
6	1	1515002-6	SMP	200	200	200	As Received	S1	
7	1	1515002-7	SMP	200	200	200	As Received	S1	
8	1	1515002-8	SMP	200	200	200	As Received	S1	
9	1	1515002-9	SMP	200	200	200	As Received	S1	
10	1	1515002-10	SMP	200	200	200	As Received	S1	
11	1	1515002-11	SMP	200	200	200	As Received	S1	
12	1	1515002-12	SMP	200	200	200	As Received	S1	
13	1	1515002-13	SMP	200	200	200	As Received	S1	
14	1	1515002-14	SMP	200	200	200	As Received	S1	
15	1	1515002-15	SMP	200	200	200	As Received	S1	
16	1	1515002-16	SMP	200	200	200	As Received	S1	
17	1	1515002-17	SMP	200	200	200	As Received	S1	
18	1	1515002-18	SMP	200	200	200	As Received	S1	
19	1	1515002-19	SMP	200	200	200	As Received	S1	
20	1	1515002-20	SMP	200	200	200	As Received	S1	
21	1	1515002-21	SMP	200	200	200	As Received	S1	
22	1	1515002-22	SMP	200	200	200	As Received	S1	
23	1	1515002-23	SMP	200	200	200	As Received	S1	
24	1	1515002-24	SMP	200	200	200	As Received	S1	

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-1

Prep Procedure: GROSS\_ALPH

Reviewed By: jkb *SeB* Review Date: 3/10/2015

Non-Routine Pre-Treatment? Y ☒ Batch: *NA* Re-Prep? Y ☒ Batch: *NA* Prep QASS / NCR? Y ☒ *NA*

Prep SOP: PAI 702 Rev: 20 Balance: 13  
 Prep SOP: NONE Balance:  
 Matrix Class: liquid Prep Dept: RS

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes

Comments  
 Cs-137 Drinking water mass attenuation calibration curve

Spiked By: Jennie Kill-Bowden Date: 3/10/2015  
 Witnessed By: Dayna K. Lewis Date: 3/10/2015

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Cs-137	1019.4095 83	3.929.816	DPM/ml	03/10/15
				1	ml
					RS-005

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-1

Prep Procedure: GROSS\_ALPHA

Prep Batch Not Validated!!!

Reviewed By: Review Date:

Non-Routine Pre-Treatment? Y / N Batch:

Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Balance: 13

Balance:

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1515002-1	SMP	200	200	200	S1	S1	Added SAH (C) 51.4 mg/mL to 8N H <sub>2</sub> O <sub>3</sub> 10 mg
2	1	1515002-2	SMP	200	200	200	S1	S1	
3	1	1515002-3	SMP	200	200	200	S1	S1	
4	1	1515002-4	SMP	200	200	200	S1	S1	
5	1	1515002-5	SMP	200	200	200	S1	S1	
6	1	1515002-6	SMP	200	200	200	S1	S1	
7	1	1515002-7	SMP	200	200	200	S1	S1	
8	1	1515002-8	SMP	200	200	200	S1	S1	
9	1	1515002-9	SMP	200	200	200	S1	S1	
10	1	1515002-10	SMP	200	200	200	S1	S1	
11	1	1515002-11	SMP	200	200	200	S1	S1	
12	1	1515002-12	SMP	200	200	200	S1	S1	
13	1	1515002-13	SMP	200	200	200	S1	S1	
14	1	1515002-14	SMP	200	200	200	S1	S1	
15	1	1515002-15	SMP	200	200	200	S1	S1	
16	1	1515002-16	SMP	200	200	200	S1	S1	
17	1	1515002-17	SMP	200	200	200	S1	S1	
18	1	1515002-18	SMP	200	200	200	S1	S1	
19	1	1515002-19	SMP	200	200	200	S1	S1	
20	1	1515002-20	SMP	200	200	200	S1	S1	
21	1	1515002-21	SMP	200	200	200	S1	S1	
22	1	1515002-22	SMP	200	200	200	S1	S1	
23	1	1515002-23	SMP	200	200	200	S1	S1	
24	1	1515002-24	SMP	200	200	200	S1	S1	

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-1

**Prep Batch Not Validated!!!**

Prep Procedure: GROSS\_ALPH

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch:

Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Balance: 13

Prep SOP: NONE

Balance:

Matrix Class: liquid

Prep Analyst: Jennie Kili-Bowden

Prep Date: 3/10/2015

Prep Dept: RS

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards
------------	----------	-------	---------	----------	-------------	------------	------------	-----------

Prep Notes

Comments

Cs-137 Drinking water calibrations

Spiked By: SKS Date: 3/10/15

Witnessed By: [Signature] Date: 3/10/15

## Spike Solution Information

Soln #	Nuclide	SolntID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1019.4095.83	3.929.816	DPM/ml	03/10/15	1	ml	RS-005

exp: 3/5/18

# Radiochemistry Gravimetric Worksheet

ALS Environmental -- FC

Prep Batch: AB150310-1

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb

Review Date: 3/10/2015

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1515002-1	SMP	10	9.1899	0.0000	0	0	0	200	9.2012	11.3	0.2	
1	2	1515002-2	SMP	10	9.1596	0.0000	0	0	0	200	9.1709	11.3	0.2	
1	3	1515002-3	SMP	10	9.0331	0.0000	0	0	0	200	9.0590	25.9	0.5	
1	4	1515002-4	SMP	10	9.0509	0.0000	0	0	0	200	9.0783	27.4	0.5	
1	5	1515002-5	SMP	10	9.0156	0.0000	0	0	0	200	9.0588	43.2	0.8	
1	6	1515002-6	SMP	10	9.0106	0.0000	0	0	0	200	9.0543	43.7	0.8	
1	7	1515002-7	SMP	10	9.0285	0.0000	0	0	0	200	9.0868	58.3	1.1	
1	8	1515002-8	SMP	10	9.0514	0.0000	0	0	0	200	9.1089	57.5	1.1	
1	9	1515002-9	SMP	10	9.0464	0.0000	0	0	0	200	9.1223	75.9	1.4	
1	10	1515002-10	SMP	10	9.0310	0.0000	0	0	0	200	9.1071	76.1	1.4	
1	11	1515002-11	SMP	10	9.0266	0.0000	0	0	0	200	9.1168	90.2	1.7	
1	12	1515002-12	SMP	10	9.0222	0.0000	0	0	0	200	9.1113	89.1	1.7	
1	13	1515002-13	SMP	10	9.0296	0.0000	0	0	0	200	9.1330	103.4	2	
1	14	1515002-14	SMP	10	9.0428	0.0000	0	0	0	200	9.1484	105.6	2	
1	15	1515002-15	SMP	10	8.9994	0.0000	0	0	0	200	9.1204	121	2.3	
1	16	1515002-16	SMP	10	9.0252	0.0000	0	0	0	200	9.1435	118.3	2.3	
1	17	1515002-17	SMP	10	9.0588	0.0000	0	0	0	200	9.1949	136.1	2.6	
1	18	1515002-18	SMP	10	9.0090	0.0000	0	0	0	200	9.1423	133.3	2.6	
1	19	1515002-19	SMP	10	9.0241	0.0000	0	0	0	200	9.1761	152	2.9	
1	20	1515002-20	SMP	10	9.0445	0.0000	0	0	0	200	9.2009	156.4	2.9	
1	21	1515002-21	SMP	10	9.0316	0.0000	0	0	0	200	9.2099	178.3	3.2	
1	22	1515002-22	SMP	10	9.0493	0.0000	0	0	0	200	9.2250	175.7	3.2	
1	23	1515002-23	SMP	10	9.0285	0.0000	0	0	0	200	9.2176	189.1	3.5	
1	24	1515002-24	SMP	10	9.0449	0.0000	0	0	0	200	9.2335	188.6	3.5	

NA

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150423-3

Prep Procedure: GROSS ALPHA BETA

Mass Attenuation (200mg → 300mg)

Analytical QASS / NCR? Y (N) NA

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Pos Chk By	Cnt 1 Inst/Det	Cnt 2 File	Cnt 2 Pos Chk By	Cnt 2 Inst/Det	Cnt 3 File	Cnt 3 Pos Chk By	Cnt 3 Inst/Det	Notes
1	1516011-1	SMP	200	200	ml	pCi/l	215.7									1515002-25
1	1516011-2	SMP	200	200	ml	pCi/l	226.6									-26
1	1516011-3	SMP	200	200	ml	pCi/l	240.2									-27
1	1516011-4	SMP	200	200	ml	pCi/l	245.8									-28
1	1516011-5	SMP	200	200	ml	pCi/l	273.5									-29
1	1516011-6	SMP	200	200	ml	pCi/l	286.7									-30
1	1516011-7	SMP	200	200	ml	pCi/l	305.7									-31
1	1516011-8	SMP	200	200	ml	pCi/l	300.4									-32
1	1516011-9	SMP	200	200	ml	pCi/l	342.9									
1	1516011-10	SMP	200	200	ml	pCi/l	337.3									

\* Over 300 mg, no need to count JP 4/24/15

Spiked Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date
S1	Cs-137	1019.4095.83	3.918.900	DPM/ml	04/23/15

## Sample Barcodes

1516011-1 AB150423-3PS1	1516011-2 AB150423-3PS2	1516011-3 AB150423-3PS3
1516011-4 AB150423-3PS4	1516011-5 AB150423-3PS5	1516011-6 AB150423-3PS6
1516011-7 AB150423-3PS7	1516011-8 AB150423-3PS8	1516011-9 AB150423-3PS9
1516011-10 AB150423-3PS10		

A Samples re-named 1515002-ZS-3Z For Calibration purposes JP 6/8/15

ALS Environmental -- FC

## Reporting Units

LabID:	TstGrpName:	RptUnits:
1516011-1	GrossAlpha_DW	pCi/l
1516011-2	GrossAlpha_DW	pCi/l
1516011-3	GrossAlpha_DW	pCi/l
1516011-4	GrossAlpha_DW	pCi/l
1516011-5	GrossAlpha_DW	pCi/l
1516011-6	GrossAlpha_DW	pCi/l
1516011-7	GrossAlpha_DW	pCi/l
1516011-8	GrossAlpha_DW	pCi/l
1516011-9	GrossAlpha_DW	pCi/l
1516011-10	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150423-3

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb *[Signature]* Review Date: 4/23/2015

Non-Routine Pre-Treatment? Y / N Batch: \_\_\_\_\_

Prep QASS / NCR? Y / N \_\_\_\_\_

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 4/23/2015

Prep Dept: RS

Balance: 13

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1516011-1	SMP		200	200	Unfiltered	S1	<i>[Handwritten: 4/23/15]</i>
2	1	1516011-2	SMP		200	200	Unfiltered	S1	
3	1	1516011-3	SMP		200	200	Unfiltered	S1	
4	1	1516011-4	SMP		200	200	Unfiltered	S1	
5	1	1516011-5	SMP		200	200	Unfiltered	S1	
6	1	1516011-6	SMP		200	200	Unfiltered	S1	
7	1	1516011-7	SMP		200	200	Unfiltered	S1	
8	1	1516011-8	SMP		200	200	Unfiltered	S1	
9	1	1516011-9	SMP		200	200	Unfiltered	S1	
10	1	1516011-10	SMP		200	200	Unfiltered	S1	

Comments

Cs-137 mass calibration planchets

Spiked By: Jennie Kill-Bowden Date: 4/23/2015

Witnessed By: Dayna K. Lewis Date: 4/23/2015

Spike Solution Information					
Soln #	Nuclide	SolnID	Prep Conc	Units	Pipet ID
S1	Cs-137	1019 4095 83	3 918 900	DPM/ml	04/23/15
				1	ml
					RS-005

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150423-3

**Prep Batch Not Validated!!!**

Prep Procedure: GROSS\_ALPHA

Review Date:

Reviewed By:

Prep QASS / NCR? Y / N

Non-Routine Pre-Treatment? Y / N Batch:

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 4/23/2015

Prep Dept: RS

Balance:

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Prep Notes
1	1	1516011-1	SMP	200	200	200	51	4.0mL salt
2	1	1516011-2	SMP	200	200	200	51	4.0
3	1	1516011-3	SMP	200	200	200	51	4.5
4	1	1516011-4	SMP	200	200	200	51	4.5
5	1	1516011-5	SMP	200	200	200	51	5.0
6	1	1516011-6	SMP	200	200	200	51	5.0
7	1	1516011-7	SMP	200	200	200	51	5.5
8	1	1516011-8	SMP	200	200	200	51	5.5
9	1	1516011-9	SMP	200	200	200	51	6.0
10	1	1516011-10	SMP	200	200	200	51	6.0

Comments

Spiked By: 3/CD Date: 4/23/15  
 Witnessed By: D Date: 4/23/15

CS-137 1019.4095.83  
 sub 1mL RS-005

ex: 3/6/16

Prepare an Intermediate dilution of Th-230 P50# 853 of approximately 1200 dpm/ml

1) Prepare 0.5M  $\text{HNO}_3$ , 31 ml  $\text{HNO}_3$  and 969 ml DI water, lot # 073602

2) Determine density of 0.5M  $\text{HNO}_3$

Mass of 100 ml vol. flask:

Mass of flask + 100 ml 0.5M  $\text{HNO}_3$ :

Net mass of 0.5M  $\text{HNO}_3$ :

Bal. 12

68.9999g

169.4539g

100.4539g

$$\rho = 1.015 \text{ g/ml}$$

3) Transfer contents of vial to 1000ml Nalgene

Mass of full standard vial:

Mass of empty standard vial:

Net mass of standard transferred:

8.2827

3.2327

5.05g

4) Dilute with 0.5M  $\text{HNO}_3$

Mass of Nalgene w/ lid (empty):

Mass of Nalgene with standard:

Mass of Nalgene, standard, and diluent:

Net mass of standard:

73.664

73.78g

78.71g

1085.2

1011.54g

ppc 1/1000

Bal. 36

5) Final activity calculation

$$(1.983 \times 10^4 \text{ g}) (5.15119 \text{ g}) = 3849.60 \text{ g} \times \left( \frac{603}{1 \text{ MIN}} \right) = 230,975.755 \text{ dpm}$$

$$(3849.60 \text{ g}) \cdot \left( \frac{5.05 \text{ g}}{1011.54 \text{ g}} \right) \cdot (1.015 \text{ g/ml}) = 1166.38 \text{ dpm/ml}$$

Std ID: 853.3020.89

Description: Th-230

Expiration: 2/5/2009

Activity: 1166.38 dpm/mL

2s Uncertainty: 23.33 dpm/mL

Ref. Date: 11/6/2007

Ref Time: N/A

Prep Date: 12/12/2007 Prep by: DC

Matrix/Comp. 0.5 M  $\text{HNO}_3$

Half Life (y): 7.70E+04

#### Reverification Log

Analysis Date	Initials	Expiration Date
5/5/09	RG	5/5/2010
11/19/10	RG	11/19/2011
12/13/14	JP	12/13/2015

Continued on Page

Signature:

12/12/07

DC

Read and Understood By

Signature:

MC

7/13/08



**Eckert & Ziegler**  
Analytics

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.analyticsinc.com

**CERTIFICATE OF CALIBRATION**  
Standard Radionuclide Source

76253-307

Th-230 5 mL Liquid in Flame Sealed Vial

Customer: Paragon Analytics / Fort Collins, CO  
P.O. No.: 72805-REL 10-30-07, Item 1

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.18, Revision 1.

Isotope:	Th-230
Activity (Bq):	1.983 E4
Half-Life:	7.838 E4 years
Calibration Date:	November 8, 2007 12:00 EST
Relative Expanded Uncertainty (k=2):	2.0%

**Comments:**

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%.  
5.15119 grams 0.5M HNO<sub>3</sub> solution.

Source Prepared By: N. E. Kiesman  
N. E. Kiesman, Radiochemist

QA Approved: D. M. Montgomery  
D. M. Montgomery, QA Manager

Date: 11-19-07

End of Certificate

Corporate Office  
24937 Avenue Tibbitts Valencia, California 91355

Laboratory  
1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

Prepare a working dilution of RSO#1019

12/3/15

1. Density of 0.1M HCl, lot # 0000094396

Mass of 100mL vol. flask:

56.4421 gBalance # 12

Mass of flask &amp; 100mL acid:

156.2152 gBalance # 12

Net Mass:

99.7731 g

Density:

0.9977 g/mL2. Mass of RSO#1019 transferred:

Mass of empty nalgene:

74.1899 gBalance # 12

Mass of nalgene &amp; standard

79.0859 gBalance # 12

Net mass of standard transferred:

4.8960 g

3. Dilute to final volume:

Mass of nalgene, standard, &amp; diluent:

629.3 gBalance # 26

Mass of empty nalgene:

74.1899 gBalance # 12

Net mass of new dilution:

555.1101 g

4. Final activity calculation:

$$3,727 \text{ Bq} \left( \frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left( \frac{4.8960 \text{ g}}{4.99800 \text{ g}} \right) \left( \frac{0.9977 \text{ g/mL}}{555.1101 \text{ g}} \right) = 3,937.10 \text{ dpm/mL}$$

Std ID: 1019.4095.83

Description: Cs-137

Expiration: 3/6/2016

Activity: 3937.10 dpm/mL

2s Uncertainty: 70.87 dpm/mL

Ref. Date: 2/9/2015

Ref Time: N/A

Prep Date: 3/5/2015 Prep by: TE

Matrix/Comp. 0.1 MHC1

Half Life (y): 3.01E+01

## Reverification Log

Analysis Date Initials Expiration Date


Continued on Page

Signed

Date

Read and Understood By

Signed

Date

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Eckert & Ziegler

Analytics

RSO#  
1019

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318  
Tel 404-352-8677  
Fax 404-352-2837  
www.ezag.com

## CERTIFICATE OF CALIBRATION

### Standard Reference Source

99575

Cs-137 5 mL Liquid in Flame Sealed Vial

**Customer:** ALS Laboratory Group

**P.O. No.:** FC000610, Item 3

**Product Code:** 8137

This standard radionuclide source was prepared gravimetrically from a master solution calibrated with an ionization chamber. The ionization chamber was calibrated by the National Physical Laboratory, Teddington, U.K., and is traceable to national standards. Radionuclide calibration and purity were checked by germanium gamma-ray spectrometry, liquid scintillation counting, and/or alpha spectrometry, as applicable. The nuclear decay rate and reference date for this source are given below. Eckert & Ziegler Analytics (EZA) maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Revision 2, July 2007, and compliance with ANSI N42.22-1995, "Traceability of Radioactive Sources to NIST."

Isotope	Half-Life, Days	Activity (Bq)	Uncertainty*, %			Reference Date (12:00 PM EST)
			Type	u <sub>A</sub>	u <sub>B</sub>	
Cs-137	1.099E+04	3.727E+04	0.1	0.9	1.8	02/09/2015

\*Uncertainty: U - Relative expanded uncertainty, k = 2. See NIST Technical Note 1297, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results."

**Comments:**

Impurities:  $\gamma$ -impurities < 0.1%.

4.99800 g 0.1M HCl solution with approximately 30  $\mu$ g/g Cs carrier.

Source Prepared by:

K. Eardley, Radiochemist

QC Approved:

A. Chen, Spectroscopist

Date: 7 Feb 15

**Internal Calculation Verifications**

**ICBs**

**&**

**ICVs**

# Gross Alpha/Beta LB4100C ICV's/ICB's Th-230/CS137

Atten. Constants		b	m	a	x0
Alpha	Alpha	0.8148	0.9902	0.8822	0
	Beta	0.9764	0.9988	0.9758	0.0

X-Talk Constants		m	b
α > β	α > β	0.9981	0.2652
	β > α	0.0004	-1.070E-07

Detector	Sample ID	Initial Aliquot	Final Sam. Size	Count Date	Count Dur.	Alpha					Beta							
						Residual Mass (mg)	Gross CPM	Bkg CPM	$\beta > \alpha$ X-Talk	Net CPM	Assn.	Efficiency	Gross CPM	Bkg CPM	$\alpha > \beta$ X-Talk	Net CPM	Atten.	Efficiency
A1	1518005-1	0.200	0.200	6/18/2015	150	53	12.080	0.124	0.017	11.939	0.514	0.2345	45.847	1.476	3.5070	40.8640	0.9176	0.4119
B1	1518005-2	0.200	0.200	6/18/2015	150	52	12.867	0.114	0.016	12.737	0.519	0.2254	43.140	1.623	3.7336	37.7834	0.9187	0.4049
C1	1518005-3	0.200	0.200	6/18/2015	150	52.5	12.080	0.102	0.017	11.961	0.516	0.2355	46.220	1.840	4.0376	40.3424	0.9181	0.4062
D2	1518005-4	0.200	0.200	6/18/2015	150	55.1	12.187	0.093	0.017	12.077	0.505	0.2281	43.987	1.646	3.5616	38.7794	0.9154	0.4179
A2	AB150616-2AMB	0.200	0.200	6/18/2015	150	51.6	0.127	0.157	0.000	0.030	0.520	0.2280	1.967	1.588	0.0000	0.3790	0.9191	0.4183
B2	AB150616-2BMB	0.200	0.200	6/18/2015	150	55.1	0.160	0.122	0.000	0.038	0.505	0.2196	1.733	1.657	0.0112	0.0648	0.9154	0.4074
C2	AB150616-2CMB	0.200	0.200	6/18/2015	150	47.5	0.147	0.112	0.001	0.034	0.539	0.2292	1.987	1.850	0.0101	0.1269	0.9235	0.4164
D3	AB150616-2DMB	0.200	0.200	6/18/2015	150	52.6	0.147	0.090	0.001	0.056	0.516	0.2334	1.807	1.600	0.0166	0.1904	0.9180	0.4244

Spike Information		Alpha				Beta			
Alpha Sid ID	Ref. Date	Act (dpm/ml)	Spike Vol (mL)	Decay Corr. Spike Act. Added	Beta Sid ID	Ref. Date	Act (dpm/ml)	Spike Vol (mL)	Decay Corr. Spike Act. Added
760.4095.67	7/13/2004	96.660	1.0	94.980	1013.4095.81	9/30/2005	129.760	1.0	103.767

Spike Information		Alpha				Beta			
Alpha Sid ID	Ref. Date	Act (dpm/ml)	Spike Vol (mL)	Decay Corr. Spike Act. Added	Beta Sid ID	Ref. Date	Act (dpm/ml)	Spike Vol (mL)	Decay Corr. Spike Act. Added
1013.4095.81	9/30/2005	129.760	1.0	103.767					

Acceptance criteria for LCS's -> 80-120%

Sample ID	Alpha					Beta				
	Act (pCi/L)	TPU (2 sig)	MDC	% Recov.	Act<MDCs	Act (pCi/L)	TPU (2 sig)	MDC	% Recov.	Act<MDCs
1518005-1	223.03	37.1	3.00	104.3%	NA	243.50	39.4	5.16	104.2%	NA
1518005-2	245.41	40.7	2.99	114.7%	NA	228.77	37.1	5.43	97.9%	NA
1518005-3	221.53	36.8	2.76	103.6%	NA	243.63	39.4	5.67	104.2%	NA
1518005-4	236.21	39.2	2.82	110.4%	NA	228.33	37.0	5.21	97.7%	NA
AB150616-2AMB	-0.57	1.21	3.20	NA	PASS	2.22	1.46	2.91	NA	PASS
AB150616-2AMB	0.77	1.41	3.06	NA	PASS	0.39	1.39	3.07	NA	PASS
AB150616-2CMB	0.62	1.21	2.85	NA	PASS	0.74	1.45	3.14	NA	PASS
AB150616-2DMB	1.05	1.24	2.48	NA	PASS	1.10	1.37	2.89	NA	PASS

Alpha CU		Alpha TPU		Beta CU		Beta TPU	
(1 sig)	(1 sig)	(1 sig)	(1 sig)	(1 sig)	(1 sig)	(1 sig)	(1 sig)
5.3092	18.5349	3.4257	19.6883	5.6503	20.3401	3.3935	18.5284
5.2631	18.4070	3.5052	19.7119	5.5821	19.6184	3.3236	16.4908
0.6013	0.6031	0.7103	0.7320	0.7004	0.7031	0.6961	0.6968
0.6040	0.6060	0.7212	0.7236	0.6137	0.6194	0.6780	0.6837

OK TR 6/19/15

# PAI - Gas Flow Proportional Sample Analysis LB4100-C

Unit Type: LB4100 -C  
Counting Unit ID: Magenta  
High Voltage Mode: Simultaneous  
Application Revision: Standard  
Rev:120108 JCP

Data file name: ABC0618C  
Batch ID: AB150616-2  
Count Preset (m): 150  
Batch Ended: 6/18/2015 12:28

2

Background logfiles: BKGABW  
Date of Bkg. Cal: 6/6/2015  
Alpha efficiency logfile: TH230-06/15  
Alpha attenuation calibration: AT140609\_0610  
Beta efficiency logfile: Ca-137-06/15  
Beta attenuation calibration: ACS0605\_0604A

Alpha prog. logfile: n/a  
Alpha prog. attenuation: n/a  
Beta prog. logfile: n/a  
Beta prog. attenuation: n/a

Alpha Attenuation Calibration $y = b \cdot m^a \cdot (e^{(mass-a)})$	Beta Attenuation Calibration $y = b \cdot m^a \cdot (e^{(mass-a)})$
Alpha $b =$ m= a= x0=	Beta $b =$ m= a= x0=
Alpha to Beta X-talk $y = b \cdot m^a \cdot mass$	Beta to Alpha X-talk $y = b \cdot m^a \cdot m$
a → b xtalk b = a → b xtalk m =	b → a xtalk b = b → a xtalk m =

Del. ID	Sample ID	Count End Date & Time	Count Dur. (min)	Resid. Mass (mg)	Alpha Activity				Beta Activity			
					Gross CPM	Bkg. CPM	b>a xtalk CPM	Base Cor.Fact.	Progeny Eff	Progeny Cor.Fact.	Base Cor.Fact.	Progeny Cor.Fact.
A1	1518005-1	6/18/2015 12:28	150.00	53.0	12.080	0.124	0.017	0.2345	0.514	n/a	0.4110	0.918
A2	AB150616-2AMB	6/18/2015 12:28	150.00	51.6	0.127	0.157	0.000	0.2260	0.520	n/a	0.4183	0.918
C1	1518005-3	6/18/2015 12:28	150.00	52.5	12.080	0.102	0.017	0.2355	0.516	n/a	0.4062	0.918
C2	AB150616-2CMB	6/18/2015 12:28	150.00	47.5	0.147	0.112	0.000	0.2281	0.539	n/a	0.4184	0.924
D2	1518005-4	6/18/2015 12:28	150.00	55.1	12.187	0.093	0.017	0.2281	0.505	n/a	0.4178	0.915
D3	AB150616-2DMB	6/18/2015 12:28	150.00	52.6	0.147	0.090	0.000	0.2334	0.516	n/a	0.4244	0.918
B1	1518005-2	6/18/2015 12:28	150.00	52.0	12.067	0.114	0.016	0.2254	0.519	n/a	0.4046	0.919
B2	AB150616-2BMB	6/18/2015 12:28	150.00	55.1	0.160	0.122	0.000	0.2186	0.503	n/a	0.4074	0.915

DP 6/19/15

Date 6/18/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13						(HB)			OLB
14						P			P
15									
16	✓	✓			✓				✓

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK0605W			
Dr B				
Dr C				
Dr D	✓			

Dr = Drawer

*Gas Supply*

	P-10 Supply		P-10 Flow
Tank 1	250	Dr A	0.1
	✓	Dr B	
Tank 2	2100	Dr C	
		Dr D	✓

Comments:

Date 6/18/15

ALS

Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

SOP 724r 11

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	1506181-1	AB150617-1	α/B	30	5:39	JP	FFC0618	JP
1-16	1506201-1	AB150617-1	α/B	60	5:46	JP	BKCO618	JP
2	1506236-1	AB150617-1	α/B	180	6:50	JP	ABCO618	JP
3	1506236-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
4	2651	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
5	266-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
6	267-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
7	AB150617-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
8	1506212-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
9	1-145	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
10	213-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
11	215-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
12	215-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
14	AB150617-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
15	AB150617-1	AB150617-1	α/B	30	6:52	JP	ABCO6184	JP
16	1506234-7	AB150611-1	α/B	120	7:25	JP	ABCO618B	JP
9	11	AB150611-1	α/B	120	7:25	JP	ABCO618B	JP
10	32	AB150611-1	α/B	120	7:25	JP	ABCO618B	JP
11	32D	AB150611-1	α/B	120	7:25	JP	ABCO618B	JP
12	1506106-1	AB150611-1	α/B	120	7:25	JP	ABCO618B	JP
14	3	AB150611-1	α/B	120	7:25	JP	ABCO618B	JP
15	6	AB150611-1	α/B	120	7:25	JP	ABCO618B	JP
16	1518005-1	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
5	2	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
9	3	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
14	4	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
15	6	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
16	1518005-1	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
2	AB150611-2	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
6	CM8	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
10	CM8	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
15	DM8	AB150611-2	α/B	150	9:56	JP	ABCO618C	JP
3	1506106-14	AB150611-1	α/B	120	12:47	JP	ABCO618D	JP
4	1506106-14	AB150611-1	α/B	120	12:47	JP	ABCO618D	JP
7	1506106-14	AB150611-1	α/B	120	12:47	JP	ABCO618D	JP
8	1506106-14	AB150611-1	α/B	120	12:47	JP	ABCO618D	JP
11	AB150611-1	AB150611-1	α/B	120	12:47	JP	ABCO618D	JP
1	1506184-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP
2	1506184-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP
3	1506184-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP
4	1506184-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP
5	1506184-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP
6	AB150614-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP
7	1506184-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP
8	1506184-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP
9	1506184-1	AB150614-1	α/B	1006	12:47	JP	ABCO618E	JP

Comments:

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(cont. from page NA B)

Form 78078 doc (6/23/06)

Reviewed By / Date

JP 6/19/15

Date 6/19/15SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13						(HB)			OLB
14						P			P
15									
16									

Det = Detector; α = Alpha; β = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKCO60SW	JP	P	BKCO619W
Dr B			P	
Dr C			9-11 → P, 12-1 HB	
Dr D			14-16 → P, 13 → HB	

Dr = Drawer

*Gas Supply*

P-10 Supply		P-10 Flow	
Tank 1	900	Dr A	0.
		Dr B	
Tank 2	2100	Dr C	
		Dr D	

Comments:Page No.: 455216 **A**

Form 780r8.doc (6/23/06)

Reviewed By / Date JMG/19/15

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150616-2

Prep Procedure: GROSS\_ALPHA

ICV's / ICB's 150M

Analytical QASS / NCR? Y

QNA

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Chk By	Notes
1	1518005-1	SMP	200	200	ml	pCi/l	53	AB00618C	1	SS							
1	1518005-2	SMP	200	200	ml	pCi/l	52		5								
1	1518005-3	SMP	200	200	ml	pCi/l	52.5		9								
1	1518005-4	SMP	200	200	ml	pCi/l	55.1		14								
1	AB150616-2a	MB	200	200	ml	pCi/l	51.6		2								
1	AB150616-2b	MB	200	200	ml	pCi/l	55.1		6								
1	AB150616-2c	MB	200	200	ml	pCi/l	47.5		10								
1	AB150616-2d	MB	200	200	ml	pCi/l	52.6		15								

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1013.4095.81	103.771	DPM/ml	06/16/15	1	ml	RS-005
S2	Th-230	760.4095.67	96.654	DPM/ml	06/16/15	1	ml	RS-005

## Sample Barcodes

1518005-1 AB150616-2PS1		1518005-2 AB150616-2PS2		1518005-3 AB150616-2PS3	
1518005-4 AB150616-2PS4		AB150616-2aMB AB150616-2PS5		AB150616-2bMB AB150616-2PS6	
AB150616-2cMB AB150616-2PS7		AB150616-2dMB AB150616-2PS8			

## Reporting Units

LabID:	TstGrpName:	RptUnits:
1518005-1	GrossAlpha_DW	pCi/l
1518005-2	GrossAlpha_DW	pCi/l
1518005-3	GrossAlpha_DW	pCi/l
1518005-4	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150616-2

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb

Review Date: 6/17/2015

Non-Routine Pre-Treatment? ☒ Batch: NA

Prep QASS / NCR? ☒ Y / ☒ N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 6/16/2015

Prep Dept: RS

Balance: 13

Balance:

Batch: NA

Re-Prep? ☒ Y / ☒ N

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1518005-1	SMP		200	200	As Received	S1, S2	
2	1	1518005-2	SMP		200	200	As Received	S1, S2	
3	1	1518005-3	SMP		200	200	As Received	S1, S2	
4	1	1518005-4	SMP		200	200	As Received	S1, S2	
5	1	AB150616-2a	MB		200	200	As Received	NA	
6	1	AB150616-2b	MB		200	200	As Received		
7	1	AB150616-2c	MB		200	200	As Received		
8	1	AB150616-2d	MB		200	200	As Received		

Comments

ICV/ICBs USGS method

Spiked By: Jennie Kill-Bowden Date: 6/17/2015

Witnessed By: Peter Workman Date: 6/17/2015

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Pipet ID
S1	Cs-137	1013.4095.81	103.771	DPM/ml	06/16/15	RS-005
S2	Th-230	760.4095.67	96.654	DPM/ml	06/16/15	RS-005

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150616-2

Prep Procedure: GROSS\_ALPHA

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

Non-Routine Pre-Treatment? Y / N Batch:

Prep QASS / NCR? Y / N

Re-Prep? Y / N Batch:

Prep SOP: PAI 702 Rev: 20

Prep Analyst: Jennie Kill-Bowden *JKB*

Balance:

Prep Date: 6/16/2015

Balance:

Prep SOP: NONE

Prep Dept: RS

Matrix Class: liquid

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Standards	Prep Notes
1	1	1518005-1	SMP		200	200		\$1,52	
2	1	1518005-2	SMP		200	200		\$1,52	
3	1	1518005-3	SMP		200	200		\$1,52	
4	1	1518005-4	SMP		200	200		\$1,52	
5	1	AB150616-2a	MB		200	200			
6	1	AB150616-2b	MB		200	200			
7	1	AB150616-2c	MB		200	200			
8	1	AB150616-2d	MB		200	200			

Comments

ICV/ICBs USGS method

Spiked By: *JKB* Date: *6/17/15*

Witnessed By: *RAW* Date: *6/17/15*

Spike Solution Information						
Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Pipet ID
S1	Cs-137	1013.4095.81	103.771	DPM/ml	06/16/15	RS-005
S2	Th-230	760.4095.67	96.654	DPM/ml	06/16/15	RS-005

*1/23/14*

*4/12/16*

# Radiochemistry Gravimetric Worksheet

ALS Environmental -- FC

Prep Batch: AB150616-2

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb 7105 Review Date: 6/17/2015

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Gross Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1518005-1	SMP	10	9.4227	0.0000	0	0	0	200	9.4757	53	1	
1	2	1518005-2	SMP	10	9.1605	0.0000	0	0	0	200	9.2125	52	1	
1	3	1518005-3	SMP	10	9.1329	0.0000	0	0	0	200	9.1854	52.5	1	
1	4	1518005-4	SMP	10	9.3753	0.0000	0	0	0	200	9.4304	55.1	1	
1	5	AB150616-2a	MB	10	9.3869	0.0000	0	0	0	200	9.4385	51.6	1	
1	6	AB150616-2b	MB	10	9.0283	0.0000	0	0	0	200	9.0834	55.1	1	
1	7	AB150616-2c	MB	10	9.4330	0.0000	0	0	0	200	9.4805	47.5	1	
1	8	AB150616-2d	MB	10	9.4183	0.0000	0	0	0	200	9.4709	52.6	1	

NA

Th-230 760.4095.67 working std

Prepare a working dilution of 760.3020.08

1. Density of 0.5M HNO<sub>3</sub> lot # 0000084176

Mass of 100mL vol. flask:

68.5632g

Balance # 12

Mass of flask &amp; 100mL acid:

169.6732g

Balance# 12

Net Mass:

101.1100g

Density:

1.011g/mL

2. Mass of 760.3020.08 transferred:

Mass of open empty nalgene:

74.1983g

Balance# 12

Mass of nalgene &amp; standard:

77.2060g

Balance# 12

Net mass of standard transferred:

3.0077g

Balance# NA

3. Dilute to final volume:

Mass of nalgene, standard, &amp; diluent:

908.9g

Balance# 26

Mass of empty nalgene (from above):

74.1983g

Balance# 12

Net mass of new dilution:

834.7017g

Balance# NA

4. Final activity calculation:

$$26,534.43 \text{ dpm/g} (1.011 \text{ g/mL}) \frac{(3.0077 \text{ g})}{(834.7017 \text{ g})} = 96.66 \text{ dpm/mL}$$

Std ID: 760.4095.67

Description: Th-230

Expiration: 4/12/2016

Activity: 96.66 dpm/mL

2s Uncertainty: 3.19 dpm/mL

Ref. Date: 7/13/2004

Ref Time: N/A

Prep Date: 12/8/2014 Prep by: TE

Matrix/Comp. 0.5 M HNO<sub>3</sub>

Half Life (y): 7.54E+04

## Reverification Log

Analysis Date Initials Expiration Date


JP 4/15/15

Continued on Page

Signed

Date

Read and Understood By

Signed

Date

PROJECT

760-3020.08

Th-230

Notebook No.

Continued From Page

Prepare a primary solution of R50 #760 (Analytical # 65750-307) in 0.5 M HNO<sub>3</sub> to a concentration of approx 30,000 dpm/ml.

1) Prepare 0.5 M HNO<sub>3</sub> by diluting 5 ml of conc. (16M) HNO<sub>3</sub> (END lot # 44257) to a final volume of 1000 ml.

2) Determine density of 0.5 M HNO<sub>3</sub>

Mass of 100ml volumetric flask =	66.4289 g (Bal 12)
Mass of flask + 0.5 M HNO <sub>3</sub> =	167.5792 g
Net mass of solution =	101.503949 g
÷ 100 ml = density =	1.0115 g/ml

3) Transfer # 760 to a 40 ml VOA vial.

Mass of bottle without lid =	21.5801 g (Bal 12)
Mass of 346 + bottle	26.5278 g
Net mass of 346 transferred	4.9477 g

4) Dilute to volume w/ 0.5 M HNO<sub>3</sub>

Mass of bottle + 346 + soln =	61.8912 g (Bal 12)
Mass of bottle (from above)	21.5801 g
Net mass of 346	40.3111 g

5) Final activity calc.

$$\frac{(1.830 \times 10^4 \text{ dpm/sec}) (4.9477 \text{ g}) (1.0115 \text{ g/ml})}{(5.08447) (40.3111 \text{ g})} = 26,534.43 \text{ dpm/g}$$

Continued on Page

Read and Understood By

Alastair Baird

Signed

1/24/06

Date

[Signature]

Signed

1/27/06

Date



ANALYTICS

RSO# 760 Rec'd 7/14/04 B

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318 - U.S.A.

Phone (404) 352-8577  
Fax (404) 352-2337

## CERTIFICATE OF CALIBRATION

Standard Radionuclide Source.

68750-307

Th-230 5 mL Liquid in Flame Sealed Vial

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

ISOTOPE:	Th-230
ACTIVITY (dps):	1.832 E4
HALF-LIFE:	7.538 E4 years
CALIBRATION DATE:	July 13, 2004 12:00 EST
RELATIVE EXPANDED UNCERTAINTY (k=2):	3.3%

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%

5.08447 grams 0.5M HNO<sub>3</sub> solution.

P O NUMBER 70635, Item 1.

SOURCE PREPARED BY:

M. D. Currie  
M. D. Currie, Radiochemist

Q A APPROVED:

Rec'd 7/13/04

Prepare a working dilution of 1013.4095.76

1. Density of 4% HCl, lot # 0000094396  
Mass of 100mL vol. flask: 56.4410 g Balance # 12  
Mass of flask & 100mL acid: 156.9528 g Balance# 12  
Net Mass: 100.5118 g  
Density: 1.0051 g/mL

2. Mass of 1013.4095.76 transferred:  
Mass of open empty nalgene: 74.7387 g Balance# 12  
Mass of nalgene & standard: 75.7309 g Balance# 12  
Net mass of standard transferred: 0.9922 g

3. Dilute to final volume:  
Mass of nalgene, standard, & diluent: 846.26 g Balance# 26  
Mass of empty nalgene (from above): 74.7387 g Balance# 12  
Net mass of new dilution: 771.8613 g

4. Final activity calculation:

$$100,443.61 \text{ dpm/g} \left( \frac{1.0051 \text{ g/mL}}{771.8613 \text{ g}} \right) (0.9922 \text{ g}) = 129.78 \text{ dpm/mL}$$

Std ID: 1013.4095.81

Description: Cs-137  
Expiration: 1/23/2016  
Activity: 129.78 dpm/mL

2s Uncertainty: 0.91 dpm/mL

Ref. Date: 9/30/2005

Ref Time: N/A

Prep Date: 1/22/2015 Prep by: TE

Matrix/Comp. 4% HCl

Half Life (y): 3.01E+01

Reverification Log		
Analysis Date	Initials	Expiration Date

Continued on Page \_\_\_\_\_

7 Elliot

Signature

1/22/15

Date

JP 2/9/15

Signed

02/09/15

Date

Project CS-13.7 intermediate standard 1013.4015.76  
 Continued from Page 1

7/11/15

Prepare an intermediate dilution of KSC #1013

1. Density of 4% HCl, lot # 0000094396

Mass of 100mL vol. flask: 27.5652g

Balance # 12

Mass of flask & 100mL acid: 119.0154g

Balance # 12

Net Mass: 100.4502g

Density: 1.0045 g/mL

2. Mass of RSC #1013 transferred:

Mass of open empty bottle: 398.34g

Balance # 26

Mass of bottle and standard: 403.33g

Balance # 26

Net mass of standard transferred: 4.99g

3. Dilute to final volume:

Mass of open empty bottle: 398.34g

Balance # 26

Mass of bottle, standard, & diluent: 1228.4g

Balance # 26

Net mass of new dilution: 890.06g

4. Final activity calculation:

$$298.6 \text{ kBq/g} \left( \frac{1000 \text{ Bq}}{1 \text{ kBq}} \right) \left( \frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left( \frac{4.99 \text{ g}}{890.06 \text{ g}} \right) = 100,443.61 \text{ dpm/g}$$

7/11/15

Continued on P.

1/16/15

1/16/15

Lead by (activity)

[Signature]

1-16-15



750<sup>th</sup>  
1013

# National Institute of Standards & Technology Certificate

## Standard Reference Material 4233E Cesium-137 Radioactivity Standard

This Standard Reference Material (SRM) consists of radioactive cesium-137 chloride, non-radioactive cesium chloride, and hydrochloric acid dissolved in 5 mL of distilled water. The solution is contained in a flame-sealed NIST borosilicate-glass ampoule. The SRM is intended for the calibration of ionization chambers and solid-state gamma-ray spectrometry systems.

**Radiological Hazard:** The SRM ampoule contains cesium-137 with a total activity of approximately 1.5MBq. Cesium-137 decays by beta-particle emission to barium-137m, which decays by internal conversion. During the decay process X-rays and gamma rays with energies from approximately 3 keV to 662 keV are emitted. Most of these photons escape from the SRM ampoule and can represent a radiation hazard. Approximate unshielded dose rates at several distances (as of the reference time) are given in note [a]\*. Appropriate shielding and/or distance should be used to minimize personnel exposure. The SRM should be used only by persons qualified to handle radioactive material.

**Chemical Hazard:** The SRM ampoule contains hydrochloric acid with a concentration of 1 mole per liter of water. The solution is corrosive and represents a health hazard if it comes in contact with eyes or skin. If the ampoule is to be opened to transfer the solution, the recommended procedure is given on page 2. The ampoule should be opened only by persons qualified to handle both radioactive material and strong acid solution.

**Storage and Handling:** The SRM should be stored and used at a temperature between 5 and 65 °C. The solution in an unopened ampoule should remain stable and homogeneous until at least September 2015. The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material. If the ampoule is transported, it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The solution in the ampoule is a dangerous good (hazardous material) because of both the radioactivity and the strong acid.

**Preparation:** This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, M.P. Unterwieser, Acting Group Leader. The overall technical direction and physical measurements leading to certification were provided by L.L. Lucas, R. Collé and L. Laureano-Pérez of the Radioactivity Group. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program.

Lisa R. Karam, Deputy Chief  
Ionizing Radiation Division

Gaithersburg, Maryland 20899  
October 2005

Robert L. Watters, Jr., Chief  
Measurement Services Division

### **Recommended Procedure for Opening the SRM Ampoule**

- 1) If the SRM solution is to be diluted, it is recommended that the diluting solution have a composition comparable to that of the SRM solution.
- 2) Wear eye protection, gloves, and protective clothing and work over a tray with absorbent paper in it. Work in a fume hood. In addition to the radioactive material, the solution contains strong acid and is corrosive.
- 3) Shake the ampoule to wet all of the inside surface of the ampoule. Return the ampoule to the upright position.
- 4) Check that all of the liquid has drained out of the neck of the ampoule. If necessary, gently tap the neck to speed the process.
- 5) Holding the ampoule upright, score the narrowest part of the neck with a scribe or diamond pencil.
- 6) Lightly wet the scored line. This reduces the crack propagation velocity and makes for a cleaner break.
- 7) Hold the ampoule upright with a paper towel, a wiper, or a support jig. Position the scored line away from you. Using a paper towel or wiper to avoid contamination, snap off the top of the ampoule by pressing the narrowest part of the neck away from you while pulling the tip of the ampoule towards you.
- 8) Transfer the solution from the ampoule using a pycnometer or a pipet with dispenser handle. **NEVER PIPETTE BY MOUTH.**
- 9) Seal any unused SRM solution in a flame-sealed glass ampoule, if possible, to minimize the evaporation loss.

See also reference [4]\*.

# PROPERTIES OF SRM 4233E

## Certified values

Radionuclide	Cesium-137
Reference time	1200 EST, 30 September 2005
Massic activity of the solution [c]*	298.6 kBq·g <sup>-1</sup>
Relative expanded uncertainty (k=2)	0.70% [d] [e]
Solution mass	(5.0668 ± 0.0009) g [b]
Solution density	(1.015 ± 0.002) g·mL <sup>-1</sup> at 20 °C [b]

## Uncertified values

Physical Properties:			
Source description	Liquid in flame-sealed NIST borosilicate-glass ampoule		
Ampoule specifications	Body outside diameter	(16.5 ± 0.5) mm	
	Wall thickness	(0.60 ± 0.04) mm	
	Barium content	Less than 2.5%	
	Lead-oxide content	Less than 0.02%	
	Other heavy elements	Trace quantities	
Chemical Properties:			
Solution composition	Chemical Formula	Concentration (mol·L <sup>-1</sup> )	Mass Fraction (g·g <sup>-1</sup> )
	H <sub>2</sub> O	54	0.96
	HCl	1.0	0.04
	CsCl	1.6 × 10 <sup>-4</sup>	2.7 × 10 <sup>-5</sup>
	<sup>137</sup> CsCl	6.9 × 10 <sup>-7</sup>	1.2 × 10 <sup>-7</sup>
Radiological Properties:			
Photon-emitting impurities	None detected [f]		
Half lives used	Cesium-137: (10983 ± 11) d [g] [5] Radium-226: (1600 ± 7) a [g] [5]		
Calibration method and measuring instrument(s)	Pressurized "4π"γ ionization chamber A calibrated using an cesium-137 solution whose activity was determined by the 4π(e+X)-γ-coincidence efficiency-extrapolation technique.		

**EVALUATION OF THE UNCERTAINTY OF THE MASSIC ACTIVITY [d]\***

Input Quantity $x_i$ , the source of uncertainty  (and individual uncertainty components where appropriate)	Method Used To Evaluate $u(x_i)$ , the standard uncertainty of $x_i$ (A) denotes evaluation by statistical methods (B) denotes evaluation by other methods	Relative Uncertainty Of Input Quantity, $u(x_i)/x_i$ , (%) [h]	Relative Sensitivity Factor, $ \partial y/\partial x_i  \cdot$ $(x_i/y)$ [i]	Relative Uncertainty Of Output Quantity, $u(y)/y$ , (%) [j]
PIC A net response per gram of SRM 4233E, measured relative to RRS20 [k]	Standard deviation of the mean (within-measurement precision ) for 20 to 100 repeated measurements (A)	0.02	1.0	0.02
	Standard deviation (between- measurement precision) for 4 sets of measurement (A)	0.13	1.0	0.13
PIC A net response per Bq of cesium-137 in solution, measured relative to RRS20.	Standard deviation of the mean (for both between- and within- measurement precision) for >100 repeated measurements (A)	0.01	1.0	0.01
Activity used to calibrate PIC A net response per Bq of cesium-137 in solution	Standard uncertainty of the activity determined by the $4\pi(e+X)$ - $\gamma$ -coincidence efficiency-extrapolation technique. (B)	0.31	1.0	0.31
Half life of cesium-137 Half life of radium-226	Standard uncertainty of the half life (A)	0.10 [m] 0.44 [m]	0.0001 [n] 0.010 [n]	0.00001 0.004
Gravimetric measurements	Estimated (B)	0.03	1.0	0.03
PIC A charge collection	Estimated (B)	0.05	1.0	0.05
Charge collection measurement time [p]	Estimated (B)	0.05	1.0	0.05
Long-term RRS positioning	Estimated (B)	0.05	1.0	0.05
Photon-emitting impurities	Limit of detection (B) [q]	100.	0.0001	0.01
Relative Combined Standard Uncertainty of the Output Quantity, $u_c(y)/y$ , (%)				0.35
Coverage Factor, $k$				<u>x 2</u>
Relative Expanded Uncertainty of the Output Quantity, $U/y$ , (%)				0.70

## NOTES

- [a] The Sievert is the SI unit for dose equivalent. See reference [1]. One  $\mu\text{Sv}$  is equal to 0.1 mrem.  
 Distance from Ampoule (cm):           1       30       100  
 Approximate Dose Rate ( $\mu\text{Sv/h}$ ):   300       4       0.3
- [b] The stated uncertainty is two times the standard uncertainty.
- [c] **Massic activity** is the preferred name for the quantity activity divided by the total mass of the sample. See reference [1].
- [d] The reported value,  $y$ , of massic activity (activity per unit mass) at the reference time was not measured directly but was derived from measurements and calculations of other quantities. This can be expressed as  $y = f(x_1, x_2, x_3, \dots, x_n)$ , where  $f$  is a mathematical function derived from the assumed model of the measurement process. The value,  $x_i$ , used for each input quantity  $i$  has a **standard uncertainty**,  $u(x_i)$ , that generates a corresponding uncertainty in  $y$ ,  $u_i(y) \equiv |\partial y / \partial x_i| \cdot u(x_i)$ , called a **component of combined standard uncertainty** of  $y$ . The **combined standard uncertainty** of  $y$ ,  $u_c(y)$ , is the positive square root of the sum of the squares of the components of combined standard uncertainty. The combined standard uncertainty is multiplied by a **coverage factor** of  $k = 2$  to obtain  $U$ , the **expanded uncertainty** of  $y$ .
- Since it can be assumed that the possible estimated values of the massic activity are approximately normally distributed with approximate standard deviation  $u_c(y)$ , the unknown value of the massic activity is believed to lie in the interval  $y \pm U$  with a level of confidence of approximately 95 percent.
- For further information on the expression of uncertainties, see references [2] and [3].
- [e] The value of each component of combined standard uncertainty, and hence the value of the expanded uncertainty itself, is a best estimate based upon all available information, but is only approximately known. That is to say, the "uncertainty of the uncertainty" is large and not well known. This is true for uncertainties evaluated by statistical methods (e.g., the relative standard deviation of the standard deviation of the mean for the massic response is approximately 50%) and for uncertainties evaluated by other methods (which could easily be over estimated or under estimated by substantial amounts). The unknown value of the expanded uncertainty is believed to lie in the interval  $U/2$  to  $2U$  (i.e., within a factor of 2 of the estimated value).
- [f] Estimated limits of detection for photon-emitting impurities, as of 3 October 2005 (3 days after the reference time), expressed as massic photon emission rates, are:  
 $< 40 \gamma \cdot \text{s}^{-1} \cdot \text{g}^{-1}$  for energies between 40 keV and 1350 keV, and  
 $< 4 \gamma \cdot \text{s}^{-1} \cdot \text{g}^{-1}$  for energies between 1350 keV and 3600 keV,
- [g] The stated uncertainty is the standard uncertainty.
- [h] Relative standard uncertainty of the input quantity  $x_i$ .
- [i] The relative change in the output quantity  $y$  divided by the relative change in the input quantity  $x_i$ . If  $|\partial y / \partial x_i| \cdot (x_i / y) = 1.0$ , then a 1% change in  $x_i$  results in a 1% change in  $y$ . If  $|\partial y / \partial x_i| \cdot (x_i / y) = 0.05$ , then a 1% change in  $x_i$  results in a 0.05% change in  $y$ .

- [j] Relative component of combined standard uncertainty of output quantity  $y$ , rounded to two significant figures or less. The relative component of combined standard uncertainty of  $y$  is given by  $u(y)/y = |\partial y/\partial x_i| \cdot u(x_i)/y = |\partial y/\partial x_i| \cdot (x_i/y) \cdot u(x_i)/x_i$ . The numerical values of  $u(x_i)/x_i$ ,  $|\partial y/\partial x_i| \cdot (x_i/y)$ , and  $u(y)/y$ , all dimensionless quantities, are listed in columns 3, 4, and 5, respectively. Thus, the value in column 5 is equal to the value in column 4 multiplied by the value in column 3. The input quantities are independent, or very nearly so. Hence the covariances are zero or negligible.
- [k] The response of pressurized ionization chamber A (PIC A) is determined from measurement of the time required to collect a given amount of charge on a stable fixed capacitor. All of the response measurements in the NIST pressurized ionization chambers are made relative to the response of one or more artifact standards. These artifact standards consist of microgram quantities of aged radium-226 in small welded stainless-steel capsules. These capsules are encapsulated in plastic rods whose dimensions are similar to those of the standard NIST ampoule. The artifact standards are called **Radium Reference Sources** and are designated as RRSx, where x is the nominal mass (in micrograms) of radium-226 in the capsule.
- [m] The relative standard uncertainty of  $\lambda \cdot t$  is determined by the relative standard uncertainty of  $\lambda$  (i.e., of the half life). The relative standard uncertainty of  $t$  is negligible.
- [n]  $|\partial y/\partial x_i| \cdot (x_i/y) = |\lambda \cdot t|$
- [p] The charge collection measurement time is determined by counting the pulses from a gated crystal-controlled oscillator.
- [q] The standard uncertainty for each undetected impurity that might reasonably be expected to be present is estimated to be equal to the estimated limit of detection for that impurity, i.e.  $u(x_i)/x_i = 100\%$ .  $|\partial y/\partial x_i| \cdot (x_i/y) = \{(\text{response per Bq of impurity})/(\text{response per Bq of cesium-137})\} \cdot \{(\text{Bq of impurity})/(\text{Bq of cesium-137})\}$ . Thus  $u(y)/y$  is the relative change in  $y$  if the impurity were present with a massic activity equal to the estimated limit of detection.

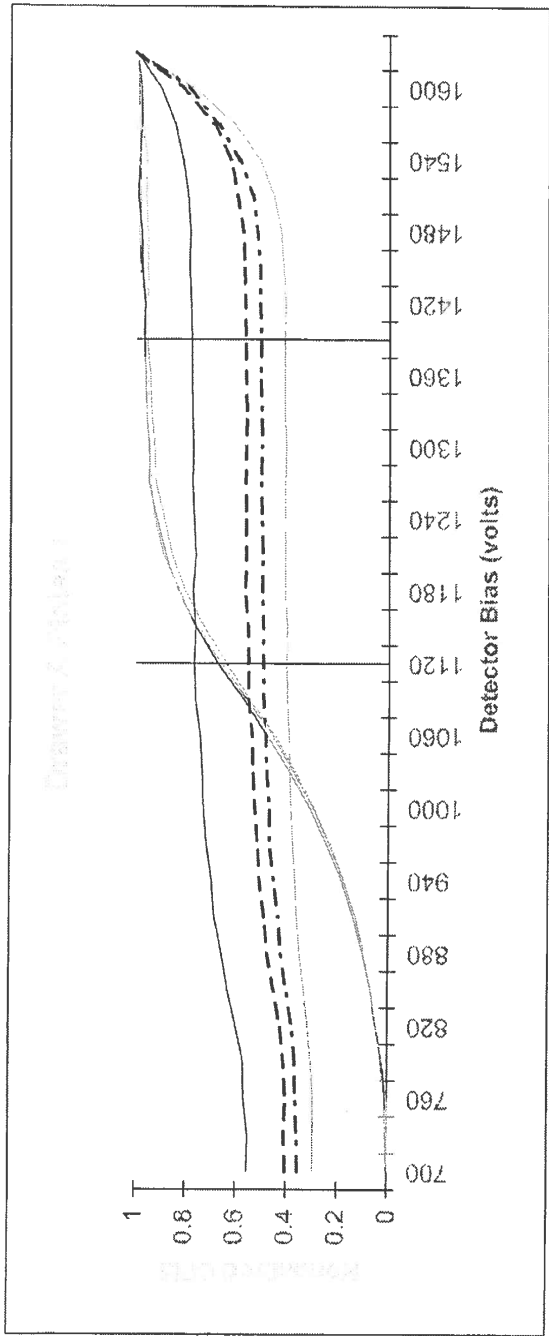
## REFERENCES

- [1] International Organization for Standardization (ISO), *ISO Standards Handbook - Quantities and Units*, 1993. Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
- [2] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993 (corrected and reprinted, 1995). Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
- [3] B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407, U.S.A.
- [4] National Council on Radiation Protection and Measurements Report No. 58, *A Handbook of Radioactivity Measurements Procedures*, Second Edition, 1985. Available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Bethesda, MD 20814 U.S.A.
- [5] Evaluated Nuclear Structure Data File (ENSDF), September 2005.

# **Addendum**

Unit Type: LB4100/W  
Date Performed: 6/2/16 09:00  
FileName: PTA0602  
Batch ID: DRAWER A PLAT CHECK

Unit Id: Magenta  
Application Revision: 2  
Application Version: Standard



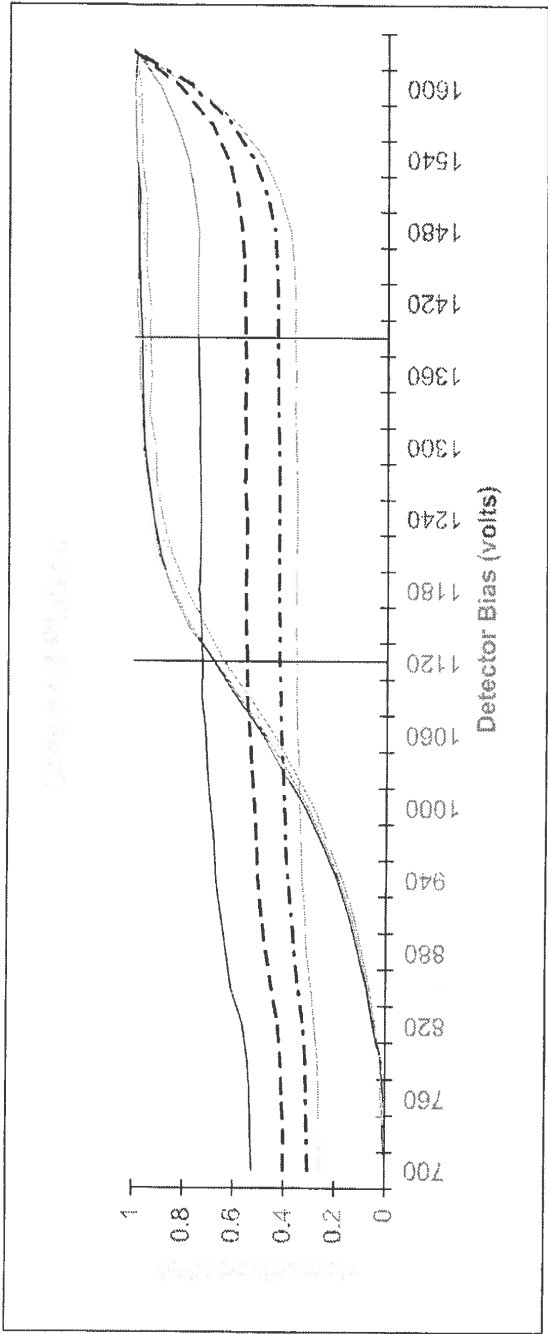
Optimum alpha beta simultaneous operating voltage: 1402.5

Optimum alpha only operating voltage: 1120

	A1	A2	A3	A4
Beta slope at beta voltage	1.18%	1.57%	1.58%	2.52%
Alpha slope at beta voltage	0.99%	1.20%	0.76%	0.72%
Alpha slope at alpha voltage	2.63%	3.48%	2.64%	2.19%

Unit Type: LB4100/NW  
Date Performed: 6/2/16 09:00  
File Name: PTB0602  
Batch ID: DRAWER B PLAT CHECK

Unit Id: Magenta  
Application Revision: 2  
Application Version: Standard



Optimum alpha beta simultaneous operating voltage: 1402.5

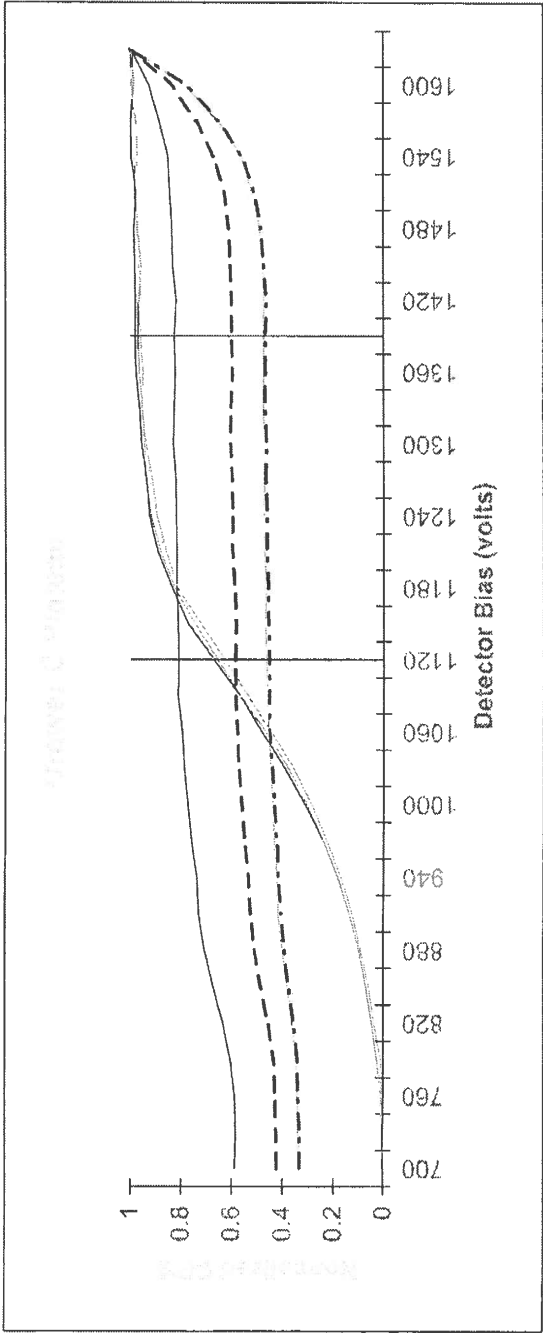
Optimum alpha only operating voltage: 1120

	B1	B2	B3	B4
Beta slope at beta voltage	1.44%	1.61%	1.23%	1.72%
Alpha slope at beta voltage	0.76%	0.74%	0.97%	1.24%
Alpha slope at alpha voltage	2.82%	2.66%	2.19%	2.27%

OK 6/3/16

Unit Type: LB4100/W  
Date Performed: 6/2/16 14:38  
File Name: PTC0602  
Batch ID: DRAWER C PLAT CHECK

Unit Id: Magenta  
Application Revision: 2  
Application Version: Standard



Optimum alpha beta simultaneous operating voltage: 1402.5

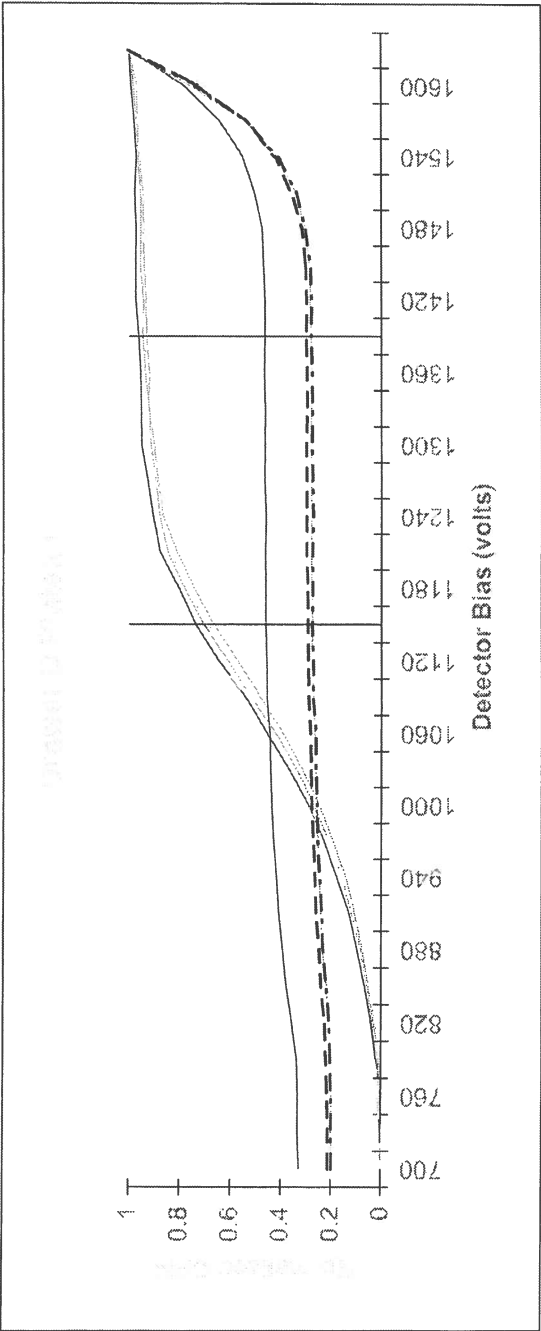
Optimum alpha only operating voltage: 1120

	C1	C2	C3	C4
Beta slope at beta voltage	1.41%	0.80%	1.18%	1.89%
Alpha slope at beta voltage	0.30%	0.41%	0.45%	0.26%
Alpha slope at alpha voltage	1.84%	1.03%	2.10%	1.37%

OK JTW/3/13

Unit Type: LB4100/W  
Date Performed: 6/2/16 14:38  
File Name: PTD0602  
Batch ID: DRAWER D PLAT CHECK

Unit Id: Magenta  
Application Revision: 2  
Application Version: Standard



Optimum alpha beta simultaneous operating voltage: 1402.5

Optimum alpha only operating voltage: 1150

	D1	D2	D3	D4
Beta slope at beta voltage	2.11%	2.90%	1.74%	0.82%
Alpha slope at beta voltage	0.97%	1.51%	2.02%	2.23%
Alpha slope at alpha voltage	1.28%	1.73%	2.15%	0.89%

OK JP 6/13/16

4/11/16 Drawn C+D removed from Instrument and sent back to Canberra in order to fix guard detector / detector slide tray connection so the 3 guard pins holding the two detectors together stop moving around and popping out when the drawers are opened & closed, resulting in  $\uparrow \uparrow$  beta cpm,  $\downarrow$  gamma cpm

5-24-16 Power outage. Instrument was turned off. Turned back on when power was restored. Daily checks were performed. All in control. Instrument on-line, resumed to normal.

6-2-16

Platform check run for drawers A-D on 6-2-16.

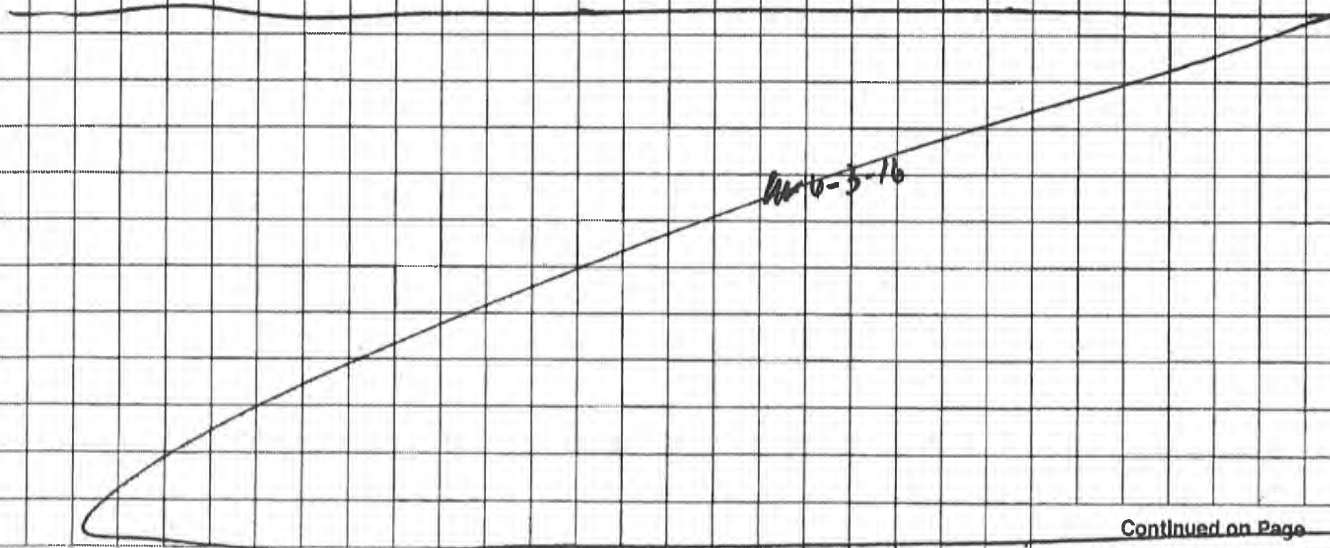
2 Sources used	Detectors	3 Sources used
410 Am241	A1 B1 C1 D1	406 Sr90/Y90
411 17800dpm	A2 B2 C2 D2	407 29600dpm
412 2-16-95	A3 B3 C3 D3	408 9-15-95
413	A4 B4 C4 D4	409

Parameters:

Starting voltage 700      Count preset 40,000  
Ending voltage 1650      Time between steps 0.1  
30V/step      Weak check times 0.1  
5min/step      Weak check limits 20

File names:

PTA0602  
PTB0602  
PTC0602  
PTD0602



Continued on Page

*[Signature]*

Signed

6-3-16

Date

Read and Understood By

*[Signature]*

Signed

6/3/16

Date

Date 6/2/16SOP 724r 11

**ALS**  
**Low Background Gas Flow Proportional Counter Log**  
**Instrument: LB4100C**

*Instrument Daily Response and Background Checks*

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									OLB
10									P
11									
12									
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed*Weekly Background Calibration*

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BKCO531W			
Dr B				
Dr C	BKCO601W			
Dr D				

Dr = Drawer

*Gas Supply*

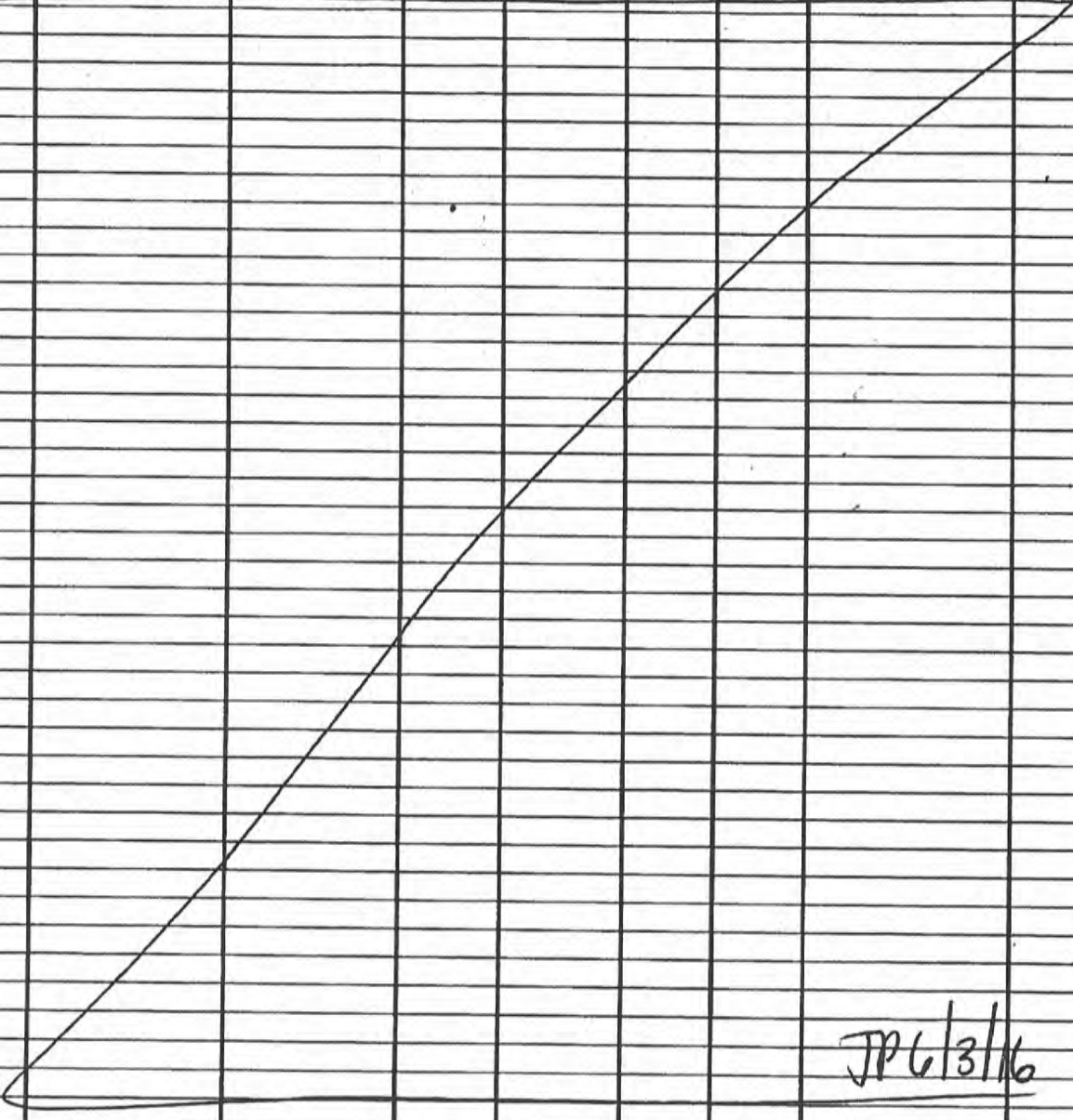
P-10 Supply		P-10 Flow	
Tank 1	1950	Dr A	10.0
		Dr B	
Tank 2	350	Dr C	
		Dr D	

Comments:

Date 6/2/16SOP 724r 11

ALS

Low Background Gas Flow Proportional Counter Log  
Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Dark EQ	—	—	30	7:33	JP	EFC0602	JP
1-16	Dark Bkg	—	—	60	7:42	JP	BK0602	JP
1-4	Alpha/Beta	Drawer A Plat Check	Platow	5 Min/STEP	9:00	JP	PTA0602	JP
5-8	Beta/Alpha	Drawer B Plat Check					PTB0602	
9-12	Alpha/Beta	Drawer C Plat Check			14:38	JP	PTC0602	
13-16	Beta/Alpha	Drawer D Plat Check					PTD0602	
								
						JP 6/3/16		

Comments:

Page No.: 465424 **B**

Form 780r8.doc (6/23/06)

Reviewed By / Date JP 6/3/16(cont. from page ms **B**)

**Gross Alpha/Beta LB4100C ICV's/ICB's Th-230/CS137**

Atten. Constants		b	m	a	x0
Alpha Beta	Alpha	0.8148	0.9902	0.8822	0
	Beta	0.9764	0.9988	0.9758	0.0

X-Talk Constants		m	b
$\alpha > \beta$ $\beta > \alpha$	$\alpha > \beta$	0.9981	0.2652
	$\beta > \alpha$	0.0004	-1.070E-07

Detector	Sample ID	Initial Aliquot	Final Sam. Size	Count Date	Count Dur.	Alpha				Beta				Efficiency			
						Residual Mass (mg)	Gross CPM	Bkg CPM	$\beta > \alpha$ X-Talk	Net CPM	Atten.	Efficiency	Gross CPM		Bkg CPM	$\alpha > \beta$ X-Talk	Net CPM
A1	1518005-1	0.200	0.200	6/9/2016	150	53	12.680	0.096	0.017	12.567	0.514	43.920	1.747	3.6912	38.4818	0.9176	0.4119
B2	1518005-2	0.200	0.200	6/9/2016	150	52	11.740	0.113	0.016	11.611	0.519	41.460	1.632	3.4040	36.4240	0.9187	0.4074
C1	1518005-3	0.200	0.200	6/9/2016	150	52.5	12.440	0.111	0.017	12.312	0.516	43.960	1.585	3.6130	38.7620	0.9181	0.4062
D1	1518005-4	0.200	0.200	6/9/2016	150	55.1	10.887	0.096	0.015	10.776	0.505	40.113	1.606	3.1778	35.3292	0.9154	0.4068
A4	AB150616-2AMB	0.200	0.200	6/9/2016	150	51.6	0.147	0.111	0.000	0.036	0.520	1.553	1.471	0.0104	0.0716	0.9191	0.4088
B3	AB150616-2BMB	0.200	0.200	6/9/2016	150	55.1	0.067	0.104	0.000	-0.037	0.505	1.773	2.176	0.0000	-0.4030	0.9154	0.3997
C2	AB150616-2CMB	0.200	0.200	6/9/2016	150	47.5	0.220	0.116	0.000	0.104	0.539	1.713	1.610	0.0302	0.0728	0.9235	0.4164
D4	AB150616-2DMB	0.200	0.200	6/9/2016	150	52.6	0.073	0.117	0.000	-0.044	0.516	1.680	1.624	0.0000	0.0560	0.9180	0.4064

Spike Information					
Alpha Sid ID	Ref. Date	Act (dpm/ml)	Spike Vol (mL)	Decay Corr. Spike Act. Added	
760.4095.67	7/13/2004	96.660	1.0	94.831	

Spike Information					
Beta Sid ID	Ref. Date	Act (dpm/ml)	Spike Vol (mL)	Decay Corr. Spike Act. Added	
1013.4095.81	9/30/2005	129.780	1.0	101.457	

Acceptance criteria for LCS's --> 80-120%

Sample ID	Alpha					Beta				
	Act (pCi/L)	TPU (2 sig)	MDC	% Recov.	Act-MDCa	Act (pCi/L)	TPU (2 sig)	MDC	% Recov.	Act-MDCa
1518005-1	234.77	38.9	2.72	109.9%	NA	229.31	37.1	5.38	100.4%	NA
1518005-2	229.62	38.2	3.05	107.5%	NA	219.19	35.5	5.24	95.9%	NA
1518005-3	228.03	37.9	2.85	106.8%	NA	234.08	37.9	5.34	102.4%	NA
1518005-4	208.75	34.8	2.80	97.7%	NA	213.64	34.6	5.13	93.5%	NA
AB150616-2AMB	0.66	1.21	2.64	NA	PASS	0.43	1.31	2.88	NA	PASS
AB150616-2BMB	-0.73	0.93	2.76	NA	PASS	-2.48	1.51	3.56	NA	PASS
AB150616-2CMB	1.90	1.48	2.69	NA	PASS	0.43	1.35	2.95	NA	PASS
AB150616-2DMB	-0.82	0.93	2.77	NA	PASS	0.34	1.37	3.03	NA	PASS

Alpha CU (1 sig)	Alpha TPU (1 sig)	Beta CU (1 sig)	Beta TPU (1 sig)
5.4382	19.4673	3.3664	18.5655
5.5404	19.1036	3.3000	17.7611
5.3410	18.9255	3.4094	18.9471
5.2260	17.4234	3.2576	17.3189
0.6032	0.6054	0.6537	0.6546
0.4614	0.4650	0.7283	0.7546
0.7249	0.7404	0.6737	0.6745
0.4601	0.4648	0.6836	0.6841

OK J8 6/13/16

Alpha Attenuation Calibration	Beta Attenuation Calibration
$y = b \cdot \ln(e^{(m \cdot \ln(x))})$ Alpha $b = 0.81480$ $m = 0.39020$ $a = 0.8822$ $x0 = 0.0000$	$y = b \cdot \ln(e^{(m \cdot \ln(x))})$ Beta $b = 0.9764$ $m = 0.3986$ $a = 0.9758$ $x0 = 0.0000$
Alpha to Beta X-talk $y = b \cdot \ln(m \cdot \ln(x))$ $a > b$ xtalk $b = 0.2852$ $a > b$ xtalk $m = 0.9981$	Beta to Alpha X-talk $y = b \cdot \ln(m \cdot \ln(x))$ $b > a$ xtalk $b = -1.07E-07$ $b > a$ xtalk $m = 0.0004$

Background logfile: BKGABW  
Date of Bkg. Cal: 6/1/2016  
Alpha efficiency logfile: Th230-06/1  
Alpha attenuation calibration: ATH0609,  
Beta efficiency logfile: Cs-137-06/1  
Beta attenuation calibration: ACS0608,0

Beta Activity	Base	Base
	Eff	Cor.Fact
	0.4119	0.918
	0.4088	0.919
	0.4062	0.918
	0.4164	0.924
	0.4074	0.919
	0.3997	0.915
	0.4069	0.915
	0.4064	0.918

Me 6-10-16

Date 6/9/16SOP 724r 11

## ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

## Instrument Daily Response and Background Checks

Det.	Daily Response Check				Background Check				Det. Status
	Start 1	Status	Start 2	Status	Start 1	Status	Start 2	Status	
1	JP	P			JP	P			P
2									
3									
4									
5									
6									
7									
8									
9									
10									
11		(LB)	JP	P					
12		P							
13									
14									
15									
16									

Det = Detector;  $\alpha$  = Alpha;  $\beta$  = Beta; P = Pass; H = High; L = Low; OL = Offline; R = Recount; W = Weekly; NP = Not Processed

## Weekly Background Calibration

	Current Calib. File ID	Weekly Calib. Started	Status	File ID
Dr A	BK0531W			
Dr B				
Dr C	BK0601W/0603W			
Dr D				

Dr = Drawer

## Gas Supply

P-10 Supply		P-10 Flow	
Tank 1	1550	Dr A	10
		Dr B	
Tank 2	300	Dr C	
		Dr D	

Comments:

Date 6/9/16SOP 724r 11

ALS

## Low Background Gas Flow Proportional Counter Log

Instrument: LB4100C

Det.	Sample ID	Batch	Test	Count Dur. (min)	Start Time	Analyst Initials	File ID	Output Initials
1-16	Dark EP	—	—	30	6:57	JP	EFC0609	JP
11	Dark EP	—	—	30	7:08	JP	EFC0609R	JP
1-16	Dark BKG	—	—	60	7:19	JP	BK0609	JP
1	1605213-1	RA160602-10	Ra228	90	9:11	JP	RAC0609	JP
2	↓ -2	↓	↓	↓	↓	↓	↓	↓
3	↓ -3	↓	↓	↓	↓	↓	↓	↓
4	↓ -4	↓	↓	↓	↓	↓	↓	↓
5	↓ -5	↓	↓	↓	↓	↓	↓	↓
6	↓ -6	↓	↓	↓	↓	↓	↓	↓
7	↓ -7	↓	↓	↓	↓	↓	↓	↓
8	↓ -8	↓	↓	↓	↓	↓	↓	↓
9	↓ -9	↓	↓	↓	↓	↓	↓	↓
10	↓ -10	↓	↓	↓	↓	↓	↓	↓
11	↓ -11	↓	↓	↓	↓	↓	↓	↓
12	↓ -12	↓	↓	↓	↓	↓	↓	↓
13	↓ -13	↓	↓	↓	↓	↓	↓	↓
14	↓ -14	↓	↓	↓	↓	↓	↓	↓
15	↓ -15	↓	↓	↓	↓	↓	↓	↓
16	↓ -16	↓	↓	↓	↓	↓	↓	↓
1	1618003-1	RA160606-1	Ra228	90	10:47	JP	RAC0609A	JP
2	↓ -2	↓	↓	↓	↓	↓	↓	↓
3	↓ -3	↓	↓	↓	↓	↓	↓	↓
4	↓ -4	↓	↓	↓	↓	↓	↓	↓
5	↓ -5	↓	↓	↓	↓	↓	↓	↓
6	RA160606-1AMB	↓	↓	↓	↓	↓	↓	↓
7	↓ B	↓	↓	↓	↓	↓	↓	↓
8	↓ C	↓	↓	↓	↓	↓	↓	↓
1	161518005-1	AB150616-2	Ra228	150	17:30	JP	ABC0609	JP
6	↓ -2	↓	↓	↓	↓	↓	↓	↓
9	↓ -3	↓	↓	↓	↓	↓	↓	↓
13	↓ -4	↓	↓	↓	↓	↓	↓	↓
14	AB150616-2AMB	↓	↓	↓	↓	↓	↓	↓
7	↓ B	↓	↓	↓	↓	↓	↓	↓
10	↓ C	↓	↓	↓	↓	↓	↓	↓
16	↓ D	↓	↓	↓	↓	↓	↓	↓

Comments:

Page No.: 465432 **B**

Form 780r8.doc (6/23/06)

Reviewed By / Date

(cont. from page 14 **B**)

JP 6/10/16

# Radiochemistry Instrument Worksheet

ALS Environmental -- FC

Prep Batch: AB150616-2

Prep Procedure: GROSS\_ALPHA

Analytical QASS / NCR? Y N

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	Residual Mass (mg)	Cnt 1 File	Cnt 1 Inst/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Inst/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Inst/Det	Cnt 3 Pos Chk By	Notes
1	1518005-1	SMP	200	200	ml	pCi/l	53	ABC0609	1	JP							
1	1518005-2	SMP	200	200	ml	pCi/l	52		6								
1	1518005-3	SMP	200	200	ml	pCi/l	52.5		9								
1	1518005-4	SMP	200	200	ml	pCi/l	55.1		13								
1	AB150616-2a	MB	200	200	ml	pCi/l	51.6		4								
1	AB150616-2b	MB	200	200	ml	pCi/l	55.1		7								
1	AB150616-2c	MB	200	200	ml	pCi/l	47.5		10								
1	AB150616-2d	MB	200	200	ml	pCi/l	52.6		16								

6-6-96

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1013.4095.81	103.771	DPM/ml	06/16/15	1	ml	RS-005
S2	Th-230	760.4095.67	96.654	DPM/ml	06/16/15	1	ml	RS-005

## Sample Barcodes

1518005-1 AB150616-2PS1		1518005-2 AB150616-2PS2		1518005-3 AB150616-2PS3	
1518005-4 AB150616-2PS4		AB150616-2aMB AB150616-2PS5		AB150616-2bMB AB150616-2PS6	
AB150616-2cMB AB150616-2PS7		AB150616-2dMB AB150616-2PS8			

## Reporting Units

LabID:	TstGrpName:	RptUnits:
1518005-1	GrossAlpha_DW	pCi/l
1518005-2	GrossAlpha_DW	pCi/l
1518005-3	GrossAlpha_DW	pCi/l
1518005-4	GrossAlpha_DW	pCi/l

# Radiochemistry Prep Worksheet

ALS Environmental -- FC

Prep Batch: AB150616-2

Prep Procedure: GROSS\_ALPHA

Reviewed By: jkb

Review Date: 6/17/2015

Non-Routine Pre-Treatment? Y / N Batch: Re-Prep? Y / N Batch: Prep QASS / NCR? Y / N

Prep SOP: PAI 702 Rev: 20

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Jennie Kill-Bowden

Prep Date: 6/16/2015

Prep Dept: RS

Balance: 13

Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1518005-1	SMP		200	200	As Received	S1,S2	
2	1	1518005-2	SMP		200	200	As Received	S1,S2	
3	1	1518005-3	SMP		200	200	As Received	S1,S2	
4	1	1518005-4	SMP		200	200	As Received	S1,S2	
5	1	AB150616-2a	MB		200	200	As Received		
6	1	AB150616-2b	MB		200	200	As Received		
7	1	AB150616-2c	MB		200	200	As Received		
8	1	AB150616-2d	MB		200	200	As Received		

Comments

ICV/ICBs USGS method

Spiked By: Jennie Kill-Bowden Date: 6/17/2015

Witnessed By: Peter Workman Date: 6/17/2015

## Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Cs-137	1013.4095.81	103.771	DPM/ml	06/16/15	1	ml	RS-005
S2	Th-230	760.4095.67	96.654	DPM/ml	06/16/15	1	ml	RS-005

# Radiochemistry Gravimetric Worksheet

ALS Environmental -- FC

Prep Batch: AB150616-2

Prep Procedure: GROSS\_ALPH

Reviewed By: jkb

Review Date: 6/17/2015

Prep Num	Planc. Num	LabID	QC Type	Test Alq (ml)	Tare Mass (g)	Initial Gross Mass (g)	Initial Net Mass (mg)	Suggested Alq (ml)	Samp Vol Available (ml)	Samp Vol Taken (ml)	Fin Gross Mass (g)	Final Net Mass (mg)	Salt Sol. Added (ml)	Flag
1	1	1518005-1	SMP	10	9.4227	0.0000	0	0	0	200	9.4757	53	1	
1	2	1518005-2	SMP	10	9.1605	0.0000	0	0	0	200	9.2125	52	1	
1	3	1518005-3	SMP	10	9.1329	0.0000	0	0	0	200	9.1854	52.5	1	
1	4	1518005-4	SMP	10	9.3753	0.0000	0	0	0	200	9.4304	55.1	1	
1	5	AB150616-2a	MB	10	9.3869	0.0000	0	0	0	200	9.4385	51.6	1	
1	6	AB150616-2b	MB	10	9.0283	0.0000	0	0	0	200	9.0834	55.1	1	
1	7	AB150616-2c	MB	10	9.4330	0.0000	0	0	0	200	9.4805	47.5	1	
1	8	AB150616-2d	MB	10	9.4183	0.0000	0	0	0	200	9.4709	52.6	1	

Th-230 760.4095.67 working std

Prepare a working dilution of 760.3020.08

1. Density of 0.5M HAD lot # 0000084176

Mass of 100mL vol. flask:

68.5632g

Balance # 12

Mass of flask & 100mL acid:

169.6732g

Balance# 12

Net Mass:

101.1100g

Density:

1.011g/mL

2. Mass of 760.3020.08 transferred:

Mass of open empty nalgene:

74.1983g

Balance# 12

Mass of nalgene & standard:

77.2060g

Balance# 12

Net mass of standard transferred:

3.0077g

Balance# NA

3. Dilute to final volume:

Mass of nalgene, standard, & diluent:

908.9g

Balance# 26

Mass of empty nalgene (from above):

74.1983g

Balance# 12

Net mass of new dilution:

834.7017g

Balance# NA

4. Final activity calculation:

$$26,534.43 \text{ dpm/g} (1.011 \text{ g/mL}) \frac{(3.0077 \text{ g})}{(834.7017 \text{ g})} = 96.66 \text{ dpm/mL}$$

Std ID: 760.4095.67

Description: Th-230

Expiration: 4/12/2016

Activity: 96.66 dpm/mL

2s Uncertainty: 3.19 dpm/mL

Ref. Date: 7/13/2004

Ref Time: N/A

Prep Date: 12/8/2014 Prep by: TE

Matrix/Comp. 0.5 M HNO3

Half Life (y): 7.54E+04

Reverification Log		
Analysis Date	Initials	Expiration Date

Continued on Page

Signed

Date

Read and Understood By

Signed

Date

PROJECT

760-3020.08

Th-230

Notebook No.

Continued From Page

Prepare a primary dilution of R50 #760 (Analyte # 65750-307) in 0.5 M HNO<sub>3</sub> to a concentration of approx 30,000 dpm/mL.

1) Prepare 0.5M HNO<sub>3</sub> by diluting 5 mL of conc. (16M) HNO<sub>3</sub> (END lot # 44257) to a final volume of 1000 mL.

2) Determine Density of 0.5M HNO<sub>3</sub>

Mass of 100 mL volumetric flask =	66.4289 g (Bal 12)
Mass of flask + 0.5M HNO <sub>3</sub> =	167.5792 g
Net mass of solution =	101.1502 g
→ 100 mL = density =	1.0015 g/mL

3) Transfer # 760 to a 40 mL VOA vial.

Mass of bottle without lid =	21.5801 g (Bal 12)
Mass of std + bottle	26.5278 g
Net mass of std transferred	4.9477 g

4) Dilute to volume w/ 0.5M HNO<sub>3</sub>

Mass of bottle + std + soln =	61.8912 g (Bal 12)
Mass of bottle (from above)	21.5801 g
Net mass of std	40.3111 g

5) Final activity calc.

$$\frac{(1.880 \times 10^4 \text{ dpm/g}) (4.9477 \text{ g}) (1.0015 \text{ g/mL})}{(5.08447) (40.3111 \text{ g})} = 26,534.43 \text{ dpm/g}$$

Continued on Page

Read and Understood By

Debra Baker

Signed

1/24/06

Date

[Signature]

Signed

1/27/06

Date



ANALYTICS

RSO# 760 Rec'd 7/14/04 JCB

1380 Seaboard Industrial Blvd.  
Atlanta, Georgia 30318 - U.S.A.

Phone (404) 352-8877  
Fax (404) 352-2857

## CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

68750-307

Th-230 5 mL Liquid in Flame Sealed Vial

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

ISOTOPE:	Th-230
ACTIVITY (dps):	1.832 Bq
HALF-LIFE:	7.538 Bq years
CALIBRATION DATE:	July 13, 2004 12:00 EST
RELATIVE EXPANDED UNCERTAINTY (k=2):	3.3%

Impurities:  $\gamma$ -impurities <0.1%,  $\alpha$ -impurities <0.01%

5.08447 grams 0.5M HNO<sub>3</sub> solution.

P O NUMBER 70635, Item 1.

SOURCE PREPARED BY:

M. D. Currie  
M. D. Currie, Radiochemist

Q A APPROVED:

Rec'd 7/13/04

Prepare a working dilution of 1013.4095.76

1. Density of 4% HCl, lot # 0000094396

Mass of 100mL vol. flask:

56.4410g

Balance # 12

Mass of flask & 100mL acid:

156.9528g

Balance # 12

Net Mass:

100.5118g

Density:

1.0051g/mL

2. Mass of 1013.4095.76 transferred:

Mass of open empty nalgene:

74.7387g

Balance # 12

Mass of nalgene & standard:

75.7309g

Balance # 12

Net mass of standard transferred:

0.9922g

3. Dilute to final volume:

Mass of nalgene, standard, & diluent:

846.6g

Balance # 26

Mass of empty nalgene (from above):

74.7387g

Balance # 12

Net mass of new dilution:

771.8613g

4. Final activity calculation:

$$100,443.61 \text{ dpm/g} \left( \frac{1.0051 \text{ g/mL}}{771.8613 \text{ g}} \right) (0.9922 \text{ g}) = 129.78 \text{ dpm/mL}$$

Std ID: 1013.4095.81

Description: Cs-137

Expiration: 1/23/2016

Activity: 129.78 dpm/mL

2s Uncertainty: 0.91 dpm/mL

Ref. Date: 9/30/2005

Ref Time: N/A

Prep Date: 1/22/2015 Prep by: TE

Matrix/Comp: 4% HCl

Half Life (y): 3.01E+01

Reverification Log		
Analysis Date	Initials	Expiration Date

Read and Understood By

Signed

Continued on Page

Date

Project CS-13.7 intermediate standard 1013.40915.76

Continued from Page 1

12/11/15

Prepare an intermediate dilution of KSCN #1013

1. Density of 48% HCl, lot # 0000094396

Mass of 100mL vol. flask: 27.5652g

Mass of flask & 100mL acid: 119.0154g

Net Mass: 100.4502g

Density: 1.0145 g/mL

Balance # 13

Balance # 13

2. Mass of KSCN #1013 transferred:

Mass of open empty bottle: 398.34g

Mass of bottle and standard: 403.33g

Net mass of standard transferred: 4.99g

Balance # 26

Balance # 26

3. Dilute to final volume:

Mass of open empty bottle: 398.34g

Mass of bottle, standard, & diluent: 1278.4g

Net mass of new dilution: 876.06g

Balance # 26

Balance # 26

4. Final activity calculation:

$$298.6 \text{ kBq/g} \left( \frac{1000 \text{ Bq}}{1 \text{ kBq}} \right) \left( \frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left( \frac{4.99 \text{ g}}{876.06 \text{ g}} \right) = 100,443.61 \text{ dpm/g}$$

12/11/15

Continued on Page 2

12/11/15

12/11/15

12/11/15

12/11/15



750<sup>th</sup>  
1013

# National Institute of Standards & Technology Certificate

## Standard Reference Material 4233E Cesium-137 Radioactivity Standard

This Standard Reference Material (SRM) consists of radioactive cesium-137 chloride, non-radioactive cesium chloride, and hydrochloric acid dissolved in 5 mL of distilled water. The solution is contained in a flame-sealed NIST borosilicate-glass ampoule. The SRM is intended for the calibration of ionization chambers and solid-state gamma-ray spectrometry systems.

**Radiological Hazard:** The SRM ampoule contains cesium-137 with a total activity of approximately 1.5MBq. Cesium-137 decays by beta-particle emission to barium-137m, which decays by internal conversion. During the decay process X-rays and gamma rays with energies from approximately 3 keV to 662 keV are emitted. Most of these photons escape from the SRM ampoule and can represent a radiation hazard. Approximate unshielded dose rates at several distances (as of the reference time) are given in note [a]\*. Appropriate shielding and/or distance should be used to minimize personnel exposure. The SRM should be used only by persons qualified to handle radioactive material.

**Chemical Hazard:** The SRM ampoule contains hydrochloric acid with a concentration of 1 mole per liter of water. The solution is corrosive and represents a health hazard if it comes in contact with eyes or skin. If the ampoule is to be opened to transfer the solution, the recommended procedure is given on page 2. The ampoule should be opened only by persons qualified to handle both radioactive material and strong acid solution.

**Storage and Handling:** The SRM should be stored and used at a temperature between 5 and 65 °C. The solution in an unopened ampoule should remain stable and homogeneous until at least September 2015. The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material. If the ampoule is transported, it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The solution in the ampoule is a dangerous good (hazardous material) because of both the radioactivity and the strong acid.

**Preparation:** This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, M.P. Unterwieser, Acting Group Leader. The overall technical direction and physical measurements leading to certification were provided by L.L. Lucas, R. Collé and L. Laureano-Pérez of the Radioactivity Group. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program.

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### **Recommended Procedure for Opening the SRM Ampoule**

- 1) If the SRM solution is to be diluted, it is recommended that the diluting solution have a composition comparable to that of the SRM solution.
- 2) Wear eye protection, gloves, and protective clothing and work over a tray with absorbent paper in it. Work in a fume hood. In addition to the radioactive material, the solution contains strong acid and is corrosive.
- 3) Shake the ampoule to wet all of the inside surface of the ampoule. Return the ampoule to the upright position.
- 4) Check that all of the liquid has drained out of the neck of the ampoule. If necessary, gently tap the neck to speed the process.
- 5) Holding the ampoule upright, score the narrowest part of the neck with a scribe or diamond pencil.
- 6) Lightly wet the scored line. This reduces the crack propagation velocity and makes for a cleaner break.
- 7) Hold the ampoule upright with a paper towel, a wiper, or a support jig. Position the scored line away from you. Using a paper towel or wiper to avoid contamination, snap off the top of the ampoule by pressing the narrowest part of the neck away from you while pulling the tip of the ampoule towards you.
- 8) Transfer the solution from the ampoule using a pycnometer or a pipet with dispenser handle. **NEVER PIPETTE BY MOUTH.**
- 9) Seal any unused SRM solution in a flame-sealed glass ampoule, if possible, to minimize the evaporation loss.

See also reference [4]\*.

# PROPERTIES OF SRM 4233E

## Certified values

Radionuclide	Cesium-137
Reference time	1200 EST, 30 September 2005
Massic activity of the solution [c]*	298.6 kBq·g <sup>-1</sup>
Relative expanded uncertainty (k=2)	0.70% [d] [e]
Solution mass	(5.0668 ± 0.0009) g [b]
Solution density	(1.015 ± 0.002) g·mL <sup>-1</sup> at 20 °C [b]

## Uncertified values

Physical Properties:			
Source description	Liquid in flame-sealed NIST borosilicate-glass ampoule		
Ampoule specifications	Body outside diameter	(16.5 ± 0.5) mm	
	Wall thickness	(0.60 ± 0.04) mm	
	Barium content	Less than 2.5%	
	Lead-oxide content	Less than 0.02%	
	Other heavy elements	Trace quantities	
Chemical Properties:			
Solution composition	Chemical Formula	Concentration (mol·L <sup>-1</sup> )	Mass Fraction (g·g <sup>-1</sup> )
	H <sub>2</sub> O	54	0.96
	HCl	1.0	0.04
	CsCl	1.6 × 10 <sup>-4</sup>	2.7 × 10 <sup>-5</sup>
	<sup>137</sup> CsCl	6.9 × 10 <sup>-7</sup>	1.2 × 10 <sup>-7</sup>
Radiological Properties:			
Photon-emitting impurities	None detected [f]		
Half lives used	Cesium-137: (10983 ± 11) d [g] [5] Radium-226: (1600 ± 7) a [g] [5]		
Calibration method and measuring instrument(s)	Pressurized "4π"γ ionization chamber A calibrated using an cesium-137 solution whose activity was determined by the 4π(e+X)-γ-coincidence efficiency-extrapolation technique.		

# EVALUATION OF THE UNCERTAINTY OF THE MASSIC ACTIVITY [d]\*

Input Quantity $x_i$ , the source of uncertainty  (and individual uncertainty components where appropriate)	Method Used To Evaluate $u(x_i)$ , the standard uncertainty of $x_i$ , (A) denotes evaluation by statistical methods (B) denotes evaluation by other methods	Relative Uncertainty Of Input Quantity, $u(x_i)/x_i$ , (%) [h]	Relative Sensitivity Factor, $ \partial y/\partial x_i  \cdot$ $(x_i/y)$ [i]	Relative Uncertainty Of Output Quantity, $u(y)/y$ , (%) [j]
PIC A net response per gram of SRM 4233E, measured relative to RRS20 [k]	Standard deviation of the mean (within-measurement precision ) for 20 to 100 repeated measurements (A)	0.02	1.0	0.02
	Standard deviation (between- measurement precision) for 4 sets of measurement (A)	0.13	1.0	0.13
PIC A net response per Bq of cesium-137 in solution, measured relative to RRS20.	Standard deviation of the mean (for both between- and within- measurement precision) for > 100 repeated measurements (A)	0.01	1.0	0.01
Activity used to calibrate PIC A net response per Bq of cesium-137 in solution	Standard uncertainty of the activity determined by the $4\pi(e+X)\text{-}\gamma$ -coincidence efficiency-extrapolation technique. (B)	0.31	1.0	0.31
Half life of cesium-137 Half life of radium-226	Standard uncertainty of the half life (A)	0.10 [m] 0.44 [m]	0.0001 [n] 0.010 [n]	0.00001 0.004
Gravimetric measurements	Estimated (B)	0.03	1.0	0.03
PIC A charge collection	Estimated (B)	0.05	1.0	0.05
Charge collection measurement time [p]	Estimated (B)	0.05	1.0	0.05
Long-term RRS positioning	Estimated (B)	0.05	1.0	0.05
Photon-emitting impurities	Limit of detection (B) [q]	100.	0.0001	0.01
Relative Combined Standard Uncertainty of the Output Quantity, $u_c(y)/y$ , (%)				0.35
Coverage Factor, $k$				<u>x 2</u>
Relative Expanded Uncertainty of the Output Quantity, $U/y$ , (%)				0.70

## NOTES

- [a] The Sievert is the SI unit for dose equivalent. See reference [1]. One  $\mu\text{Sv}$  is equal to 0.1 mrem.  
 Distance from Ampoule (cm):           1       30       100  
 Approximate Dose Rate ( $\mu\text{Sv/h}$ ):       300       4       0.3
- [b] The stated uncertainty is two times the standard uncertainty.
- [c] **Massic activity** is the preferred name for the quantity activity divided by the total mass of the sample. See reference [1].
- [d] The reported value,  $y$ , of massic activity (activity per unit mass) at the reference time was not measured directly but was derived from measurements and calculations of other quantities. This can be expressed as  $y = f(x_1, x_2, x_3, \dots, x_n)$ , where  $f$  is a mathematical function derived from the assumed model of the measurement process. The value,  $x_i$ , used for each input quantity  $i$  has a standard uncertainty,  $u(x_i)$ , that generates a corresponding uncertainty in  $y$ ,  $u_i(y) = |\partial y / \partial x_i| \cdot u(x_i)$ , called a component of combined standard uncertainty of  $y$ . The combined standard uncertainty of  $y$ ,  $u_c(y)$ , is the positive square root of the sum of the squares of the components of combined standard uncertainty. The combined standard uncertainty is multiplied by a coverage factor of  $k = 2$  to obtain  $U$ , the expanded uncertainty of  $y$ .
- Since it can be assumed that the possible estimated values of the massic activity are approximately normally distributed with approximate standard deviation  $u_c(y)$ , the unknown value of the massic activity is believed to lie in the interval  $y \pm U$  with a level of confidence of approximately 95 percent.
- For further information on the expression of uncertainties, see references [2] and [3].
- [e] The value of each component of combined standard uncertainty, and hence the value of the expanded uncertainty itself, is a best estimate based upon all available information, but is only approximately known. That is to say, the "uncertainty of the uncertainty" is large and not well known. This is true for uncertainties evaluated by statistical methods (e.g., the relative standard deviation of the standard deviation of the mean for the massic response is approximately 50%) and for uncertainties evaluated by other methods (which could easily be over estimated or under estimated by substantial amounts). The unknown value of the expanded uncertainty is believed to lie in the interval  $U/2$  to  $2U$  (i.e., within a factor of 2 of the estimated value).
- [f] Estimated limits of detection for photon-emitting impurities, as of 3 October 2005 (3 days after the reference time), expressed as massic photon emission rates, are:  
 $< 40 \text{ } \gamma \cdot \text{s}^{-1} \cdot \text{g}^{-1}$  for energies between 40 keV and 1350 keV, and  
 $< 4 \text{ } \gamma \cdot \text{s}^{-1} \cdot \text{g}^{-1}$  for energies between 1350 keV and 3600 keV,
- [g] The stated uncertainty is the standard uncertainty.
- [h] Relative standard uncertainty of the input quantity  $x_i$ .
- [i] The relative change in the output quantity  $y$  divided by the relative change in the input quantity  $x_i$ . If  $|\partial y / \partial x_i| \cdot (x_i / y) = 1.0$ , then a 1% change in  $x_i$  results in a 1% change in  $y$ . If  $|\partial y / \partial x_i| \cdot (x_i / y) = 0.05$ , then a 1% change in  $x_i$  results in a 0.05% change in  $y$ .

- [j] Relative component of combined standard uncertainty of output quantity  $y$ , rounded to two significant figures or less. The relative component of combined standard uncertainty of  $y$  is given by  $u_i(y)/y = |\partial y / \partial x_i| \cdot u(x_i)/y = |\partial y / \partial x_i| \cdot (x_i/y) \cdot u(x_i)/x_i$ . The numerical values of  $u(x_i)/x_i$ ,  $|\partial y / \partial x_i| \cdot (x_i/y)$ , and  $u_i(y)/y$ , all dimensionless quantities, are listed in columns 3, 4, and 5, respectively. Thus, the value in column 5 is equal to the value in column 4 multiplied by the value in column 3. The input quantities are independent, or very nearly so. Hence the covariances are zero or negligible.
- [k] The response of pressurized ionization chamber A (PIC A) is determined from measurement of the time required to collect a given amount of charge on a stable fixed capacitor. All of the response measurements in the NIST pressurized ionization chambers are made relative to the response of one or more artifact standards. These artifact standards consist of microgram quantities of aged radium-226 in small welded stainless-steel capsules. These capsules are encapsulated in plastic rods whose dimensions are similar to those of the standard NIST ampoule. The artifact standards are called Radium Reference Sources and are designated as RRSx, where x is the nominal mass (in micrograms) of radium-226 in the capsule.
- [m] The relative standard uncertainty of  $\lambda \cdot t$  is determined by the relative standard uncertainty of  $\lambda$  (i.e., of the half life). The relative standard uncertainty of  $t$  is negligible.
- [n]  $|\partial y / \partial x_i| \cdot (x_i/y) = |\lambda \cdot t|$
- [p] The charge collection measurement time is determined by counting the pulses from a gated crystal-controlled oscillator.
- [q] The standard uncertainty for each undetected impurity that might reasonably be expected to be present is estimated to be equal to the estimated limit of detection for that impurity, i.e.  $u(x_i)/x_i = 100\%$ .  $|\partial y / \partial x_i| \cdot (x_i/y) = \{(\text{response per Bq of impurity})/(\text{response per Bq of cesium-137})\} \cdot \{(\text{Bq of impurity})/(\text{Bq of cesium-137})\}$ . Thus  $u_i(y)/y$  is the relative change in  $y$  if the impurity were present with a massic activity equal to the estimated limit of detection.

## REFERENCES

- [1] International Organization for Standardization (ISO), *ISO Standards Handbook - Quantities and Units*, 1993. Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
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- [4] National Council on Radiation Protection and Measurements Report No. 58, *A Handbook of Radioactivity Measurements Procedures*, Second Edition, 1985. Available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Bethesda, MD 20814 U.S.A.
- [5] Evaluated Nuclear Structure Data File (ENSDF), September 2005.