



facility 755652

facility 755653

project 10243

Radium-226

Case Narrative

COGCC

PW NORM 2017 – 10048

Work Order Number: 1706286

1. This report consists of the analytical results and supporting documentation for two water samples received by ALS on 06/13/2017.
2. These samples were prepared according to the current revision of SOP 701. Modifications were made to the method as described on QASS #472128.
3. The samples were analyzed for the presence of ^{224}Ra and ^{226}Ra according to the current revision of SOP 714. The analyses were completed on 06/26/2017.
4. The analysis results for these samples are reported in units of pCi/L. The samples were filtered prior to analysis.
5. Samples 1706286-1 and -3 contained Ba concentrations which required reduced aliquant volumes to be analyzed. For further information regarding this occurrence, please refer to QASS #472128 in section 6 of this report.
6. The requested MDC for Ra-226 was not met for samples 1706286-1, -1DUP, and -3. The reported activity for these samples is greater than the achieved MDC. These samples are identified with an "M3" flag on the final reports.
7. The requested MDC for Ra-224 for samples 1706286-1, -1DUP, and -3 was not achieved. These samples were prepared at a reduced aliquot due to suspected matrix interference. These samples were counted for a maximum count time of 1000 minutes and results are reported without further qualification. The results are identified with an "M" qualifier on the final reports.
8. No further anomalous situations were encountered during the preparation or analysis of these samples. 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.

Jean Anderson
Jean Anderson
Radiochemistry Primary Data Reviewer

7/24/17
Date

Shirley Lomax
Radiochemistry Final Data Reviewer

7/26/17
Date

Section 1

CHAIN OF CUSTODY

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 1706286

Client Name: COGCC

Client Project Name: PW NORM 2017

Client Project Number: 10048

Client PO Number: CT 2017-3066

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
755652 Coalview	1706286-1		WATER	13-Jun-17	10:16
755652 Coalview	1706286-2		WATER	13-Jun-17	10:16
755653 Oscar Y	1706286-3		WATER	13-Jun-17	11:36
755653 Oscar Y	1706286-4		WATER	13-Jun-17	11:36



Chain-of-Custody

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

ALSWORKORDER #

982907

[illegible]



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

ALS WORKORDER #[illegible]



ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: COGCC

Workorder No: 1706286

Project Manager: SS

Initials: JNS

Date: 6/13/17

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: <u> </u> < green pea <u> </u> > green pea	N/A	<u>YES</u>	NO
15. Do any water samples contain sediment? Amount Amount of sediment: <u> </u> dusting <u>X</u> moderate <u> </u> heavy	N/A	<u>YES</u>	NO
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*: #2 <u>#4</u>	RAD ONLY	<u>YES</u>	NO
Cooler #:	<u>1</u>	<u>2</u>	<u>3</u>
Temperature (°C):	<u>amb</u>	<u>amb</u>	<u>4</u>
No. of custody seals on cooler:	<u>0</u>	<u>0</u>	<u>0</u>
External µR/hr reading:	<u>1.2</u>		
Background µR/hr reading:	<u>10</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: Philab Date/Time:

Project Manager Signature / Date: Philab

Section 2



SAMPLE RESULTS SUMMARY

Isotopic Radium by Alpha Spectroscopy Sample Results Summary

Client Name: COGCC
Client Project Name: PW NORM 2017
Client Project Number: 10048
Laboratory Name: ALS -- Fort Collins
PAI Work Order: 1706286

Page: 1 of 1
Reported on: Monday, July 17, 2017
10:25:13 AM

Lab Sample ID	Client Sample ID	Sample Type	Nuclide	Result +/- 2 s TPU	MDC	DL	Units	Matrix	Prep Batch	Date Analyze	Flags
1706286-1	755652 Coalview	Sample	Ra-224	1.2E+01 +/- 1.2E+01	2.5E+01	NA	pCi/l	WATER	RAS170614-1	6/15/2017	U,M
1706286-1	755652 Coalview	Sample	Ra-226	1.25E+02 +/- 2.1E+01	4E+00	NA	pCi/l	WATER	RAS170614-1	6/15/2017	M3
1706286-3	755653 Oscar Y	Sample	Ra-224	2.5E+00 +/- 3.2E+00	6.6E+00	NA	pCi/l	WATER	RAS170614-1	6/15/2017	U,M
1706286-3	755653 Oscar Y	Sample	Ra-226	2E+01 +/- 3.8E+00	1.1E+00	NA	pCi/l	WATER	RAS170614-1	6/15/2017	M3

Comments:

Data Package ID: RAS1706286-1

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



Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Method Blank Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: RAS170614-1MB

Sample Matrix: WATER

Prep SOP: PAI 701 Rev 1

Date Collected: 14-Jun-17

Date Prepared: 14-Jun-17

Date Analyzed: 15-Jun-17

Prep Batch: RAS170614-1

QCBatchID: RAS170614-1-1

Run ID: RAS170614-1

Count Time: 1000 minutes

Final Aliquot: 500 ml

Result Units: pCi/l

File Name: Spectrum #1

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13233-32-4	Ra-224	6E-03 +/- 9.5E-02	2.19E-01	1E+00	NA	U
13982-63-3	Ra-226	-9E-03 +/- 2.1E-02	5.1E-02	1E+00	NA	U

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	1.180E+01	8.940E+00	pCi/l	75.9	60 - 100 %	

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: RAS1706286-1

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13
Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins
Work Order Number: 1706286
Client Name: COGCC
ClientProject ID: PW NORM 2017 10048

Lab ID: RAS170614-1LCS

Sample Matrix: WATER
Prep SOP: PAI 701 Rev 1
Date Collected: 14-Jun-17
Date Prepared: 14-Jun-17
Date Analyzed: 15-Jun-17

Prep Batch: RAS170614-1
QCBatchID: RAS170614-1-1
Run ID: RAS170614-1
Count Time: 1000 minutes

Final Aliquot: 500 ml
Result Units: pCi/l
File Name: Spectrum #1

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
13233-32-4	Ra-224	9.6E+00 +/- 1.3E+00	2E-01	8.950E+00	107	75 - 125	P
13982-63-3	Ra-226	9.2E+00 +/- 1.3E+00	0E-02	9.210E+00	99.6	75 - 125	P

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	1.180E+01	9.500E+00	pCi/l	80.6	60 - 100 %	

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: RAS1706286-1

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 755652 Coalview

Lab ID: 1706286-1DUP

Sample Matrix: WATER

Prep SOP: PAI 701 Rev 1

Date Collected: 13-Jun-17

Date Prepared: 14-Jun-17

Date Analyzed: 15-Jun-17

Prep Batch: RAS170614-1

QCBatchID: RAS170614-1-1

Run ID: RAS170614-1

Count Time: 1000 minutes

Report Basis: Filtered

Final Aliquot: 6.00 ml

Prep Basis: Filtered

Moisture(%): NA

Result Units: pCi/l

File Name: Spectrum #1

CASNO	Analyte	Sample				Duplicate				DER	DER Lim
		Result +/-	2 s TPU	MDC	Flags	Result +/-	2 s TPU	MDC	Flags		
13233-32-4	Ra-224	1.2E+01 +/- 1.2E+01		2.5E+01	U,M	1.9E+01 +/- 1.3E+01		2.5E+01	U,M	0.8695	2
13982-63-3	Ra-226	1.25E+02 +/- 2.1E+01		4E+00	M3	9.8E+01 +/- 1.7E+01		4E+00	M3	1.9604	2

Comments: This sample was filtered prior to analysis.

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: RAS1706286-1

Section 4

INDIVIDUAL SAMPLE RESULTS

4

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 755652 Coalview

Lab ID: 1706286-1

Sample Matrix: WATER

Prep SOP: PAI 701 Rev 1

Date Collected: 13-Jun-17

Date Prepared: 14-Jun-17

Date Analyzed: 15-Jun-17

Prep Batch: RAS170614-1

QCBatchID: RAS170614-1-1

Run ID: RAS170614-1

Count Time: 1000 minutes

Report Basis: Filtered

Final Aliquot: 6.00 ml

Prep Basis: Filtered

Moisture(%): NA

Result Units: pCi/l

File Name: Spectrum #1

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13233-32-4	Ra-224	1.2E+01 +/- 1.2E+01	2.5E+01	1E+00	NA	U,M
13982-63-3	Ra-226	1.25E+02 +/- 2.1E+01	4E+00	1E+00	NA	M3

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	9.820E+02	7.770E+02	pCi/l	79.2	60 - 100 %	

Comments: This sample was filtered prior to analysis.

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: RAS1706286-1

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13 Sample Duplicate Results

Lab Name: ALS -- Fort Collins
Work Order Number: 1706286
Client Name: COGCC
ClientProject ID: PW NORM 2017 10048

Field ID:	755652 Coalview
Lab ID:	1706286-1DUP

Sample Matrix: WATER
Prep SOP: PAI 701 Rev 1
Date Collected: 13-Jun-17
Date Prepared: 14-Jun-17
Date Analyzed: 15-Jun-17

Prep Batch: RAS170614-1
QCBatchID: RAS170614-1-1
Run ID: RAS170614-1
Count Time: 1000 minutes
Report Basis: Filtered

Final Aliquot: 6.00 ml
Prep Basis: Filtered
Moisture(%): NA
Result Units: pCi/l
File Name: Spectrum #1

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13233-32-4	Ra-224	1.9E+01 +/- 1.3E+01	2.5E+01	1E+00	NA	U,M
13982-63-3	Ra-226	9.8E+01 +/- 1.7E+01	4E+00	1E+00	NA	M3

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	9.820E+02	7.960E+02	pCi/l	81.0	60 - 100 %	

Comments: This sample was filtered prior to analysis.

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: RAS1706286-1

Date Printed:
Monday, July 17, 2017

ALS -- Fort Collins
LIMS Version: 6.843

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Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 755653 Oscar Y

Lab ID: 1706286-3

Sample Matrix: WATER

Prep SOP: PAI 701 Rev 1

Date Collected: 13-Jun-17

Date Prepared: 14-Jun-17

Date Analyzed: 15-Jun-17

Prep Batch: RAS170614-1

QCBatchID: RAS170614-1-1

Run ID: RAS170614-1

Count Time: 1000 minutes

Report Basis: Filtered

Final Aliquot: 26.0 ml

Prep Basis: Filtered

Moisture(%): NA

Result Units: pCi/l

File Name: Spectrum #1

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13233-32-4	Ra-224	2.5E+00 +/- 3.2E+00	6.6E+00	1E+00	NA	U,M
13982-63-3	Ra-226	2E+01 +/- 3.8E+00	1.1E+00	1E+00	NA	M3

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	2.270E+02	1.470E+02	pCi/l	65.0	60 - 100 %	

Comments: This sample was filtered prior to analysis.

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: RAS1706286-1

Section 5

RAW DATA

5

Isotopic Radium by Alpha Spectroscopy Raw Data Report

Laboratory Name: ALS -- Fort Collins

Prep SOP: PAI 701

Reported on: Friday, July 14, 2017

PAI Work Order: 1706286

Analytical SOP: PAI 714_Ra226

11:12:07 AM

Sample ID QC Type	Nuclide Type	Sample Date/Time	Prep Batch QC BatchID	Ingrowth Date /Time	Decay Date/Time	Matrix %Moist.	Samp Aliq Analy Aliq	Inst ID Det ID	AnRunID File Name	Count Date/Time	Net Cnts Bkg Cnts	BaseEff Bkg(min)	CndDur(min)	Activity +/- 2 s TPU	MDC DeclEv	ReportUnits ReportBasis	DER RPD	Spk. Recov Flags
1706286-1	Ra-224 Trg. Analyte	6/13/2017	RAS170614-1	NA	NA	WATER	6 ml	AlphaSpec2 91	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	84,000 19,000	30.24% 1000	1000	1.2E+01 79.2%	2.5E+01	pCi/l Filtered	NA	U,M
1706286-1	Ra-226 Trg. Analyte	6/13/2017	RAS170614-1	NA	NA	WATER	6 ml	AlphaSpec2 91	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	378,000 4,000	30.24% 1000	1000	1.25E+02 79.2%	4E+00	pCi/l Filtered	NA	M3
1706286-1	Ra-224 Trg. Analyte	6/13/2017	RAS170614-1	NA	NA	WATER	6 ml	AlphaSpec2 92	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	92,000 21,000	29.96% 1000	1000	1.9E+01 81.0%	2.5E+01	pCi/l Filtered	0.87	U,M
1706286-1	Ra-226 Trg. Analyte	6/13/2017	RAS170614-1	NA	NA	WATER	6 ml	AlphaSpec2 92	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	302,000 3,000	29.96% 1000	1000	9.8E+01 81.0%	4E+00	pCi/l Filtered	1.96	M3
1706286-3	Ra-224 Trg. Analyte	6/13/2017	RAS170614-1	NA	NA	WATER	26 ml	AlphaSpec2 93	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	64,000 24,000	30.51% 1000	1000	2.6E+00 65.0%	6.6E+00	pCi/l Filtered	NA	U,M
1706286-3	Ra-226 Trg. Analyte	6/13/2017	RAS170614-1	NA	NA	WATER	26 ml	AlphaSpec2 93	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	217,000 3,000	30.51% 1000	1000	2E+01 65.0%	1.1E+00	pCi/l Filtered	NA	M3
RAS170614-1	Ra-224 Trg. Analyte	6/14/2017	RAS170614-1	NA	NA	WATER	500 ml	AlphaSpec2 81	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	58,000 19,000	28.56% 1000	1000	6E-03 9.5E-02	2.19E-01	pCi/l As Received	NA	U
RAS170614-1	Ra-226 Trg. Analyte	6/14/2017	RAS170614-1	NA	NA	WATER	500 ml	AlphaSpec2 81	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	-2,000 3,000	28.56% 1000	1000	-9E-03 2.1E-02	5.1E-02	pCi/l As Received	NA	U
RAS170614-1	Ra-224 Trg. Analyte	6/14/2017	RAS170614-1	NA	NA	WATER	500 ml	AlphaSpec2 82	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	2200,000 39,000	28.77% 1000	1000	9.6E+00 80.6%	2E-01	pCi/l As Received	NA	107
RAS170614-1	Ra-226 Trg. Analyte	6/14/2017	RAS170614-1	NA	NA	WATER	500 ml	AlphaSpec2 82	RAS170614-1 Spectrum #1	6/15/2017 3:35 PM	2243,000 3,000	28.77% 1000	1000	9.2E+00 80.6%	0E-02	pCi/l As Received	NA	99.6

Comments:

Data Package ID: RAS1706286-1

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: Monday, July 17, 2017

ALS -- Fort Collins

LIMS Version: 6.843

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ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample: 1706286-1
Spectrum #1 Analysis #1

Sample

Sample Size : 0.01

Detector: 91
Batch Name: RAS170614-1_A
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition

Acquisition Start Date: 6/15/2017 3:35:08PM
Live Time: 1,000.00 min.
Real Time: 1,000.04 min.
Dead Time: 0.00 %

Calibration

Bkgd Info: Sample: B17060791; Det: 91; Spectrum #1; 6/7/2017 11:35:00 AM

Calibration Date: 6/7/2017 10:09:14AM

Efficiency Calibration: C17060791

Efficiency: 30.24% +/- 0.20% TPU(2 sigma)

Energy Calibration: C17060791

Energy Cal: Gain = 9.8810 keV / Ch

Offset = 3,028.21 keV

Quadratic = 0.0000 keV / Ch²

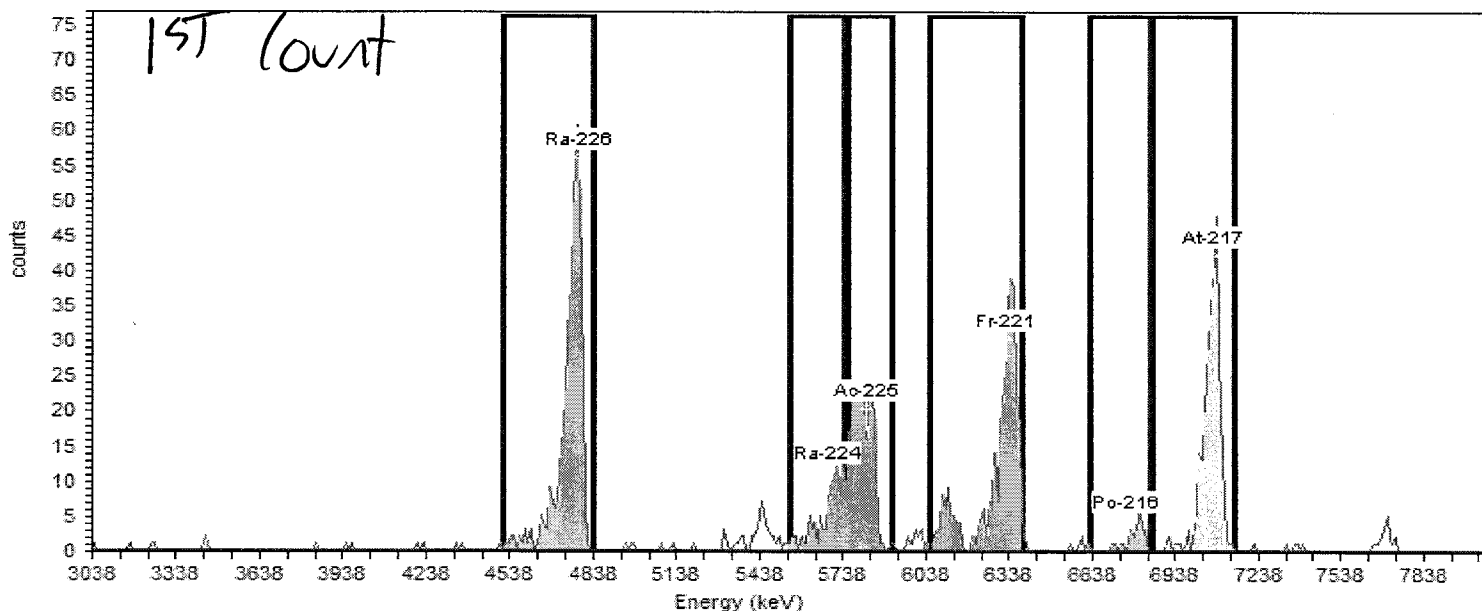
Tracer

Tracer Name: At-217

Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM

Tracer Nuclide: At-217

Tracer Recovery: 4.34%



Nuclide Summary (ROI)

Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4787.0	4510.4	4836.4	39.9	100.1	382.00	4.00	378.00	2.2E+003	2.1E+002	2.7E+001	6.9E+001
Ra-224	5686.2	5547.9	5745.5	50.6	95.1	103.00	19.00	84.00	5.1E+002	7.9E+001	6.1E+001	1.4E+002
Ac-225	5824.5	5755.4	5913.5	.0	78.3	231.00	16.00	215.00	1.6E+003	1.7E+002	6.8E+001	1.6E+002
Fr-221	6328.5	6051.8	6387.7	44.7	100.0	323.00	30.00	293.00	8.0E+005	1.3E+005	3.5E+004	7.7E+004
Po-216	6763.2	6634.8	6852.1	43.7	100.0	26.00	14.00	12.00	6.9E+001	3.7E+001	5.0E+001	1.2E+002
At-217	7079.4	6862.0	7158.5	55.2	99.9	274.00	12.00	262.00	6.5E+001	4.2E+000	4.6E+001	1.1E+002

JP

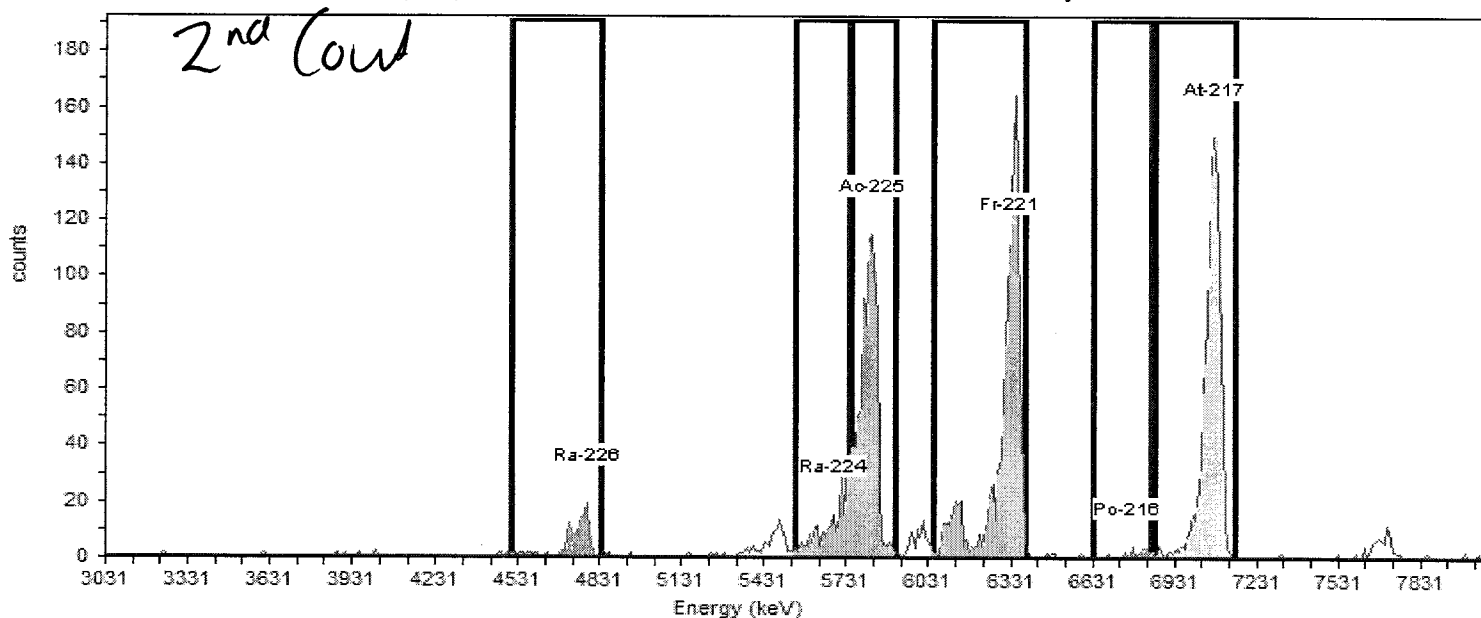
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Alpha-Spectroscopy Analysis Report

Sample		Sample
Sample: 1706286-1		Sample Size : 0.01
Spectrum #1 Analysis #1		
Acquisition		
Detector: 91		Acquisition Start Date: 6/26/2017 7:12:03AM
Batch Name: RAS170614-1_B		Live Time: 300.00 min.
Nuclide Library: Radium		Real Time: 300.02 min.
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226		Dead Time: 0.01 %
ROI Set: Ra224/Ra226		

Calibration	
Bkgd Info: Sample: B17062191; Det: 91; Spectrum #1; 6/21/2017 10:10:19 AM	
Calibration Date: 6/21/2017 9:59:58AM	Energy Calibration: C17062191
Efficiency Calibration: C17062191	Energy Cal: Gain = 9.9003 keV / Ch
Efficiency: 29.98% +/- 0.20% TPU(2 sigma)	Offset = 3,021.28 keV
	Quadratic = 0.0000 keV / Ch ²

Tracer	
Tracer Name: At-217	Tracer Nuclide: At-217
Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM	Tracer Recovery: 51.82%



Nuclide Summary (ROI)													
Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L	
Ra-226	4783.5	4506.3	4833.0	18.6	100.1	118.00	0.90	117.10	1.9E+002	2.1E+001	2.9E+000	1.0E+001	
Ra-224	5684.5	5545.9	5743.9	.0	95.1	245.00	9.30	235.70	4.0E+002	3.6E+001	9.7E+000	2.4E+001	
Ac-225	5823.1	5753.8	5912.2	66.7	78.3	819.00	6.30	812.70	1.7E+003	1.2E+002	9.7E+000	2.5E+001	
Fr-221	6328.0	6050.8	6387.4	37.0	100.0	1,063.00	15.30	1,047.70	2.2E+003	1.5E+002	1.5E+001	3.6E+001	
Po-216	6763.6	6634.9	6852.7	39.4	100.0	19.00	4.50	14.50	2.3E+001	7.9E+000	6.4E+000	1.7E+001	
At-217	7080.4	6862.6	7159.6	55.0	99.9	937.00	6.00	931.00	7.8E+002	2.6E+001	7.4E+000	1.9E+001	

JR

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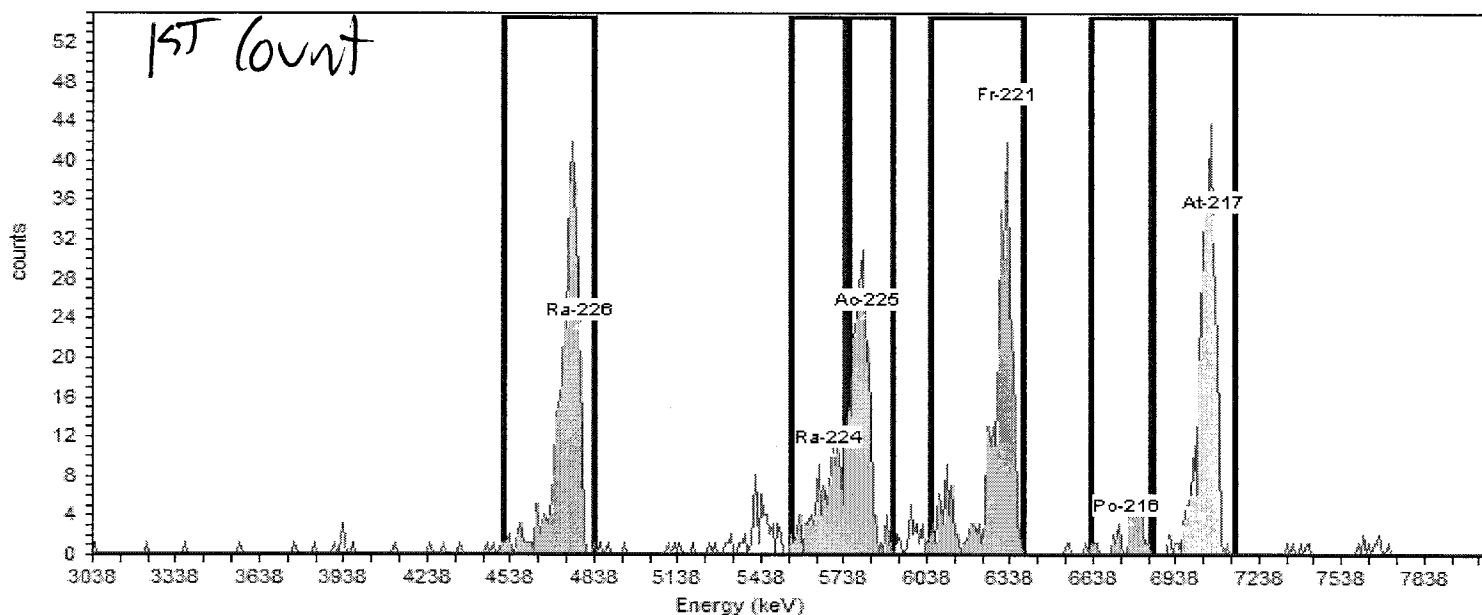
Alpha-Spectroscopy Analysis Report

Sample: 1706286-1D Sample Size : 0.01
Spectrum #1 Analysis #1

Detector: 92 Acquisition Start Date: 6/15/2017 3:35:07PM
Batch Name: RAS170614-1_A Live Time: 1,000.00 min.
Nuclide Library: Radium Real Time: 1,000.00 min.
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226 Dead Time: 0.00 %
ROI Set: Ra224/Ra226

Calibration
Bkgd Info: Sample: B17060792; Det: 92; Spectrum #1; 6/7/2017 11:35:00 AM
Calibration Date: 6/7/2017 10:09:53AM Energy Calibration: C17060792
Efficiency Calibration: C17060792 Energy Cal: Gain = 9.8810 keV / Ch
Efficiency: 29.96% +/- 0.15% TPU(2 sigma) Offset = 3,028.21 keV
Quadratic = 0.0000 keV / Ch²

Tracer Name: At-217 Tracer Nuclide: At-217
Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM Tracer Recovery: 4.38%



Nuclide Summary (ROI)

Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4787.0	4510.4	4836.4	76.2	100.1	305.00	3.00	302.00	1.7E+003	1.7E+002	2.3E+001	6.2E+001
Ra-224	5686.2	5547.9	5745.5	42.7	95.1	113.00	21.00	92.00	5.6E+002	8.4E+001	6.5E+001	1.5E+002
Ac-225	5824.5	5755.4	5913.5	.0	78.3	206.00	11.00	195.00	1.4E+003	1.6E+002	5.7E+001	1.3E+002
Fr-221	6328.5	6051.8	6387.7	51.3	100.0	305.00	30.00	275.00	7.4E+005	1.2E+005	3.5E+004	7.6E+004
Po-216	6763.2	6634.8	6852.1	56.8	100.0	37.00	8.00	29.00	1.7E+002	4.1E+001	3.8E+001	9.1E+001
At-217	7079.4	6862.0	7158.5	57.4	99.9	273.00	11.00	262.00	6.6E+001	4.2E+000	4.4E+001	1.0E+002

JP

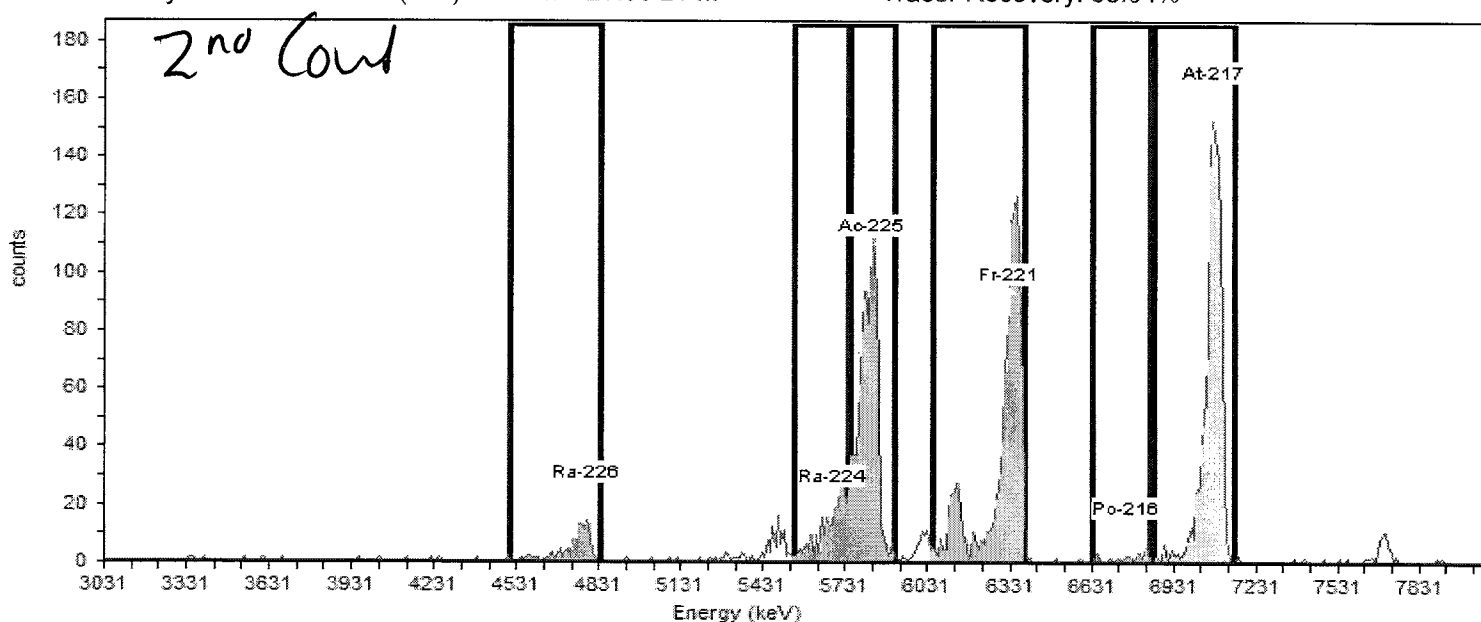
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Alpha-Spectroscopy Analysis Report

Sample		Acquisition	
Sample: 1706286-1D	Sample Size : 0.01		
Spectrum #1	Analysis #1		
Detector: 93		Acquisition Start Date: 6/26/2017 7:12:04AM	
Batch Name: RAS170614-1_B		Live Time: 300.00 min.	
Nuclide Library: Radium		Real Time: 300.00 min.	
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226		Dead Time: 0.00 %	
ROI Set: Ra224/Ra226			

Calibration	
Bkgd Info: Sample: B17062193; Det: 93; Spectrum #1; 6/21/2017 10:10:19 AM	
Calibration Date: 6/21/2017 10:00:49AM	Energy Calibration: C17062193
Efficiency Calibration: C17062193	Energy Cal: Gain = 9.9003 keV / Ch
Efficiency: 30.00% +/- 0.16% TPU(2 sigma)	Offset = 3,021.28 keV
	Quadratic = 0.0000 keV / Ch ²

Tracer	
Tracer Name: At-217	Tracer Nuclide: At-217
Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM	Tracer Recovery: 53.04%



Nuclide Summary (ROI)												
Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4783.5	4506.3	4833.0	25.4	100.1	103.00	1.50	101.50	1.6E+002	1.9E+001	3.6E+000	1.1E+001
Ra-224	5684.5	5545.9	5743.9	121.8	95.1	244.00	8.10	235.90	3.9E+002	3.5E+001	8.8E+000	2.2E+001
Ac-225	5823.1	5753.8	5912.2	71.9	78.3	832.00	7.50	824.50	1.7E+003	1.1E+002	1.0E+001	2.6E+001
Fr-221	6328.0	6050.8	6387.4	46.5	100.0	1,032.00	14.10	1,017.90	2.1E+003	1.4E+002	1.4E+001	3.4E+001
Po-216	6763.6	6634.9	6852.7	20.6	100.0	28.00	5.40	22.60	3.6E+001	9.3E+000	6.9E+000	1.8E+001
At-217	7080.4	6862.6	7159.6	51.9	99.9	961.00	7.20	953.80	8.0E+002	2.6E+001	7.9E+000	2.0E+001

JP

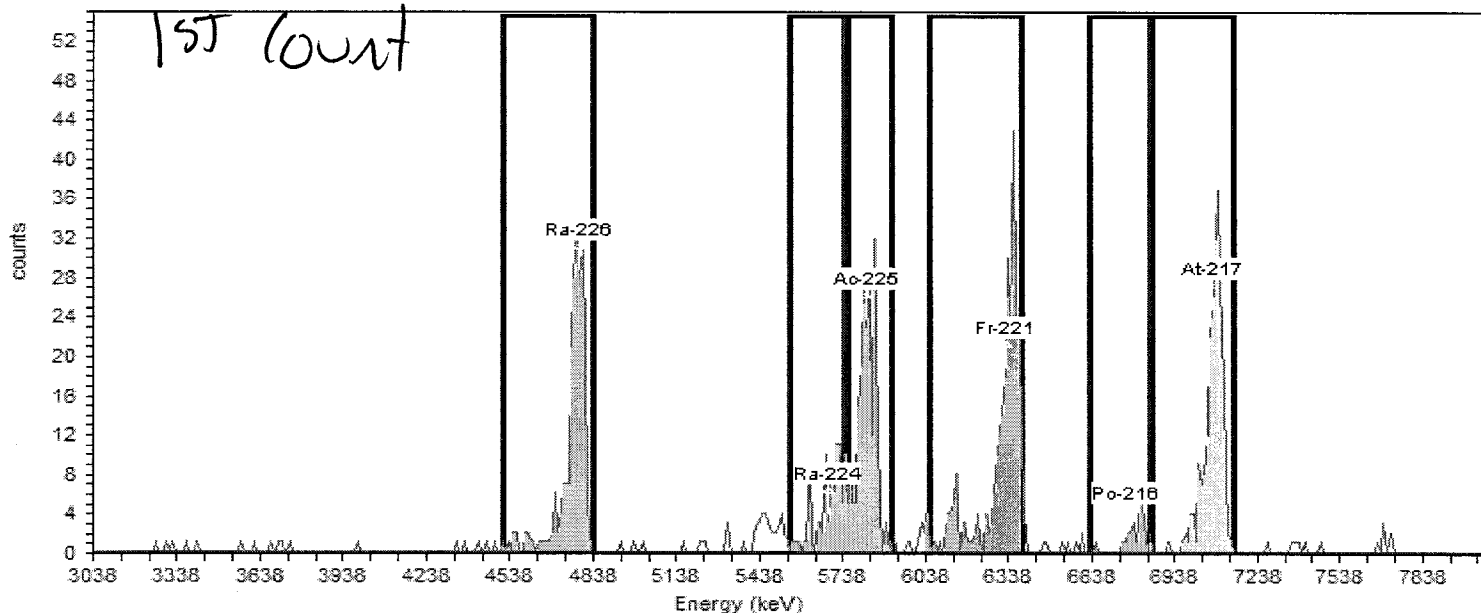
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Alpha-Spectroscopy Analysis Report

Sample		Sample Size : 0.03	
Sample: 1706286-3			
Spectrum #1	Analysis #1		
Acquisition		Acquisition Start Date: 6/15/2017 3:35:07PM	
Detector: 93		Live Time: 1,000.00 min.	
Batch Name: RAS170614-1_A		Real Time: 1,000.01 min.	
Nuclide Library: Radium		Dead Time: 0.00 %	
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226			
ROI Set: Ra224/Ra226			

Calibration	
Bkgd Info: Sample: B17060793; Det: 93; Spectrum #1; 6/7/2017 11:35:00 AM	
Calibration Date: 6/7/2017 10:10:34AM	Energy Calibration: C17060793
Efficiency Calibration: C17060793	Energy Cal: Gain = 9.8810 keV / Ch
Efficiency: 30.51% +/- 0.16% TPU(2 sigma)	Offset = 3,028.21 keV
	Quadratic = 0.0000 keV / Ch ²

Tracer			
Tracer Name: At-217		Tracer Nuclide: At-217	
Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM		Tracer Recovery: 3.28%	



Nuclide Summary (ROI)												
Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4787.0	4510.4	4836.4	32.4	100.1	220.00	3.00	217.00	3.8E+002	4.3E+001	7.0E+000	1.9E+001
Ra-224	5686.2	5547.9	5745.5	451.8	95.1	88.00	24.00	64.00	1.2E+002	2.2E+001	2.1E+001	4.7E+001
Ac-225	5824.5	5755.4	5913.5	70.8	78.3	201.00	23.00	178.00	3.9E+002	4.9E+001	2.5E+001	5.5E+001
Fr-221	6328.5	6051.8	6387.7	49.1	100.0	263.00	50.00	213.00	1.7E+005	3.1E+004	1.3E+004	2.9E+004
Po-216	6763.2	6634.8	6852.1	32.0	100.0	26.00	23.00	3.00	5.2E+000	1.2E+001	1.9E+001	4.3E+001
At-217	7079.4	6862.0	7158.5	52.6	99.9	221.00	21.00	200.00	1.1E+001	8.8E-001	1.8E+001	4.2E+001

JP

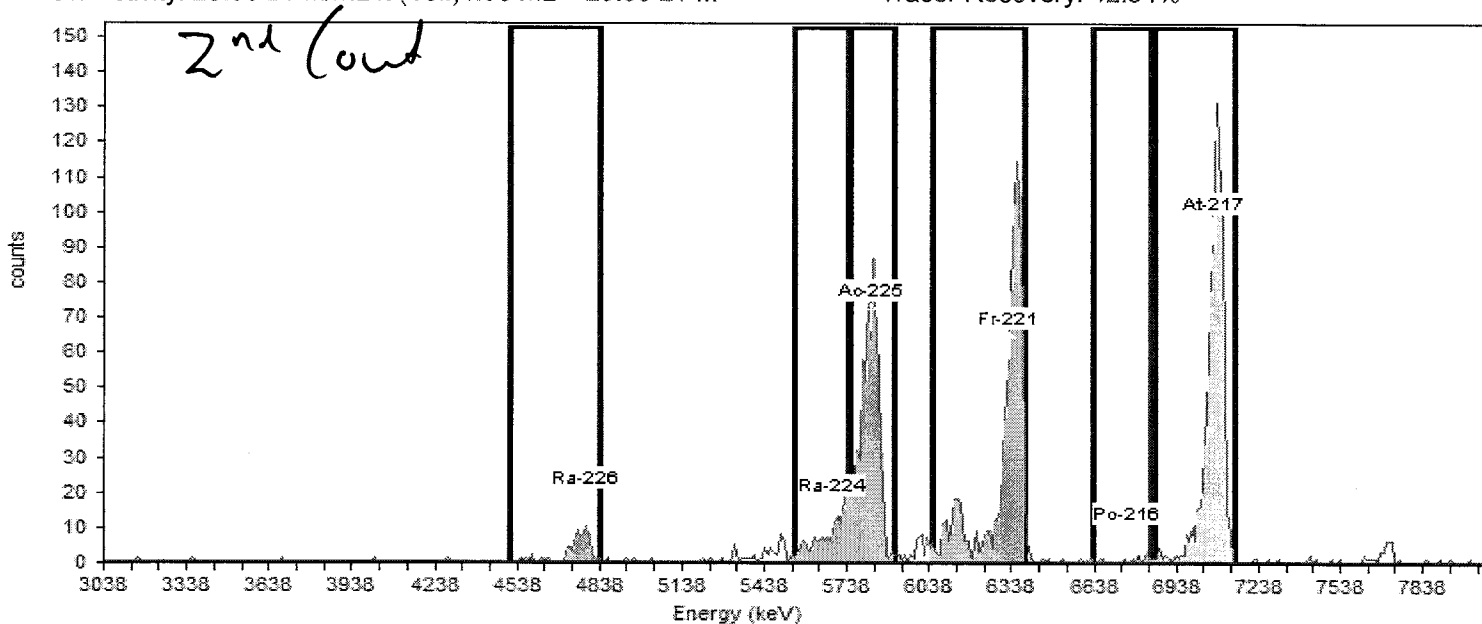
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Alpha-Spectroscopy Analysis Report

Sample		Sample Size : 0.03
Sample: 1706286-3		
Spectrum #1	Analysis #1	
Acquisition		
Detector: 94		Acquisition Start Date: 6/26/2017 7:12:04AM
Batch Name: RAS170614-1_B		Live Time: 300.00 min.
Nuclide Library: Radium		Real Time: 300.02 min.
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226		Dead Time: 0.01 %
ROI Set: Ra224/Ra226		

Calibration		
Bkgd Info: Sample: B17062194; Det: 94; Spectrum #1; 6/21/2017 10:10:19 AM		
Calibration Date: 6/21/2017 10:01:01AM		Energy Calibration: C17062194
Efficiency Calibration: C17062194		Energy Cal: Gain = 9.8810 keV / Ch
Efficiency: 30.35% +/- 0.21% TPU(2 sigma)		Offset = 3,028.21 keV
		Quadratic = 0.0000 keV / Ch ²

Tracer		
Tracer Name: At-217		Tracer Nuclide: At-217
Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM		Tracer Recovery: 42.54%



Nuclide Summary (ROI)												
Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4787.0	4510.4	4836.4	25.8	100.1	71.00	0.90	70.10	3.1E+001	4.3E+000	8.0E-001	2.8E+000
Ra-224	5686.2	5547.9	5745.5	.0	95.1	171.00	9.60	161.40	7.6E+001	7.9E+000	2.7E+000	6.7E+000
Ac-225	5824.5	5755.4	5913.5	75.5	78.3	613.00	6.60	606.40	3.5E+002	2.6E+001	2.8E+000	7.1E+000
Fr-221	6328.5	6051.8	6387.7	47.8	100.0	832.00	12.60	819.40	4.7E+002	3.4E+001	3.8E+000	9.3E+000
Po-216	6763.2	6634.8	6852.1	20.0	100.0	12.00	6.00	6.00	2.7E+000	1.9E+000	2.1E+000	5.3E+000
At-217	7079.4	6862.0	7158.5	52.7	99.9	780.00	6.30	773.70	1.5E+002	5.4E+000	2.1E+000	5.4E+000

JP

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Alpha-Spectroscopy Analysis Report

Sample: RAS170614-1MB
Spectrum #1 Analysis #1

Sample

Sample Size : 0.50

Detector: 81
Batch Name: RAS170614-1_A
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition

Acquisition Start Date: 6/15/2017 3:35:07PM
Live Time: 1,000.00 min.
Real Time: 1,000.03 min.
Dead Time: 0.00 %

Calibration

Bkgd Info: Sample: B17060781; Det: 81; Spectrum #1; 6/7/2017 11:33:04 AM

Calibration Date: 6/7/2017 8:40:46AM

Efficiency Calibration: C17060781

Efficiency: 28.56% +/- 0.16% TPU(2 sigma)

Energy Calibration: C17060781

Energy Cal: Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

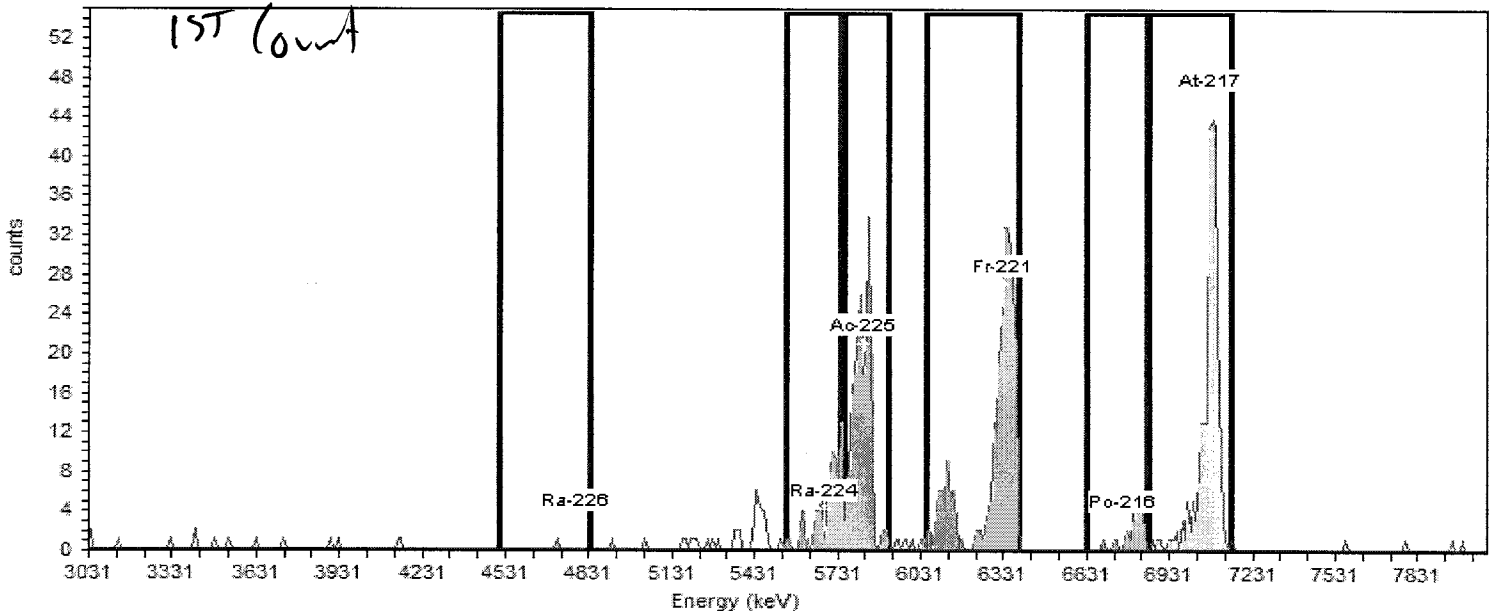
Tracer

Tracer Name: At-217

Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM

Tracer Nuclide: At-217

Tracer Recovery: 4.10%



Nuclide Summary (ROI)

Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4783.5	4506.3	4833.0	59.0	100.1	1.00	3.00	-2.00	-1.5E-001	1.5E-001	3.1E-001	8.3E-001
Ra-224	5684.5	5545.9	5743.9	19.3	95.1	77.00	19.00	58.00	4.7E+000	8.9E-001	8.2E-001	1.9E+000
Ac-225	5823.1	5753.8	5912.2	71.9	78.3	200.00	5.00	195.00	1.9E+001	2.1E+000	5.1E-001	1.3E+000
Fr-221	6328.0	6050.8	6387.4	48.5	100.0	283.00	30.00	253.00	9.2E+003	1.6E+003	4.6E+002	1.0E+003
Po-216	6763.6	6634.9	6852.7	32.8	100.0	29.00	16.00	13.00	1.0E+000	5.2E-001	7.2E-001	1.6E+000
At-217	7080.4	6862.6	7159.6	37.9	99.9	240.00	6.00	234.00	7.4E-001	5.0E-002	4.4E-001	1.1E+000

JP

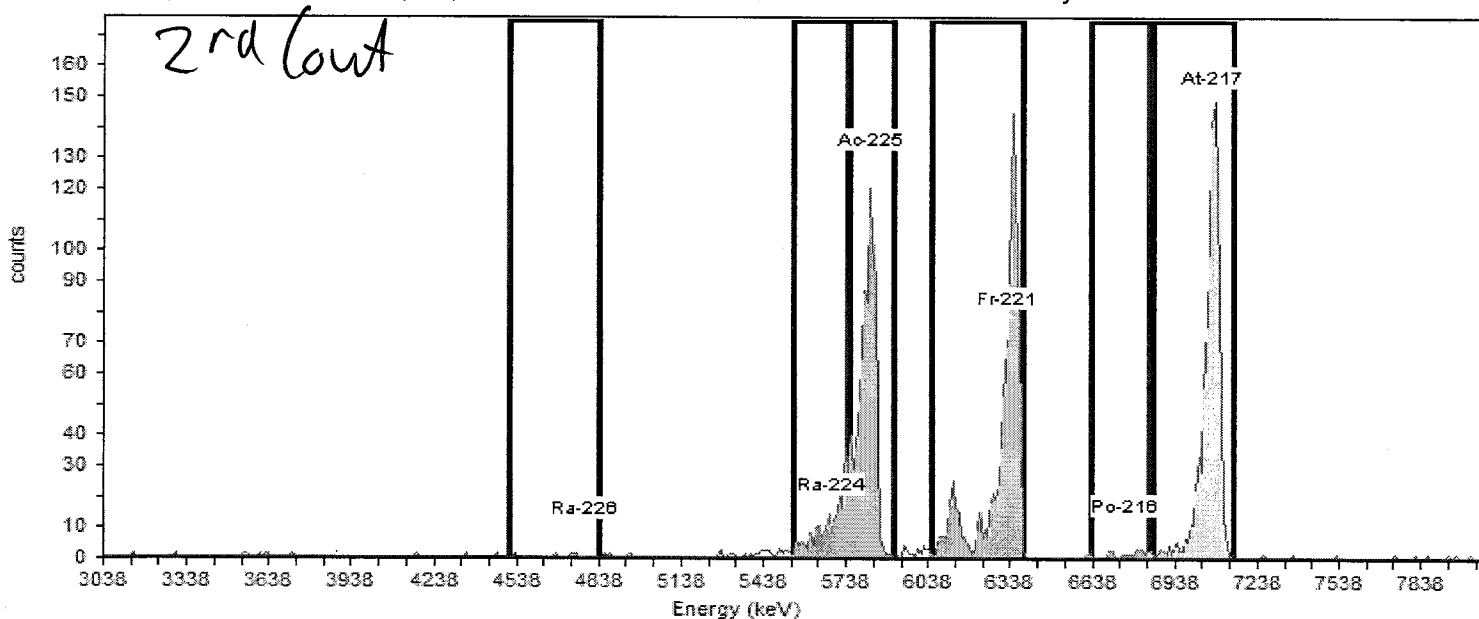
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Alpha-Spectroscopy Analysis Report

Sample	
Sample: RAS170614-1MB	Sample Size : 0.50
Spectrum #1 Analysis #1	
Acquisition	
Detector: 81	Acquisition Start Date: 6/26/2017 7:12:03AM
Batch Name: RAS170614-1_B	Live Time: 300.00 min.
Nuclide Library: Radium	Real Time: 300.00 min.
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226	Dead Time: 0.00 %
ROI Set: Ra224/Ra226	

Calibration	
Bkgd Info: Sample: B17062181; Det: 81; Spectrum #1; 6/21/2017 10:09:36 AM	
Calibration Date: 6/21/2017 9:37:47AM	Energy Calibration: C17062181
Efficiency Calibration: C17062181	Energy Cal: Gain = 9.8810 keV / Ch
Efficiency: 28.37% +/- 0.16% TPU(2 sigma)	Offset = 3,028.21 keV
	Quadratic = 0.0000 keV / Ch ²

Tracer	
Tracer Name: At-217	Tracer Nuclide: At-217
Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM	Tracer Recovery: 50.17%



Nuclide Summary (ROI)												
Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4787.0	4510.4	4836.4	258.4	100.1	5.00	0.60	4.40	9.3E-002	5.0E-002	3.1E-002	1.2E-001
Ra-224	5686.2	5547.9	5745.5	37.5	95.1	225.00	5.70	219.30	4.9E+000	4.5E-001	9.9E-002	2.6E-001
Ac-225	5824.5	5755.4	5913.5	62.3	78.3	756.00	3.00	753.00	2.0E+001	1.4E+000	8.8E-002	2.5E-001
Fr-221	6328.5	6051.8	6387.7	41.6	100.0	920.00	10.80	909.20	2.5E+001	1.7E+000	1.7E-001	4.1E-001
Po-216	6763.2	6634.8	6852.1	22.3	100.0	24.00	5.40	18.60	3.9E-001	1.2E-001	9.2E-002	2.4E-001
At-217	7079.4	6862.0	7158.5	46.4	99.9	857.00	3.90	853.10	9.0E+000	3.1E-001	7.8E-002	2.1E-001

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Alpha-Spectroscopy Analysis Report

Sample: RAS170614-1LCS
Spectrum #1 Analysis #1

Sample Size : 0.50

Detector: 82
Batch Name: RAS170614-1_A
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition

Acquisition Start Date: 6/15/2017 3:35:07PM
Live Time: 1,000.00 min.
Real Time: 1,000.01 min.
Dead Time: 0.00 %

Calibration

Bkgd Info: Sample: B17060782; Det: 82; Spectrum #1; 6/7/2017 11:33:04 AM

Calibration Date: 6/7/2017 8:41:33AM

Efficiency Calibration: C17060782

Efficiency: 28.77% +/- 0.20% TPU(2 sigma)

Energy Calibration: C17060782

Energy Cal: Gain = 9.8810 keV / Ch

Offset = 3,028.21 keV

Quadratic = 0.0000 keV / Ch²

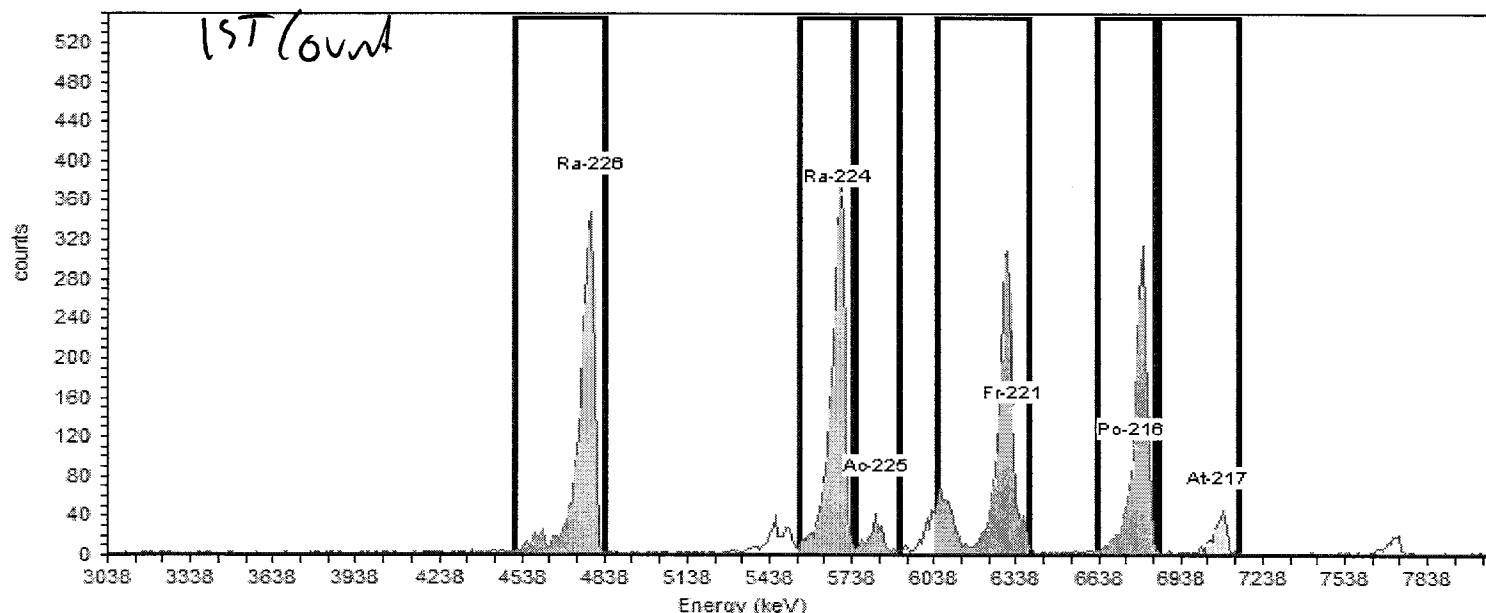
Tracer

Tracer Name: At-217

Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM

Tracer Nuclide: At-217

Tracer Recovery: 4.09%



Nuclide Summary (ROI)

Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4787.0	4510.4	4836.4	25.0	100.1	2,246.00	3.00	2,243.00	1.7E+002	1.5E+001	3.1E-001	8.2E-001
Ra-224	5686.2	5547.9	5745.5	46.2	95.1	2,239.00	39.00	2,200.00	1.8E+002	1.5E+001	1.2E+000	2.6E+000
Ac-225	5824.5	5755.4	5913.5	51.9	78.3	221.00	15.00	206.00	2.0E+001	2.3E+000	8.8E-001	2.0E+000
Fr-221	6328.5	6051.8	6387.7	75.0	100.0	2,314.00	47.00	2,267.00	8.2E+004	1.3E+004	5.8E+002	1.3E+003
Po-216	6763.2	6634.8	6852.1	47.3	100.0	1,721.00	16.00	1,705.00	1.3E+002	1.1E+001	7.1E-001	1.6E+000
At-217	7079.4	6862.0	7158.5	49.5	99.9	241.00	6.00	235.00	7.4E-001	4.9E-002	4.4E-001	1.1E+000

J

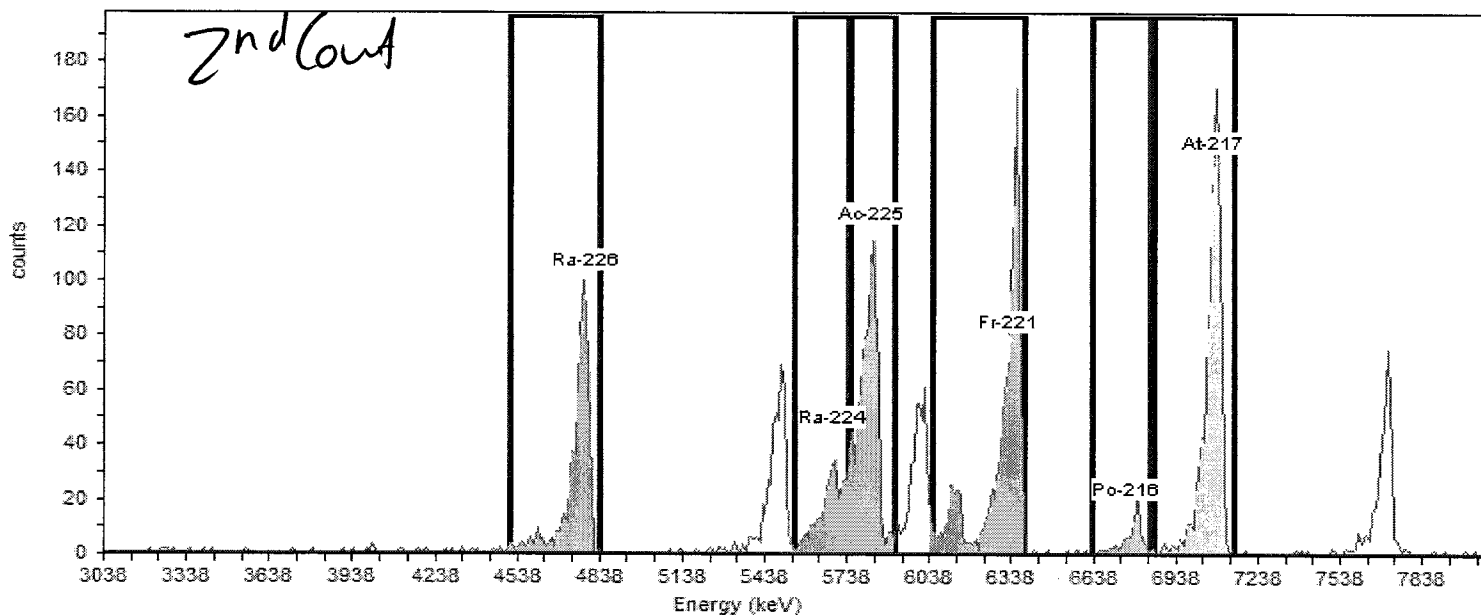
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Alpha-Spectroscopy Analysis Report

Sample		Sample
Sample: RAS170614-1LCS		Sample Size : 0.50
Spectrum #1	Analysis #1	
Acquisition		
Detector: 82		Acquisition Start Date: 6/26/2017 7:12:02AM
Batch Name: RAS170614-1_B		Live Time: 300.00 min.
Nuclide Library: Radium		Real Time: 300.00 min.
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226		Dead Time: 0.00 %
ROI Set: Ra224/Ra226		

Calibration	
Bkgd Info: Sample: B17062182; Det: 82; Spectrum #1; 6/21/2017 10:09:37 AM	
Calibration Date: 6/21/2017 9:37:57AM	Energy Calibration: C17062182
Efficiency Calibration: C17062182	Energy Cal: Gain = 9.8810 keV / Ch
Efficiency: 29.64% +/- 0.21% TPU(2 sigma)	Offset = 3,028.21 keV
	Quadratic = 0.0000 keV / Ch ²

Tracer	
Tracer Name: At-217	Tracer Nuclide: At-217
Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM	Tracer Recovery: 52.78%



Nuclide Summary (ROI)												
Nuclide	Peak Energy keV	ROI Start keV	ROI End keV	FWHM keV	B.R. %	Gross Counts	Bkgd Counts	Net Counts	Activity pCi/L	1.00Sigma TPU pCi/L	Critical Level pCi/L	MDA pCi/L
Ra-226	4787.0	4510.4	4836.4	25.2	100.1	634.00	1.80	632.20	1.2E+001	8.7E-001	4.8E-002	1.5E-001
Ra-224	5686.2	5547.9	5745.5	40.9	95.1	342.00	8.40	333.60	6.7E+000	5.5E-001	1.1E-001	2.7E-001
Ac-225	5824.5	5755.4	5913.5	72.9	78.3	826.00	5.10	820.90	2.0E+001	1.4E+000	1.0E-001	2.7E-001
Fr-221	6328.5	6051.8	6387.7	39.5	100.0	1,052.00	15.60	1,036.40	2.6E+001	1.7E+000	1.8E-001	4.3E-001
Po-216	6763.2	6634.8	6852.1	32.3	100.0	91.00	3.90	87.10	1.7E+000	2.1E-001	7.1E-002	1.9E-001
At-217	7079.4	6862.0	7158.5	45.3	99.9	940.00	2.40	937.60	9.5E+000	3.1E-001	5.6E-002	1.6E-001

ALS

Alpha Spectrometer Instrument Run Log

Date: 6/15/17

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
107	AAS170617-2A	1718015-1	Am S	1000	JP
108		-2			
109		-3			
110		-4			
112		-5			
113		AS170617-2MB			
114		LS			
127	UAS170609-2A	1705485-1	Ur S	1000	JP
128		-2			
130		1705627-1			
131		-2			
132		AS170609-2MB			
81	RAS170614-1A	RAS170614-1MB	R/L W	1000	JP
82		LS			
83		1706271-1			
84		-2			
85		1706270-2			
86		-3			
87		-4			
88		-5			
89		-SD			
90		-6			
91		1706286-1			
92		-1D			

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
93	RAS170614-1A	1706286-3	R/L W	1000	JP
94		1706299-1			
95		-2			
117		1706306-1			
118		-2			
119		-3			
120		-9			
121		-10			
122		-11			
123		-12			
124		1706329-1			
126		-2			
65	PAS170609-2A	1705485-1	R/L S	1000	JP
67		-2			
69		1705627-1			
70		-2			
72		1706059-1			
74		-2			
75		-3			
77		-4			
78		AS170609-2MB			
79		LS			
80		LS			

Notes:

Reviewed by: JP

Date: 6/16/17

471171

ALS


Alpha Spectrometer Instrument Run Log

Date: 6/25/17

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
81	TAS170620-3-B	1706326-6	Th W	1000	✓
82		↓			
83		1706343-2			
84		↓			
85		↓			
86		↓			
87		↓			
88		↓			
89		↓			
90		↓			
91		1706380-2			
93		↓			
94		↓			
95		↓			
117		AS170620-3-MB			
118		↓			
103	PL170623-1-A	1706286-3	Po W	1000	✓
104		↓			
105		1706341-1			
107		↓			
108	B	1706421-1		480	
109	↓	↓			
110	A	1706473-1		1000	
111	↓	1706426-1			
		↓			

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
112	PL170623-1-A	PL170623-1-MB	Po W	1000	✓
113	↓	↓			
81	RAS170614-1-B	RAS170614-1-MB	R, W	300	✓
82		↓			
83		1706271-1			
84		↓			
85		1706278-2			
86		↓			
87		↓			
88		↓			
89		↓			
90		↓			
91		1706286-1			
93		↓			
94		↓			
95		1706299-1			
117		↓			
118		1706306-1			
119		↓			
120		↓			
121		↓			
122		↓			
123		↓			
124		↓			
125		1706329-1			
126		↓			

Notes:

Reviewed by: 
Date: 6/29/17

471177

Section 6

QUALITY ASSURANCE SUMMARY REPORTS

6

QUALITY ASSURANCE SUMMARY SHEET

ALS W.O. # / BATCH

1706271 1706299
1706278 1706306
1706286 1706329 RAS 17064-1

TEST

Ra-224 / Ra-226

METHOD

2 SPEC

SOP/REV (PREP)

701

SOP/REV (ANAL)

714

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.

The samples were analyzed following SOP 701r1 with the following modifications:

- JA 7/7/17
1. The manganese dioxide pre-concentration step was performed by direct precipitation of manganese dioxide in the sample aliquant rather than passing the sample aliquant through manganese dioxide resin.
 2. The sample source was counted twice in order to allow a more accurate measurement of Ra-224. The 1st count was made as soon as possible to minimize Ra-224 decay and also to minimize interference from Ac-225 (progeny of the Ra-225 tracer).
 3. Net Ra-224 counts were determined by subtraction of the instrument background counts and Ac-225 counts estimated to be in the Ra-224 ROI from the Ra-224 gross counts. The Ac-225 contribution to the Ra-224 ROI was calculated by multiplying the Ac-225 counts found during the 1st count by the ratio of Ra-224 net counts to Ac-225 counts found in the 2nd count. This approach gives a sample specific correction for Ac-225 counts in the Ra-224 ROI. The magnitude of the correction is small due to making the 1st count quickly to minimize Ac-225 ingrowth

Samples 1706271-1, 1706271-2, 1706278-5, 1706286-1, 1706286-3, 1706299-1, and 1706299-2 contained Ba concentrations which required reduced aliquant volumes to be analyzed. The aliquant volume was chosen to provide an optimal amount of Ba for making the alpha counting source. Counting sources are made by making Ra/BaSO₄ micro-precipitates. If the micro-precipitate mass is too large (containing more than ~100µg of Ba), alpha particles are attenuated resulting in degraded spectral quality. The Ba concentrations for these samples are given in the raw data section of this report.

Low chemical yields were found for samples 1706329-1 (4%) and 1706329-2 (35%). The low yields were probably caused by high levels of TDS which interfered with the manganese dioxide pre-concentration step. Sample 1706329-1 will be re-prepared and re-analyzed in a later batch. Results for sample 1706329-2 are reported from this batch since spectral quality was good and adequate counts were found for Ra-224, Ra-226 and the tracer (At-217) to provide satisfactory quantification.

TECHNICIAN/ANALYST

JA 7/7/17

Jan Anderson

DATE

7/7/17

DEPARTMENT MANAGER

DR

DATE

7/12/17

RAS170614-1			Ra-224			Ra-224			Ra-224			RAS170614-1			Ra-224		
Ra-224			Ra-224			Ra-224			Ra-224			Ra-224			Ra-224		
1706278-6			1706286-1			1706286-1D			1706286-3			1706299-1			1706299-2		
6/12/17 11:00 AM	0.5	0.008	6/13/17 10:16 AM	0.006	0.028	6/13/17 10:16 AM	0.006	0.028	6/13/17 11:39 AM	0.028	0.028	6/13/17 10:00 AM	0.25	0.1	6/13/17 12:00 PM	0.1	0.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/15/17	0.3	0.3	6/15/17	0.3	0.3	6/15/17	0.3	0.3	6/15/17	0.3	0.3	6/15/17	0.3	0.3	6/15/17	0.3	0.3
12:50 PM	6/15/17	12:50 PM	6/15/17	6/15/17	12:50 PM	6/15/17	6/15/17	12:50 PM	6/15/17	6/15/17	12:50 PM	6/15/17	6/15/17	12:50 PM	6/15/17	6/15/17	6/15/17
90	91	92	92	93	94	93	94	94	94	95	95	95	95	95	95	95	95
6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17
3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17
7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM	7:12 AM
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
0.3089	0.3024	0.2996	0.3024	0.2996	0.3051	0.3051	0.3051	0.3051	0.3051	0.3051	0.3051	0.3051	0.3051	0.3051	0.3051	0.3051	0.3051
0.3078	0.2988	0.3	0.2988	0.3	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
111	103	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113
23	19	21	21	21	24	24	24	24	24	25	25	25	25	25	25	25	25
219	231	206	206	201	201	201	201	201	201	201	201	201	201	201	201	201	201
24	16	11	11	11	23	23	23	23	23	21	21	21	21	21	21	21	21
1009	937	961	961	780	780	780	780	780	780	921	921	921	921	921	921	921	921
2.4	6	7.2	7.2	6.3	6.3	6.3	6.3	6.3	6.3	6	6	6	6	6	6	6	6
236	236	236	236	161	161	161	161	161	161	184	184	184	184	184	184	184	184
819	813	825	825	606	606	606	606	606	606	760	760	760	760	760	760	760	760
32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6
11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08
260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87
0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163
0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763
1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143
13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763
0.83365	0.79161	0.81046	0.81046	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125
0.5090	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125
0.1382	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
0.23013	11.63643	19.24564	19.24564	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195	2.48195
0.0844	6.0020	6.1969	6.1969	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859	1.5859
0.0316	0.0329	0.0326	0.0326	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362
0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561
0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060
0.08567	6.04998	6.32259	6.32259	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463	1.59463
0.16015	12.08677	11.59462	11.59462	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084	3.13084
0.33850	25.52998	24.52627	24.52627	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529	6.63529
#DIV/0!																	

Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224
1706306-3	1706306-9	1706306-10	1706306-11	1706306-12	1706329-1	1706329-2	
6/13/17 2:00 PM	6/13/17 10:40 AM	6/13/17 2:45 PM	6/13/17 11:01 AM	6/13/17 11:00 AM	6/13/17 11:45 AM	6/13/17 9:30 AM	
0.5	0.5	0.5	0.5	0.5	0.5	0.5	
0	0	0	0	0	0	0	
0.3	0.3	0.3	0.3	0.3	0.3	0.3	
6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	
12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	
119	120	121	122	123	124	126	
120	121	122	123	124	125	126	
6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	
3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	
1000	1000	1000	1000	1000	1000	1000	
6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	6/26/17	
7:14 AM	7:14 AM	7:14 AM	1:59 PM	7:14 AM	7:14 AM	7:14 AM	
300	300	300	300	300	300	300	
0.3278	0.3187	0.3243	0.3278	0.3279	0.3345	0.323	
0.3322	0.3255	0.321	0.3196	0.3139	0.3284	0.3437	
1000	1000	1000	1000	1000	1000	1000	
143	120	135	624	554	179	1326	
52	32	28	29	26	18	18	
231	256	251	262	270	49	197	
16	17	28	24	15	19	26	
865	1011	1098	1094	1080	61	481	
5.4	5.4	5.4	5.1	10.2	4.3	4.8	
183	237	244	274	265	16	218	
732	904	927	891	855	53	418	
32.6	32.6	32.6	32.6	32.6	32.6	32.6	
11.08	11.08	11.08	11.08	11.08	11.08	11.08	
260.90	260.90	260.90	267.65	260.90	260.90	260.90	
0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	
0.401782	0.401782	0.401782	0.405552	0.401782	0.401782	0.401782	
1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	
13.0769	13.0769	13.0769	13.1996	13.0769	13.0769	13.0769	
0.65958	0.78749	0.86762	0.86039	0.86873	0.04502	0.35317	
0.6309	0.6144	0.6347	0.6161	0.6161	0.6198	0.6088	
0.1439	0.1626	0.1883	0.1832	0.1851	0.0098	0.0732	
0.25895	0.15584	0.25649	2.84757	2.42612	15.43917	16.65525	
0.0976	0.0763	0.0682	0.1397	0.1304	1.4334	0.5010	
0.0343	0.0317	0.0304	0.0304	0.0308	0.1368	0.0462	
0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	
0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	
0.09906	0.07698	0.07016	0.22990	0.20331	2.69777	1.31409	
0.17626	0.14800	0.12264	0.13615	0.13658	1.37775	0.34720	
0.37002	0.31148	0.25864	0.28604	0.28676	3.00743	0.72877	

RAS170614-1		Ra-226		Ra-226		Ra-226		RAS170614-1		Ra-226		Ra-226	
Ra-226		Ra-226		Ra-226		Ra-226		Ra-226		Ra-226		Ra-226	
1706278-6		1706286-1		1706286-1D		1706286-3		1706299-1		1706299-2		1706306-1	
6/12/17 11:00 AM		6/13/17 10:16 AM		6/13/17 10:16 AM		6/13/17 11:39 AM		6/13/17 10:00 AM		6/13/17 12:00 PM		6/13/17 11:00 AM	
0.5	0.006	0	0.006	0.006	0.026	0.026	0	0.25	0.1	0.5	0.5	0.5	0.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17
12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM
90	91	92	93	94	95	96	97	98	99	100	101	102	103
90	91	92	93	94	95	96	97	98	99	100	101	102	103
6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17
3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017
07:12	07:12	07:12	07:12	07:12	07:12	07:12	07:12	07:12	07:12	07:12	07:12	07:12	07:12
0.3089	0.3024	0.2996	0.3051	0.3051	0.3051	0.3051	0.3051	0.2997	0.3068	0.3068	0.3068	0.3068	0.3068
0.3078	0.2998	0.3000	0.3035	0.3035	0.3035	0.3035	0.3035	0.3068	0.3153	0.3153	0.3153	0.3153	0.3153
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
22	382	305	220	132	132	132	132	132	132	132	132	132	132
2	4	3	3	3	3	3	3	6	7	7	7	3	4
1009	937	961	780	921	921	921	921	921	1083	1083	1083	1056	1029
2.4	7.2	7.2	6.3	6.3	6.3	6.3	6.3	6	6.3	6.3	6.3	4.5	3
32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6
11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08	11.08
260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87	260.87
0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163
0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763	0.401763
1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143
13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763	13.0763
0.8336	0.7916	0.8105	0.6498	0.6498	0.6498	0.6498	0.6498	0.7603	0.8704	0.8704	0.8704	0.8332	0.8102
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.2715	0.0030	0.0031	0.0109	0.0109	0.0109	0.0109	0.0109	0.1201	0.0563	0.0563	0.0563	0.2838	0.2936
0.07365	124.78776	98.28995	19.96005	1.04884	0.88776	0.88776	0.88776	1.04884	0.88776	0.88776	0.88776	0.04229	0.39516
0.0188	6.5027	5.7304	1.3797	0.0985	0.1442	0.1442	0.1442	0.0985	0.1442	0.1442	0.1442	0.0158	0.0382
0.0316	0.0329	0.0326	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0362	0.0309	0.0313
0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561
0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060
0.0194	10.4314	8.5951	1.9222	0.1201	0.1551	0.1551	0.1551	0.1201	0.1551	0.1551	0.1551	0.0160	0.0460
0.018255	2.057635	1.836475	0.519021	0.060253	0.136386	0.136386	0.136386	0.060253	0.136386	0.136386	0.136386	0.019884	0.021233
0.037186	4.233328	3.767777	1.064841	0.124152	0.281027	0.281027	0.281027	0.124152	0.281027	0.281027	0.281027	0.040795	0.043683
#DIV/0!													

Ra-226	Ra-226	Ra-226	Ra-226	Ra-226	Ra-226	Ra-226
1706306-3	1706306-9	1706306-10	1706306-11	1706306-12	1706329-1	1706329-2
6/13/17 2:00 PM	6/13/17 10:40 AM	6/13/17 2:45 PM	6/13/17 11:01 AM	6/13/17 11:00 AM	6/13/17 11:45 AM	6/13/17 9:30 AM
0.5	0.5	0.5	0.5	0.5	0.5	0.5
0	0	0	0	0	0	0
0.3	0.3	0.3	0.3	0.3	0.3	0.3
6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17
12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM	12:50 PM
119	120	121	122	123	124	126
120	121	122	123	124	125	126
6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17	6/15/17
3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM	3:35 PM
1000	1000	1000	1000	1000	1000	1000
6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017	6/26/2017
07:14	07:14	07:14	13:59	07:14	07:14	07:14
300	300	300	300	300	300	300
0.3278	0.3187	0.3243	0.3278	0.3279	0.3345	0.323
0.3322	0.3255	0.3210	0.3196	0.3139	0.3284	0.3437
1000	1000	1000	1000	1000	1000	1000
57	30	54	260	263	1428	1352
1	5	1	2	2	2	4
865	1011	1098	1094	1080	61	481
5.4	5.4	5.4	5.1	10.2	3	4.8
32.6	32.6	32.6	32.6	32.6	32.6	32.6
11.08	11.08	11.08	11.08	11.08	11.08	11.08
260.90	260.90	260.90	267.65	260.90	260.90	260.90
0.031163	0.031163	0.031163	0.031163	0.031163	0.031163	0.031163
0.401782	0.401782	0.401782	0.405552	0.401782	0.401782	0.401782
1.0143	1.0143	1.0143	1.0143	1.0143	1.0143	1.0143
13.0769	13.0769	13.0769	13.1996	13.0769	13.0769	13.0769
0.6596	0.7875	0.8676	0.8604	0.8687	0.0450	0.3532
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.2280	0.2647	0.2967	0.2974	0.3004	0.0159	0.1203
0.24562	0.09446	0.17863	0.86750	0.86890	89.80087	11.20623
0.0340	0.0230	0.0254	0.0546	0.0544	2.3830	0.3064
0.0343	0.0317	0.0304	0.0304	0.0308	0.1368	0.0462
0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561
0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060
0.0376	0.0238	0.0279	0.0780	0.0780	13.5051	0.8729
0.018008	0.025539	0.013838	0.016667	0.016503	0.312164	0.051815
0.035837	0.052604	0.027538	0.033953	0.033617	0.635901	0.106603

Section 7

LABORATORY BENCH SHEETS



Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: RAS170614-1

Prep Procedure: RalSO

Analytical QASS NCR? (Y) N 472128

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	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
7/10	1706271-1	SMP	125	125	ml	pCi/l	62711	83 JP		62711	83 JP		62711			AB
1	1706271-2	SMP	80	80	ml	pCi/l	62712	84		62712	84		62712			
7/10	1706278-2	SMP	500	500	ml	pCi/l	62782	85		62782	85		62782			
1	1706278-3	SMP	500	500	ml	pCi/l	62783	86		62783	86		62783			
1	1706278-4	SMP	500	500	ml	pCi/l	62784	87		62784	87		62784			
1	1706278-5	SMP	250	250	ml	pCi/l	62785	88		62785	88		62785			
1	1706278-5	DUP	250	250	ml	pCi/l	62785D	89		62785D	89		62785D			
1	1706278-6	SMP	500	500	ml	pCi/l	62786	90		62786	90		62786			
7/11	1706286-1	SMP	6	6	ml	pCi/l	62861	91		62861	91		62861			
1	1706286-1	DUP	6	6	ml	pCi/l	62861D	92		62861D	93		62861D			
1	1706286-3	SMP	26	26	ml	pCi/l	62863	93		62863	94		62863			
7/12	1706299-1	SMP	250	250	ml	pCi/l	62991	94		62991	95		62991			
1	1706299-2	SMP	100	100	ml	pCi/l	62992	95		62992	117		62992			
7/12	1706306-1	SMP	500	500	ml	pCi/l	63061	117		63061	118		63061			
1	1706306-2	SMP	500	500	ml	pCi/l	63062	118		63062	119		63062			
1	1706306-3	SMP	500	500	ml	pCi/l	63063	119		63063	120		63063			
1	1706306-9	SMP	500	500	ml	pCi/l	63069	120		63069	121		63069			
1	1706306-10	SMP	500	500	ml	pCi/l	630610	121		630610	122		630610			
1	1706306-11	SMP	500	500	ml	pCi/l	630611	122		630611	123		630611			
1	1706306-12	SMP	500	500	ml	pCi/l	630612	123		630612	124		630612			
7/12	1706329-1	SMP	500	500	ml	pCi/l	63291	124		63291	125		63291			
1	1706329-2	SMP	500	500	ml	pCi/l	63292	125		63292	126		63292			
1	RAS170614-1	MB	500	500	ml	pCi/l	S17061B	81		S17061B	81		S17061B			
1	RAS170614-1	LCS	500	500	ml	pCi/l	S17061L	82		S17061L	82		S17061L			

*Reprep Low yield. See QASS 472128

Spike Solution Information									
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Ra-224	1026.4095.84		9.930	DPM/ml	06/14/17	1	ml	RS-005
S1	Ra-226	1026.4095.84		10.218	DPM/ml	06/14/17	1	ml	RS-005

Prep Procedure: RaSO

Analytical QASS / NCR? (Y / N) 5/1/25

Q1N

477128

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	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				
												S1	Rn-222	1026.4095.84	10.218	DPM/ml	06/14/17	1	ml	RS-005
												S1	Th-232	1026.4095.84	9.930	DPM/ml	06/14/17	1	ml	RS-005

Sample Barcodes

1706271-1 RAS170614-1PS1		1706271-2 RAS170614-1PS2		1706278-2 RAS170614-1PS3	
1706278-3 RAS170614-1PS4		1706278-4 RAS170614-1PS5		1706278-5 RAS170614-1PS6	
1706278-5DUP RAS170614-1PS7		1706278-6 RAS170614-1PS8		1706286-1 RAS170614-1PS9	
1706286-1DUP RAS170614-1PS10		1706286-3 RAS170614-1PS11		1706299-1 RAS170614-1PS12	
1706299-2 RAS170614-1PS13		1706306-1 RAS170614-1PS14		1706306-2 RAS170614-1PS15	
1706306-3 RAS170614-1PS16		1706306-9 RAS170614-1PS17		1706306-10 RAS170614-1PS18	
1706306-11 RAS170614-1PS19		1706306-12 RAS170614-1PS20		1706329-1 RAS170614-1PS23	
1706329-2 RAS170614-1PS24		RAS170614-1MB RAS170614-1PS21		RAS170614-1LCS RAS170614-1PS22	

Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: RAS170614-1

Reporting Units

LabID:	IstGrpName:	RptUnits:
1706299-1	Ra226_224_COGCC	pCi/l
1706329-1	Ra226_224_COGCC	pCi/l
1706286-1	Ra226_224_COGCC	pCi/l
1706271-1	Ra226_224_COGCC	pCi/l
1706306-1	Ra226_224_USGS	pCi/l
1706271-2	Ra226_224_COGCC	pCi/l
1706278-2	Ra226_224_USGS	pCi/l
1706299-2	Ra226_224_COGCC	pCi/l
1706329-2	Ra226_224_COGCC	pCi/l
1706306-2	Ra226_224_USGS	pCi/l
1706278-3	Ra226_224_USGS	pCi/l
1706306-3	Ra226_224_USGS	pCi/l
1706286-3	Ra226_224_COGCC	pCi/l
1706278-4	Ra226_224_USGS	pCi/l
1706278-5	Ra226_224_USGS	pCi/l
1706278-6	Ra226_224_USGS	pCi/l
1706306-9	Ra226_224_USGS	pCi/l
1706306-10	Ra226_224_USGS	pCi/l
1706306-11	Ra226_224_USGS	pCi/l
1706306-12	Ra226_224_USGS	pCi/l

Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: RAS170614-1

Prep Procedure: RalSO

Reviewed By: sdw

Review Date: 6/15/2017

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

Prep QASS / NCR? Y ☒ N

Batch: NA

Prep SOP: PAI 701 Rev: 1

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Steven D. White

Prep Date: 6/14/2017

Prep Dept: RS

Balance: na

Balance: na

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Ingrowth Date/Time	Micro Init	Micro Date	Standards	Prep Notes
1	1	1706271-1	SMP		125	125	Filtered		SW	6/15/17		
2	1	1706271-2	SMP		80	80	Filtered					
3	1	1706278-2	SMP		500	500	As Received					
4	1	1706278-3	SMP		500	500	As Received					
5	1	1706278-4	SMP		500	500	As Received					
6	1	1706278-5	SMP		250	250	As Received					
7	1	1706278-5	DUP		250	250	As Received					
8	1	1706278-6	SMP		500	500	As Received					
9	1	1706286-1	SMP		6	6	Filtered					
10	1	1706286-1	DUP		6	6	Filtered					
11	1	1706286-3	SMP		26	26	Filtered					
12	1	1706299-1	SMP		250	250	Filtered					
13	1	1706299-2	SMP		100	100	Filtered					
14	1	1706306-1	SMP		500	500	As Received					
15	1	1706306-2	SMP		500	500	As Received					
16	1	1706306-3	SMP		500	500	As Received					
17	1	1706306-9	SMP		500	500	As Received					
18	1	1706306-10	SMP		500	500	As Received					
19	1	1706306-11	SMP		500	500	As Received					
20	1	1706306-12	SMP		500	500	As Received					
21	1	1706329-1	SMP		500	500	Filtered					
22	1	1706329-2	SMP		500	500	Filtered					
23	1	RAS170614-1	MB		500	500	As Received					
24	1	RAS170614-1	LCS		500	500	As Received				S1	

TP 7/12/17

Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: RAS170614-1

Prep Procedure: RalSO

Reviewed By: sdw Review Date: 6/15/2017

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

Prep QASS / NCR? Y / N

Prep SOP: PAI 701 Rev: 1

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Steven D. White

Prep Date: 6/14/2017

Prep Dept: RS

Balance: na

Balance: na

Sam Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Ingrowth Date/Time	Micro Init	Micro Date	Standards	Prep Notes
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Comments

Spiked By: Steven D. White Date: 6/14/2017

Witnessed By: Steven D. White Date: 6/14/2017

Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Ra-224	1026.4095.84		9.930	DPM/ml	06/14/17	1	ml	RS-005
S1	Ra-226	1026.4095.84		10.218	DPM/ml	06/14/17	1	ml	RS-005
S1	Rn-222	1026.4095.84		10.218	DPM/ml	06/14/17	1	ml	RS-005
S1	Th-232	1026.4095.84		9.930	DPM/ml	06/14/17	1	ml	RS-005

NA

Ra-224/Ra-226 by Alpha Spectrometry (Aqueous Matrix)

Prep Batch ID: ALS170614-1 Ra-225 Tracer: D 05-24-2017
 Diphonix Resin lot #: 033111DPM
 Ra-224 QC Spike: 50 5-27-2016
 Ra-226 QC Spike: 916.4095.68
 Analyst: Steven D. White
 For LIMS purposes ONLY: QC Spike: 1026.4095.84 (1.0ml)
 1000ppm Ba ID: _____
 Date: 6-15-17 Diphonix Column Separation & Collection Date/Time: 6-15-17 @ 1250
 Duration (minutes): 1,000 Start: _____ @ 1357
 Date: 6-26-17 Refrigeration Date/Time End: _____ @ 1457
 Duration (minutes): 300

Collection Date	Time	pH	Filtered By Client/ALS	ALS Sample ID	Cup ID	Volume (ml)	Tracer Vol (ml)	QC Spike Vol (ml)	1000ppm Ba (ml)	1st Count Detector	2nd Count Detector	Notes/Comments:
na	na	na	na	MB	1	500	0.30	--na--	0.09	81 JP	81 JP	
na	na	na	na	LCS	2	500		0.10	+	82	82	
6-12-17	11:12	~2	ALS	1706271-1	3	125		--na--	0.025	83	83	
	13:10			-2	4	80		--na--	0	84	84	
6-12-17	11:00		Client	1706278-2	5	500		--na--	0.08	85	85	
	13:00			-3	6			--na--	0.05	86	86	
	10:00			-4	7			--na--	0.05	87	87	
	11:40			-5	8	250		--na--	0	88	88	
				-5 bug	9			--na--	+	89	89	
	11:00			-6	10	500		--na--	0.08	90	90	
6-13-17	10:16		ALS	1706286-1	11	6		--na--	0	91	91	
	10:16			-1 bug	12			--na--		92	92	
	11:39			-3	13	26		--na--		93	93	
	10:00				14	2500		--na--		94	94	
6-13-17	12:00				15	100		--na--		95	95	
6-13-17	11:00		Client	1706306-1	16	500		--na--	0.09	117	117	
	10:00			-2	17			--na--	+	118	118	
	14:00			-3	18			--na--	0.03	119	119	
	10:40			-9	19			--na--	+	120	120	
	14:45			-10	20			--na--	0.01	121	121	
	11:01			-11	21			--na--	0.07	122	122	
	11:00			-12	22			--na--	+	123	123	
6-13-17	11:45	~2	ALS	1706329-1	23	500		--na--	0.09	124	124	
	09:30			-2	24			--na--	+	125	125	
					26			--na--		126	126	

Due to low levels sample to be reanalyzed

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	50.0438	20.0555	50.4510	50.2116	50.2756	0.5031	1.0047	5.0503	50.3824	1.0072	1.0077	1.0016
CCB	0.0078	0.0039	0.0028	0.0059	0.0153	0.0001	0.0000	0.0000	0.0031	0.0003	-0.0011	-0.0022
100x Ba/Ca Check #1	-0.0404	-0.0389	-0.0761	-0.0721	6.0980	-0.0007	27.9373	-0.0796	-0.0525	0.0117	0.0000	0.0005
100x Ba/Ca Check #2	-0.0671	-0.0365	-0.0951	-0.0786	7.0931	-0.0009	27.6918	-0.0754	-0.0580	0.0115	-0.0014	-0.0002
100x Ba/Ca Check #3	0.1705	1.6249	-0.0757	23.7204	0.4516	0.0120	28.2280	0.0377	-0.0376	0.0747	0.0561	-0.0023
100x Ba/Ca Check #4	1.3644	-0.0208	-0.0741	0.0460	-0.2970	0.2441	26.6666	-0.0671	-0.0494	0.1029	0.0009	-0.0018
100x Ba/Ca Check #5	1.9594	-0.0373	-0.0769	7.4481	-0.2868	0.0511	27.6633	-0.0545	-0.0420	0.0177	0.0007	-0.0018
100x Ba/Ca Check #6	2.0783	-0.0309	-0.0972	-0.0155	-0.3072	0.0047	28.4191	-0.0838	-0.0253	0.0494	0.0003	-0.0025
100x Ba/Ca Check #7	1.5805	-0.0394	-0.0899	0.0903	-0.3093	0.0040	28.0680	-0.0964	-0.0451	0.0344	0.0002	-0.0018
100x Ba/Ca Check #8	1.6023	0.7954	-0.0757	0.6648	-0.2992	0.0155	27.3747	-0.0754	-0.0444	0.0986	-0.0011	-0.0007
100x Ba/Ca Check #9	1.8650	0.8014	-0.0846	0.4986	-0.3025	0.0162	27.6489	-0.0796	-0.0469	0.0983	0.0004	-0.0011
100x Ba/Ca Check #10	1.4846	0.0350	-0.0842	0.0903	-0.3043	0.0269	27.3427	-0.0922	-0.0488	0.0196	0.0002	-0.0005
100x Ba/Ca Check #11	0.8036	0.2678	-0.0810	-0.0390	-0.3000	0.1606	27.3481	-0.0754	-0.0488	0.1148	0.0001	-0.0022
100x Ba/Ca Check #12	0.9589	0.2834	-0.0846	-0.0128	-0.3004	0.1925	27.7946	-0.1006	-0.0587	0.1188	0.0002	-0.0018
100x Ba/Ca Check #13	2.1534	3.3968	-0.0870	0.0882	-0.2813	0.4032	27.2032	-0.0629	-0.0506	0.0962	-0.0010	-0.0018
100x Ba/Ca Check #14	0.7213	0.0040	-0.0858	0.0588	9.4524	0.0870	28.4097	-0.0796	-0.0562	0.1208	0.0017	-0.0002
100x Ba/Ca Check #15	0.1885	0.0643	-0.0870	-0.0230	6.9065	0.0208	28.0894	-0.1048	-0.0543	0.1194	0.0005	-0.0005
100x Ba/Ca Check #16	2.6015	-0.0232	-0.0830	0.9048	6.4910	0.0291	27.7019	-0.0922	-0.0451	0.0161	0.0011	0.0017
100x Ba/Ca Check #17	1.0511	0.0496	-0.0923	0.6750	-0.3043	0.0087	27.6546	-0.0880	-0.0401	0.0126	-0.0002	-0.0011
100x Ba/Ca Check #18	3.4095	-0.0247	-0.0899	-0.0465	-0.3110	0.0045	26.9229	-0.0796	-0.0518	0.0715	-0.0007	-0.0028
100x Ba/Ca Check #19	3.2943	-0.0355	-0.0773	0.4222	-0.3096	0.0098	27.4787	-0.0754	-0.0500	0.0729	0.0013	-0.0016
100x Ba/Ca Check #20	2.3307	-0.0364	-0.1000	0.5205	-0.3088	0.0117	27.4846	-0.0754	-0.0389	0.0920	-0.0012	-0.0016
100x Ba/Ca Check #21	2.5233	-0.0392	-0.1073	0.6760	-0.3142	0.1225	27.4043	-0.0671	-0.0383	0.0315	0.0012	-0.0025
100x Ba/Ca Check #22	2.9198	-0.0419	-0.1085	0.0321	-0.3173	0.1500	28.2636	-0.0964	-0.0476	0.0327	-0.0002	-0.0013
100x Ba/Ca Check #23	0.3767	0.0293	-0.0874	-0.0764	-0.3209	0.0103	3.3405	-0.0251	-0.0550	0.0007	-0.0017	-0.0026
100x Ba/Ca Check #24	5.3123	-0.0127	-0.0798	-0.0620	-0.3139	0.0652	22.4108	-0.0461	-0.0247	0.0119	0.0009	-0.0010
CCV	50.5319	20.1621	50.6559	50.5633	50.7252	0.5064	1.0113	5.0838	50.7223	1.0103	1.0094	1.0173
CCB	0.0193	0.0085	-0.0061	0.0123	0.0369	0.0002	0.0022	0.0126	0.0229	0.0002	-0.0001	-0.0010

Due to mn levels.

Sample Reanalyzed on 245170615-1

1706329-1

<u>Sample ID</u>	<u>Ba (ppm)</u>	<u>Maximum Aliquot Size for Ra224/Ra226 (mls)</u>	<u>Aliquot Used (mls)</u>	<u>Comments:</u>
1706271-1	0.8260	121	125	
1706271-2	1.2510	80	80	
1706278-1	0.4550	220	225	Not logged in for 224
1706278-2	0.0182	5495	500	
1706278-3	0.0805	1242	500	
1706278-4	0.0491	2037	500	
1706278-5	0.4020	249	250	Duplicate
1706278-6	0.0187	5348	500	
1706286-1	17.3710	6	6	Duplicate
1706286-3	3.8560	26	26	
1706299-1	0.4140	242	250	
1706299-2	1.0630	94	100	
1706306-1	0.0087	11494	500	
1706306-2	0.0013	76923	500	
1706306-3	0.1474	678	500	
1706306-9	0.1585	631	500	
1706306-10	0.1927	519	500	
1706306-11	0.0526	1901	500	
1706306-12	0.0523	1912	500	
1706329-1	0.1019	981	500	
1706329-2	0.0712	1404	500	

SCREENS

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	50.1346	20.0985	50.5398	50.3806	50.3343	0.4964	1.0048	5.0536	50.5037	1.0084	1.0026	1.0090
CCB	0.0038	0.0020	0.0558	-0.0044	0.0151	0.0000	0.0000	0.0313	-0.0094	-0.0002	0.0004	-0.0016
1706278-1	18.2316	0.2525	2.3982	6.7265	24.8746	0.1075	0.0611	5.8705	-0.0390	0.0455	-0.0028	-0.0019
1706278-2	141.7331	-0.0177	18.1516	47.9137	165.7411	2.4265	-0.0022	133.7054	-0.0636	0.0182	-0.0030	-0.0027
1706278-3	105.5417	0.0032	0.8868	2.6348	8.5596	0.1036	-0.0019	5.2411	-0.0107	0.0805	-0.0037	-0.0028
1706278-4	67.2205	-0.0175	0.4097	4.3848	2.8304	0.0619	-0.0018	2.5848	-0.0566	0.0491	-0.0001	-0.0037
1706278-5	82.1038	3.5065	2.3342	26.4886	19.3861	0.4080	0.0630	0.1339	-0.0698	0.4020	-0.0023	-0.0028
1706278-6	29.9766	0.1519	2.0750	3.4103	4.8400	0.1973	0.0764	8.0759	-0.0585	0.0187	-0.0030	-0.0030
CCV	49.5866	19.8743	49.6021	49.8009	49.3355	0.4901	0.9927	5.0357	49.4156	0.9926	0.9803	1.0024
CCB	0.0092	0.0040	0.0697	0.0033	0.0235	0.0000	0.0001	0.0134	-0.0107	-0.0001	-0.0019	-0.0018

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	50.2283	20.0714	50.2236	50.3504	50.1844	0.4993	1.0044	5.0086	50.2816	0.9981	1.0166	1.0017
CCB	0.0057	0.0042	0.0077	0.0000	0.0116	0.0000	0.0001	0.0043	0.0055	0.0001	-0.0016	-0.0013
1000X--1706271-1	0.6236	-0.0088	3.7608	1.0722	65.7657	0.0232	0.0017	0.9665	-0.0388	-0.0001	0.0006	-0.0015
1000X--1706271-2	0.0713	-0.0205	0.0081	-0.0326	4.3522	0.0132	-0.0014	0.0344	-0.0474	0.0002	-0.0011	-0.0008
1000X--1706286-1	0.2060	0.0303	-0.0133	-0.0198	4.3223	0.0424	-0.0011	0.0086	-0.0474	0.0164	0.0000	-0.0020
1000X--1706286-3	0.2713	0.1204	0.0016	-0.0161	6.2738	0.0464	0.0009	0.1804	-0.0566	0.0027	0.0009	-0.0015
CCV	50.5737	20.1677	50.3066	50.5505	50.3898	0.5024	1.0092	5.0644	50.4273	1.0020	1.0096	1.0089
CCB	0.0132	0.0068	0.0433	0.0070	0.0170	0.0001	0.0004	0.0043	0.0086	0.0002	0.0020	-0.0004
100X--1706271-1	6.4414	0.1077	54.0714	10.5302	272.1096	0.2276	0.0314	9.9098	-0.0431	0.0092	0.0023	0.0027
100X--1706271-2	1.2605	-0.0186	0.3389	0.1033	41.7876	0.1399	0.0011	0.3909	-0.0486	0.0118	-0.0010	-0.0012
100X--1706286-1	2.6346	0.4983	0.2528	0.2557	41.9414	0.4316	0.0047	0.0301	-0.0505	0.1755	-0.0023	-0.0012
100X--1706286-3	3.2658	1.4236	0.4675	0.3397	59.0696	0.4739	0.0242	1.8127	-0.0425	0.0384	-0.0022	0.0010
CCV	50.5960	20.1543	50.2265	50.5318	49.8920	0.5006	1.0092	5.1718	50.4403	1.0023	1.0122	1.0064
CCB	0.0298	0.0140	0.0449	0.0241	0.0494	0.0003	0.0010	0.0258	0.0209	0.0006	-0.0014	0.0005
10X--1706271-1	50.9194	1.0259	355.9730	82.7644	208.4972	1.7968	0.2710	93.9991	-0.0843	0.0826	0.0330	0.0214
10X--1706271-2	12.6825	0.0096	5.6232	1.4322	185.9444	1.3567	0.0234	3.8574	-0.0228	0.1251	0.0002	-0.0016
10X--1706286-1	25.9485	5.0259	4.1648	2.9169	208.7660	4.0903	0.0634	0.9536	-0.0498	1.7371	-0.0024	-0.0002
10X--1706286-3	31.4655	13.7031	8.4040	3.6606	247.8745	4.4120	0.2478	18.9605	-0.0356	0.3856	-0.0006	0.0205
CCV	50.3297	19.9867	51.0883	50.7303	48.5961	0.5026	1.0009	6.1985	51.5531	1.0008	1.0046	1.0023
CCB	0.0364	0.0177	0.0433	0.0342	0.1705	0.0004	0.0009	0.2534	0.0345	0.0007	0.0029	0.0001

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	50.3198	20.1203	50.4801	50.4346	50.3898	0.5045	1.0080	5.0213	50.4270	1.0073	1.0066	1.0039
CCB	0.0069	0.0052	0.0024	-0.0016	0.0128	0.0001	0.0001	-0.0171	0.0111	-0.0002	0.0018	-0.0010
1000X--1706299-1	-0.0941	-0.0369	-0.0661	-0.0931	0.8847	-0.0008	-0.0027	-0.0085	-0.0844	-0.0015	0.0007	-0.0029
100X--1706299-1	-0.0574	-0.0357	-0.0281	-0.0846	10.3796	0.0026	-0.0024	0.1280	-0.0814	0.0025	-0.0007	-0.0021
10X--1706299-1	0.2322	-0.0240	0.4467	-0.0326	89.0291	0.0355	-0.0005	1.1263	-0.0740	0.0414	0.0007	-0.0025
1000X--1706299-2	-0.0866	-0.0364	-0.0787	-0.0910	0.6613	-0.0009	-0.0025	-0.0128	-0.0771	-0.0008	-0.0006	-0.0028
100X--1706299-2	-0.0593	-0.0273	-0.0151	-0.0862	7.4800	0.0012	-0.0019	-0.0256	-0.0820	0.0089	-0.0003	-0.0022
10X--1706299-2	0.1795	0.0683	0.4006	-0.0391	67.8379	0.0212	0.0021	0.0555	-0.0820	0.1063	-0.0002	-0.0039
CCV	50.4274	20.1899	50.6963	50.6043	50.6812	0.5078	1.0102	5.0171	50.7477	1.0151	1.0046	1.0120
CCB	0.0144	0.0072	-0.0131	0.0064	0.0120	0.0001	0.0003	-0.0128	0.0130	0.0001	0.0023	-0.0010

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	49.9430	19.9555	49.9546	49.8494	49.8711	0.5015	0.9991	5.0229	49.8026	0.9996	0.9965	1.0032
CCB	0.0071	0.0032	0.0209	0.0089	0.0130	0.0001	0.0005	0.0000	0.0121	0.0003	-0.0009	0.0009
1706306-1	9.8486	-0.0021	1.3487	2.2168	5.1604	0.0784	0.0231	1.6789	-0.0685	0.0087	-0.0011	-0.0018
1706306-2	32.4501	0.1535	1.6883	13.8193	2.5768	0.0817	0.0005	5.2973	-0.0571	0.0013	-0.0007	-0.0026
1706306-3	71.0955	-0.0333	1.2787	1.7600	25.6467	0.0717	-0.0016	9.0302	-0.0654	0.1474	-0.0018	-0.0013
1706306-9	71.7203	-0.0292	0.1696	19.4516	5.1642	0.1781	0.0017	7.2095	-0.0673	0.1585	-0.0043	0.0006
1706306-10	50.4021	-0.0240	1.0548	15.4609	20.2613	0.1833	0.0014	8.8106	-0.0520	0.1927	-0.0045	0.0015
1706306-11	70.9044	-0.0339	2.1840	22.9449	26.9731	2.7081	-0.0017	23.6688	-0.0598	0.0526	-0.0046	-0.0017
1706306-12	70.8332	-0.0344	2.1832	22.9577	26.9351	2.6979	-0.0019	23.4767	-0.0586	0.0523	-0.0021	-0.0027
CCV	48.7621	19.4935	48.8805	48.6907	48.8275	0.4903	0.9752	4.9177	48.6169	0.9792	0.9569	0.9799
CCB	0.0087	0.0027	-0.0056	0.0089	0.0137	0.0002	0.0002	-0.0091	0.0305	0.0003	-0.0012	0.0007

COGCC Screens

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	50.1862	20.0760	50.2630	50.2549	50.2079	0.5037	1.0044	5.0800	50.3510	1.0073	0.9996	0.9998
CCB	0.0051	0.0029	0.0101	0.0077	0.0132	0.0000	0.0000	-0.0050	0.0068	0.0001	0.0013	0.0003
1706329-1	548.3182	0.6652	624.3866	61.3617	189.4180	15.0657	0.0178	318.0100	-0.0788	0.1019	-0.0013	0.0007
1706329-2	431.4371	0.9729	636.2442	50.3555	189.1935	10.3092	0.0390	421.9200	-0.0061	0.0712	0.0024	0.0133
CCV	49.4595	19.8166	50.2167	49.4611	40.3335	0.4980	0.9899	5.1100	49.8907	1.0017	0.9776	0.9929
CCB	0.0649	0.0077	0.0885	0.0101	0.9367	0.0015	-0.0001	0.0300	0.0102	-0.0001	0.0032	0.0002

Section 8

STANDARDS TRACEABILITY DOCUMENTS



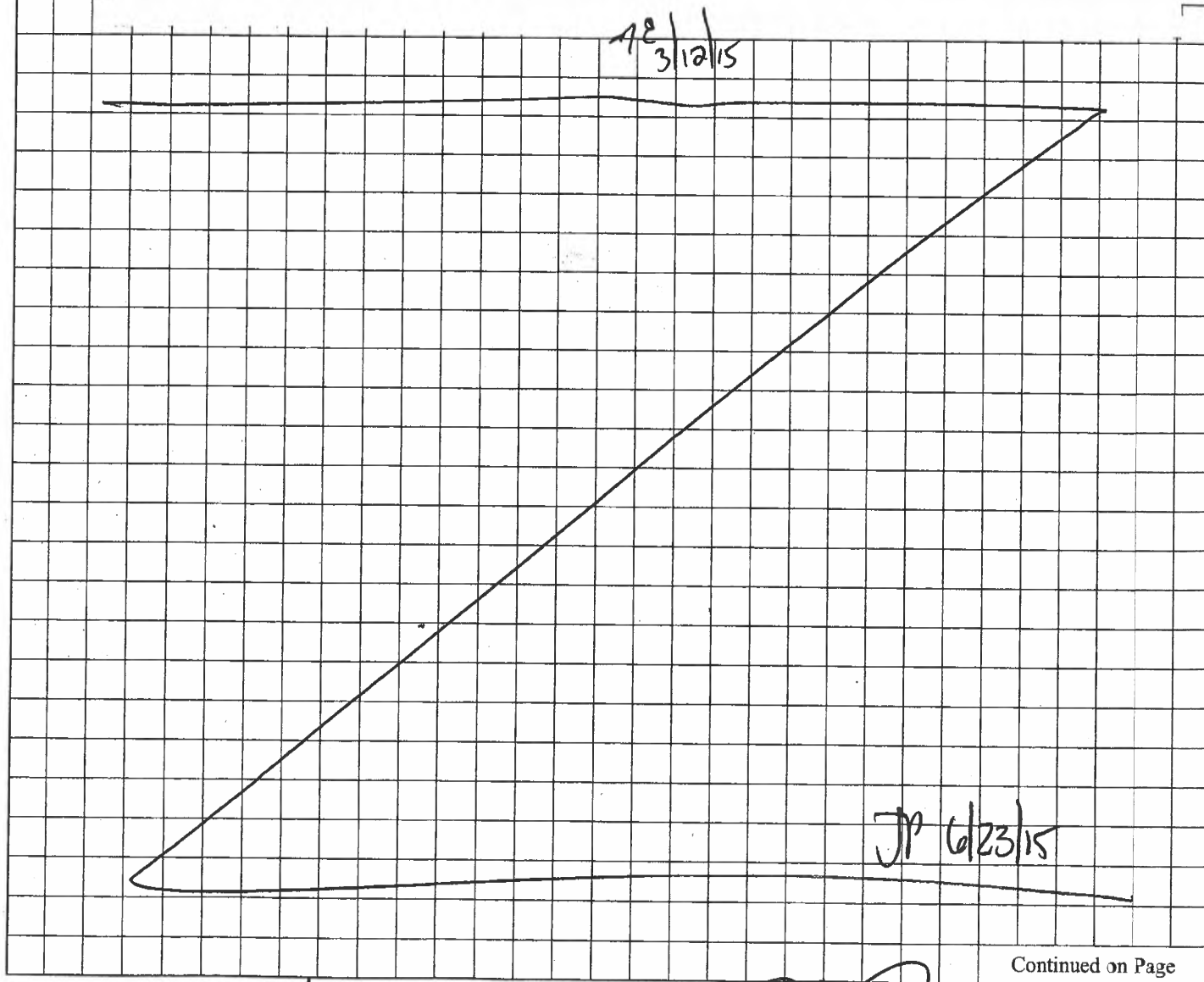
Project 1026.4095.84 Ra224/226 working standard
Continued from Page _____

10dpm/ml QC Spike Solution

2.0ml of 102.5dpm/ml Ra-226 (916.4095.68) and 0.082ml of 2442dpm/ml Ra-224 (ST100301-30) were diluted to 20ml final volume. The Ra-224 stock solution (ST100301-30) is a 10mg/ml Th-232 primary ICP standard in secular equilibrium with Th-228 (and also in secular equilibrium with Ra-224).

The QC spike solution contains:

10.25dpm/ml Ra-226 and 10.0dpm/ml Ra-224



Continued on Page _____

7 RLW

Signed

3/12/15

Date

Read and Understood By

[Signature]

Signed

03/25/15

Date

Project

Continued from Page

916.4095.68

Ra-226 working std

Prepare a working dilution of 916.3610.76

1. Density of 0.1M HCl, lot # 0000092116
 Mass of 100mL vol. flask: 68.3000g Balance # 12
 Mass of flask & 100mL acid: 168.0372g Balance# 12
 Net Mass: 99.7372g
 Density: 0.9974 g/mL

2. Mass of 916.3610.76 transferred:
 Mass of open empty nalgene: 74.5396g Balance# 12
 Mass of nalgene & standard: 77.9525g Balance# 12
 Net mass of standard transferred: 3.4129g Balance#

3. Dilute to final volume:
 Mass of nalgene, standard, & diluent: 1076.1g Balance# 26
 Mass of empty nalgene (from above): 74.5396g Balance# 12
 Net mass of new dilution: 1001.5604g Balance# NA

4. Final activity calculation:

$$30.156 \text{ dpm/g} (0.9974 \text{ g/mL}) \left(\frac{3.4129 \text{ g}}{1001.5604 \text{ g}} \right) = 102.49 \text{ dpm/mL}$$

Std ID: 916.4095.68

Description: Ra-226

Expiration: 1/6/2016

Activity: 102.49 dpm/mL

2s Uncertainty: 5.02 dpm/mL

Ref. Date: 7/1/2010

Ref Time: N/A

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

Matrix/Comp. 0.1M HCl

Half Life (y): 1.60E+03

Reverification Log

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

Continued on Page

Signed

Date

Read and Understood By

Signed

Date

Prepare a intermediate dilution of 916.3610.76

0.1 M HCl dilutant lot # 445A12

Density of diluent

Mass of 100 ml Vol Flask

68.7982 g

12

Flask + Acid

168.0565 g

2

Net

99.7883 g

$\rho = 0.9976 \text{ g/ml}$

Mass of parent transference

Mass of Open Full Ampule + Receptor

38.2022 g

12

Mass of Open Empty Ampule + Receptor

33.2251 g

4

Net

4.9831 g

Dilute to Final Vol./Mass

Mass of Open Empty 40 ml Vol. / 12.1

7.397 g

12

Mass of Vol. Std. + diluent

57.7016 g

1

Net

36.5045 g

Activity, C/L

100 9/27/10

1860 D. R₀ (10 dpm) 4.9831 g
1 R₀ 5.65176 g

36.5045 g

$= \frac{30.156 \text{ g}}{36.5045 \text{ g}} = 0.826$

30.156 g

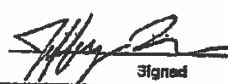
Jan 9/27/10

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Read and Understood By


Signed

9/27/10
Date


Signed

9/27/10
Date



Eckert & Ziegler
Analytics

REC
7/6/10
R50#
9/6

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

CERTIFICATE OF CALIBRATION Standard Radionuclide Source

82863-307

Ra-226 5 mL Liquid in Flame Sealed Vial

Customer: ALS Laboratory Group / Fort Collins
P.O. No.: 73828 08-10-10, Item 1

This standard radionuclide source was prepared gravimetrically from a master solution calibrated by Eckert & Ziegler Analytics, using a germanium gamma spectrometer system. Radionuclide purity and calibration were checked with a germanium gamma spectrometer system. 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 4.18, Revision 1, February, 1979, and compliance with ANSI N42.22-1998, "Traceability of Radioactive Sources to NIST." EZA is accredited by the Health Physics Society (HPS) for the production of NIST-traceable sources, and this source was produced in accordance with the HPS accreditation requirements. Customers may report any concerns with the accreditation program to the HPS Secretariat, 1313 Dolley Madison Blvd., Ste. 402, McLean, VA 22101.

Isotope	Half-Life, Days	Activity (Bq)	Uncertainty*, %			Reference Date (12:00 PM EST)
			u ₁	u ₂	U	
Ra-226	5.344E+08	1.860E+04	0.8	2.4	4.9	07/01/2010

*Uncertainty: U - Relative expanded uncertainty, k = 2. See NIST Technical Note 1287, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results."

Comments:

Impurities: γ -impurities <0.1%. 5.08176 g 0.1M HCl solution with approximately 30 μ g/g Ba carrier.

Source Prepared by:

W. Mao, Radiochemist

QA Approved:

J. D. McCorvey, QA Manager Alternate

Date:

6/30/10

ATA Form 005 Rev. 10

Single Isotope Certificate, Rev 1 9/28/2008

Corporate Office

24937 Avenue Tibbitts Valencia, California 91355



Laboratory

1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

Section 9

ADDITIONAL SUPPORTING DOCUMENTATION

Alpha Spectroscopy

Quality Control Data

Weekly Background, Energy, and Efficiency Calibrations

Calibration Data Summary

Laboratory Name: ALS -- Fort Collins
PAI Work Order: 1706286

Prep SOP: PAI 701

Analytical SOP: PAI 714_Ra226

Reported on: Friday, July 14, 2017
11:12:07 AM

Lab Sample ID Spectrum Analysis Date	QC Type	Batch ID Analysis Run	Test Name	Detector Id	Eff Spectrum Bkg Spectrum Egy Spectrum	Eff Date Bkg Date Egy Date	RESULTS %Efficiency Bkg CPM Energy keV	FLAGS Efficiency Background Energy	LCL %Efficiency Bkg CPM Energy keV	LWL %Efficiency Bkg CPM Energy keV	UWL %Efficiency Bkg CPM Energy keV	UCL %Efficiency Bkg CPM Energy keV
1706286-1 Spectrum #1 6/15/2017	SMP	RAS170614-1 RAS170614-1	RaISO	91	C17060791 B17060791 C17060791	6/7/2017 6/7/2017 6/7/2017	30.24 0.1370 5557.7	Pass Pass Pass	27.93 0.0000 5507.8	28.43 0.0500 5517.8	30.37 0.5000 5597.8	30.87 0.7500 5607.8
1706286-1 Spectrum #1 6/15/2017	DUP	RAS170614-1 RAS170614-1	RaISO	92	C17060792 B17060792 C17060792	6/7/2017 6/7/2017 6/7/2017	29.96 0.1380 5557.7	Pass Pass Pass	28.21 0.0000 5507.8	28.74 0.0500 5517.8	30.76 0.5000 5597.8	31.29 0.7500 5607.8
1706286-3 Spectrum #1 6/15/2017	SMP	RAS170614-1 RAS170614-1	RaISO	93	C17060793 B17060793 C17060793	6/7/2017 6/7/2017 6/7/2017	30.51 0.2020 5557.7	Pass Pass Pass	29.54 0.0000 5507.8	30.09 0.0500 5517.8	31.21 0.5000 5597.8	32.76 0.7500 5607.8
RAS170614-1 Spectrum #1 6/15/2017	MB	RAS170614-1 RAS170614-1	RaISO	81	C17060781 B17060781 C17060781	6/7/2017 6/7/2017 6/7/2017	28.56 0.1300 5555.8	Warning Pass Pass	28.30 0.0000 5505.8	28.86 0.0500 5515.8	30.89 0.5000 5595.8	31.42 0.7500 5605.8
RAS170614-1 Spectrum #1 6/15/2017	LCS	RAS170614-1 RAS170614-1	RaISO	82	C17060782 B17060782 C17060782	6/7/2017 6/7/2017 6/7/2017	28.77 0.3850 5557.7	Pass Pass Pass	27.98 0.0000 5496.0	28.49 0.0500 5506.0	30.51 0.5000 5586.0	31.02 0.7500 5596.0

Data Package ID: RAS1706286-1

Abbreviations:	Eff - Efficiency	Bkg - Background	LCL - Lower Control Limit	UWL - Upper Warning Limit
	Egy - Energy	CPM - Counts per Minute	LWL - Lower Warning Limit	UCL - Upper Control Limit
CI - The Analysis Date exceeds the Calibration Date by more than 14 days.				

Date Printed: Monday, July 17, 2017

ALS -- Fort Collins

LIMS Version: 6.843

Alpha Spectroscopy

Quality Control Data

Weekly Background Calibrations

Alpha Spectroscopy

Quality Control Data

Weekly Energy and Efficiency Calibrations

Alpha Spec Calibration Source Re-Certification

Recalibration performed by Isotope Products Laboratories

Primary Certified Source

Source PA ID: 180
 Planchet Label: 9
 Recalibrated on: 10/4/2016
 Received by ALS on: 10/19/2013

Values from certificate	
Source ID: 92MX223027	
Total Activity: 3745.2 dpm	
Ref. Date: 10/15/2013	

Nuclide	Act (Bq)	Act (dpm)	Half-life (yrs)	Decay Corrected
U-234:	40.54	2972.4	2.48E+05	2972.38 dpm
U-235:	1.09	65.58	7.04E+08	65.58 dpm
Am-241:	11.79	707.4	432.17	704.04 dpm
TOTAL				3741.99 dpm

Efficiency Determination for Detector:

129

Source Serial#	PA ID	Sequential #	Count Date	Am-241 net cts	U-234 net cts	U-235 net cts	count dur (s)	Total cpm	Known dpm	Detector efficiency
92MX223027	180	97-18-103-09	10/4/16	7502	32112	1070	2100	1162.40	3741.99	31.06%

Sources 1 through 8 activity determination

Source Serial#	PA ID	Sequential #	Count Date	Am-241 net cts	U-234 net cts	U-235 net cts	count dur (s)	Detector Efficiency	Am-241 dpm	U-234 dpm	U-235 dpm	Combined dpm
92MX2230326	182	97-18-103-01	10/4/16	12981	79937	2777	2100	31.06%	1193.95	7343.17	255.42	8792.54
92MX2230328	183	97-18-103-02	10/4/16	15085	148128	3863	2100	31.06%	1387.47	13824.37	355.31	15367.15
92MX2230324	184	97-18-103-03	10/4/16	67474	70483	2608	2100	31.06%	6206.06	6482.82	239.88	12928.75
92MX2230321	185	97-18-103-04	10/4/16	21961	60440	2557	2100	31.06%	2019.91	5559.09	235.19	7814.18
92MX2230325	186	97-18-103-05	10/4/16	97983	114458	3780	2100	31.06%	9002.99	10527.51	347.67	19878.16
92MX2230322	187	97-18-103-06	10/4/16	72777	78983	2564	2100	31.06%	6893.81	7347.40	237.67	14278.88
92MX2230323	188	97-18-103-07	10/4/16	43617	68953	2043	2100	31.06%	4011.76	8342.09	187.81	10541.76
92MX2230329	189	97-18-103-08	10/4/16	33968	214074	7185	2100	31.06%	3124.09	19889.89	661.77	23475.75

Efficiency Verification

Source Serial#	PA ID	Sequential #	Count Date	Am-241 net cts	U-234 net cts	U-235 net cts	Count dur (s)	Total cpm	Known dpm	Detector efficiency	RPD	FLAG
92MX223027	180	97-18-103-09	10/5/16	7807	32611	1278	2100	1181.31	3741.99	31.84%	-2.46%	PASS

Sources 1 through 8 activity re-verification

Source Serial#	PA ID	Sequential #	Combined Observed dpm	Combined Certified dpm*	Percent Difference %	Within 5% of Certified value?
92MX2230326	182	97-18-103-01	8792.54	8849.86	-0.65%	Yes
92MX2230328	183	97-18-103-02	15367.15	15992.35	-3.91%	Yes
92MX2230324	184	97-18-103-03	12928.75	13503.77	-4.26%	Yes
92MX2230321	185	97-18-103-04	7814.18	8161.24	-4.25%	Yes
92MX2230325	186	97-18-103-05	19878.16	20979.95	-5.25%	No
92MX2230322	187	97-18-103-06	14278.88	15285.63	-6.56%	No
92MX2230323	188	97-18-103-07	10541.76	10723.95	-1.70%	Yes
92MX2230329	189	97-18-103-08	23475.75	23583.84	-0.50%	Yes

* Certificate values decay corrected to the count date

Data from certificates

Reference Date	U-234 (Bq)	U-234 (dpm)	U-235 (Bq)	U-235 (dpm)	Am-241 (Bq)	Am-241 (dpm)
5/1/2003	124.10	7449.00	2.43	145.74	21.43	1285.80
5/1/2003	236.30	14358.00	4.20	252.00	23.55	1413.00
5/1/2003	119.40	7164.00	1.93	115.56	106.00	6360.00
4/1/2003	101.00	6060.00	1.26	75.84	34.50	2070.00
4/1/2003	203.00	12180.00	3.41	204.72	146.40	8784.00
4/1/2003	132.90	7974.00	3.17	189.96	121.30	7278.00
4/1/2003	107.10	6426.00	0.93	55.54	72.26	4335.80
5/1/2003	334.80	20088.00	6.55	393.18	53.02	3181.20

OK JP
 10/5/16
 Expires
 10/4/2017

Analyst: ORTEC

Detector: 129

9:14:40AM 10/5/2016

Energy Calibration: SOURCE190_10.04.16 (#9)
Description:

Calibration

Analysis Date: 10/4/2016 12:09:56PM
Calibration Type: Energy And Efficiency

Certificate ID: A9 RSO#190
Prepared by: Isotope Product Laboratories
Description:

Source Info

Certification Date: 10/15/2013 10:44:40AM

Acquisition

Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/4/2016 11:26:06AM

Energy Calibration Equation:

Gain = 9.9003 keV / Ch

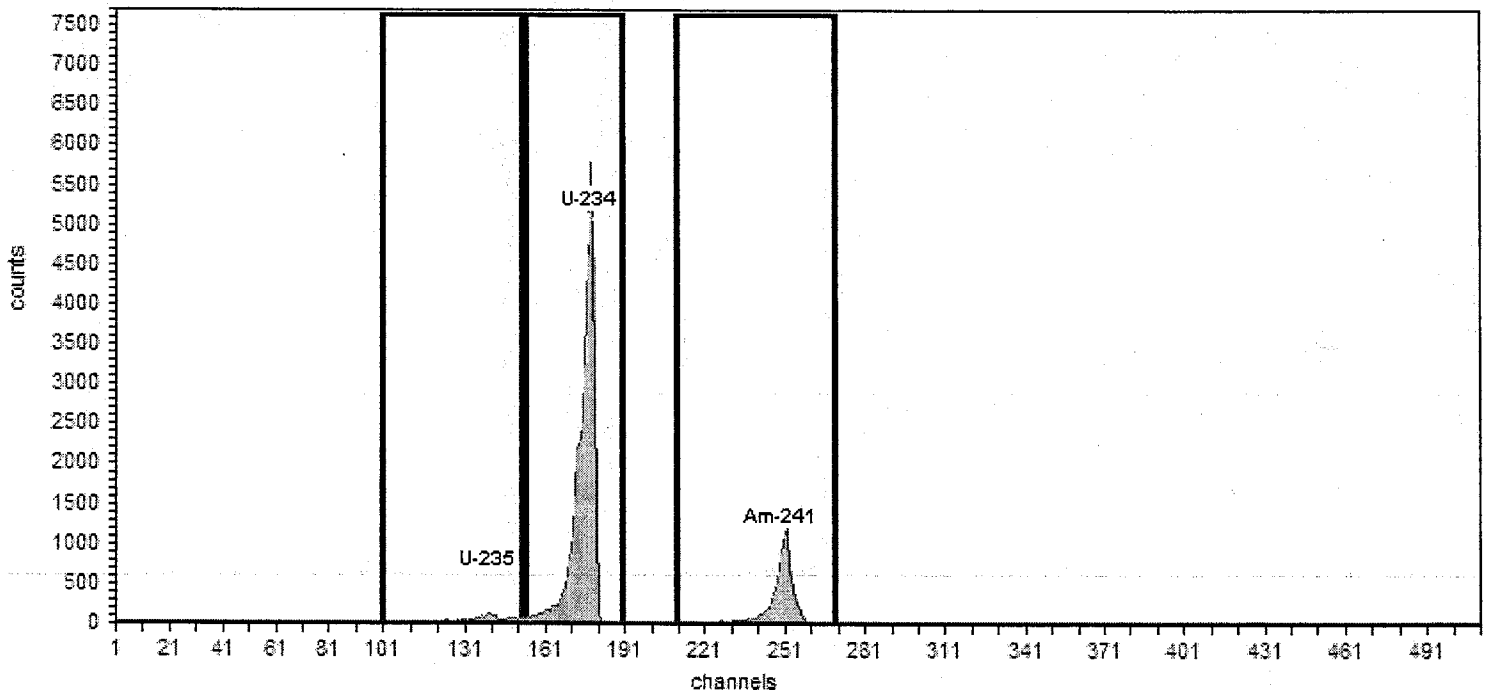
Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

Live Time: 35.00 min.
Real Time: 35.01 min.

Efficiency Calibration Name: SOURCE190_10.04.16 (#9)

Efficiency: 33.86% +/- 1.39% TPU(2 sigma)

**General Analysis**

Method: Manual (ROI)

Initial Calibration: Yes

Algorithm: Linear

Shelf: 0

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-235	139	4,396.00	100	152	0.00	1,070.00	33.71
U-234	177	4,775.80	153	190	68.12	32,112.00	953.94
Am-241	249	5,485.70	210	270	71.83	7,502.00	221.80

JP 10/4/16

Analyst: ORTEC

Detector: 129

12:49:08PM 10/4/2016

Energy Calibration: SOURCE182_10.04.16 (#1)

Description:

CalibrationAnalysis Date: 10/4/2016 12:47:23PM
Calibration Type: Energy And Efficiency

Certificate ID: A1 RSO#182

Prepared by: Isotope Product Laboratories

Description:

Source Info

Certification Date: 5/1/2003 10:27:02AM

Acquisition

Detector: 129, SN:5505430, ID: 129

Acquisition Start Date: 10/4/2016 12:11:42PM

Live Time: 35.00 min.

Real Time: 35.02 min.

Energy Calibration Equation:

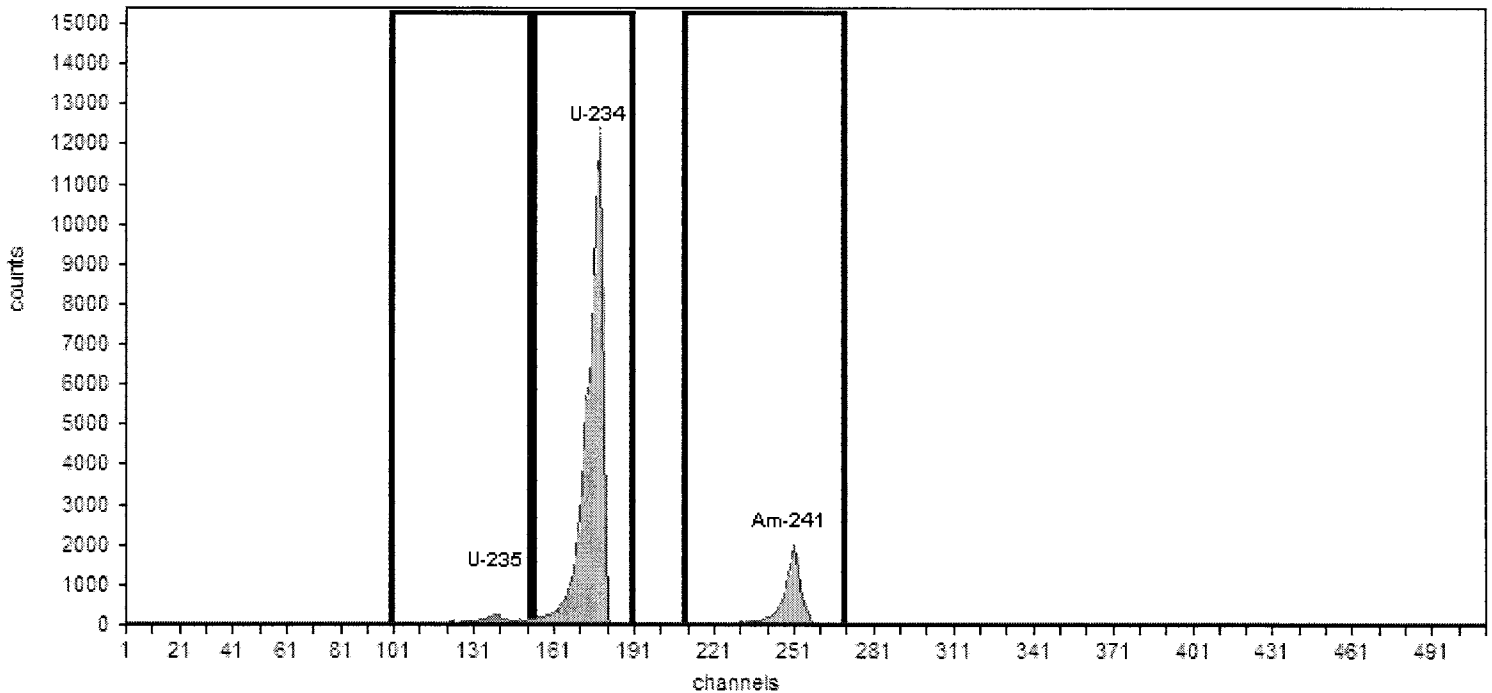
Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

Efficiency Calibration Name: SOURCE182_10.04.16 (#1)

Efficiency: 33.04% +/- 2.03% TPU(2 sigma)

**General Analysis**

Method: Manual (ROI)

Algorithm: Linear

Initial Calibration: Yes

Shelf: 0

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-235	139	4,396.00	100	152	84.43	2,777.00	79.34
U-234	177	4,775.80	153	190	71.29	79,837.00	2,281.06
Am-241	249	5,485.70	210	270	72.86	12,981.00	370.89

JP 10/4/16

Analyst: ORTEC

Detector: 129

1:25:35PM 10/4/2016

Energy Calibration: SOURCE183_10.04.16 (#2)

Description:

Calibration

Analysis Date: 10/4/2016 1:25:29PM
Calibration Type: Energy And Efficiency

Certificate ID: A2 RSO#183

Prepared by: Isotope Product Laboratories

Description:

Source Info

Certification Date: 5/1/2003 10:33:40AM

Acquisition

Detector: 129, SN:5505430, ID: 129

Acquisition Start Date: 10/4/2016 12:49:04PM

Live Time: 35.00 min.

Real Time: 35.03 min.

Energy Calibration Equation:

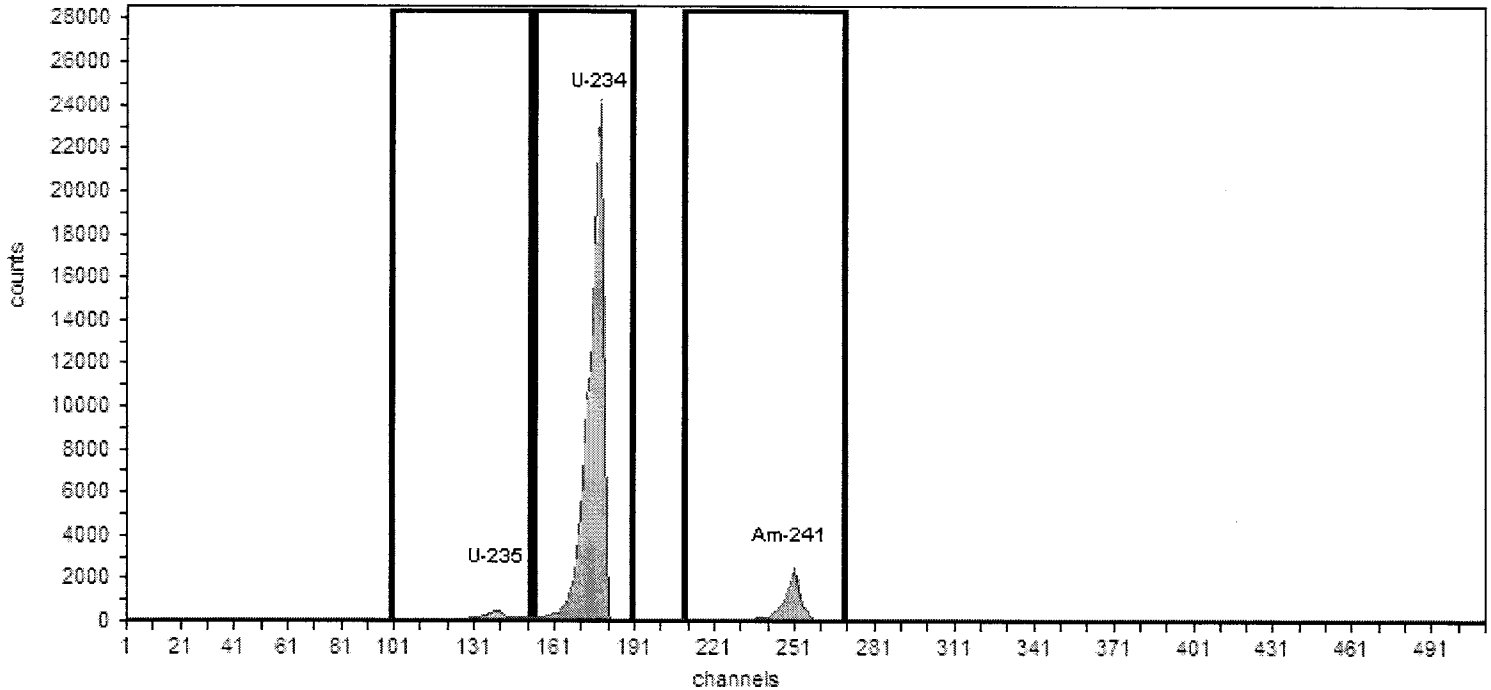
Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

Efficiency Calibration Name: SOURCE183_10.04.16 (#2)

Efficiency: 32.74% +/- 1.25% TPU(2 sigma)



General Analysis

Method: Manual (ROI)

Algorithm: Linear

Initial Calibration: Yes

Shelf: 0

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-235	139	4,396.00	100	152	75.93	3,863.00	110.37
U-234	177	4,775.80	153	190	69.70	148,128.00	4,232.23
Am-241	249	5,485.70	210	270	73.20	15,085.00	431.00

JP 10/4/16

Analyst: ORTEC

Detector: 129

2:17:25PM 10/4/2016

Energy Calibration: SOURCE184_10.04.16 (#3)

Description:

CalibrationAnalysis Date: 10/4/2016 2:16:56PM
Calibration Type: Energy And Efficiency

Certificate ID: A3 RSO#184

Prepared by: Isotope Product Laboratories

Description:

Source Info

Certification Date: 5/1/2003 10:36:52AM

Acquisition

Detector: 129, SN:5505430, ID: 129

Acquisition Start Date: 10/4/2016 1:26:53PM

Live Time: 35.00 min.

Real Time: 35.03 min.

Energy Calibration Equation:

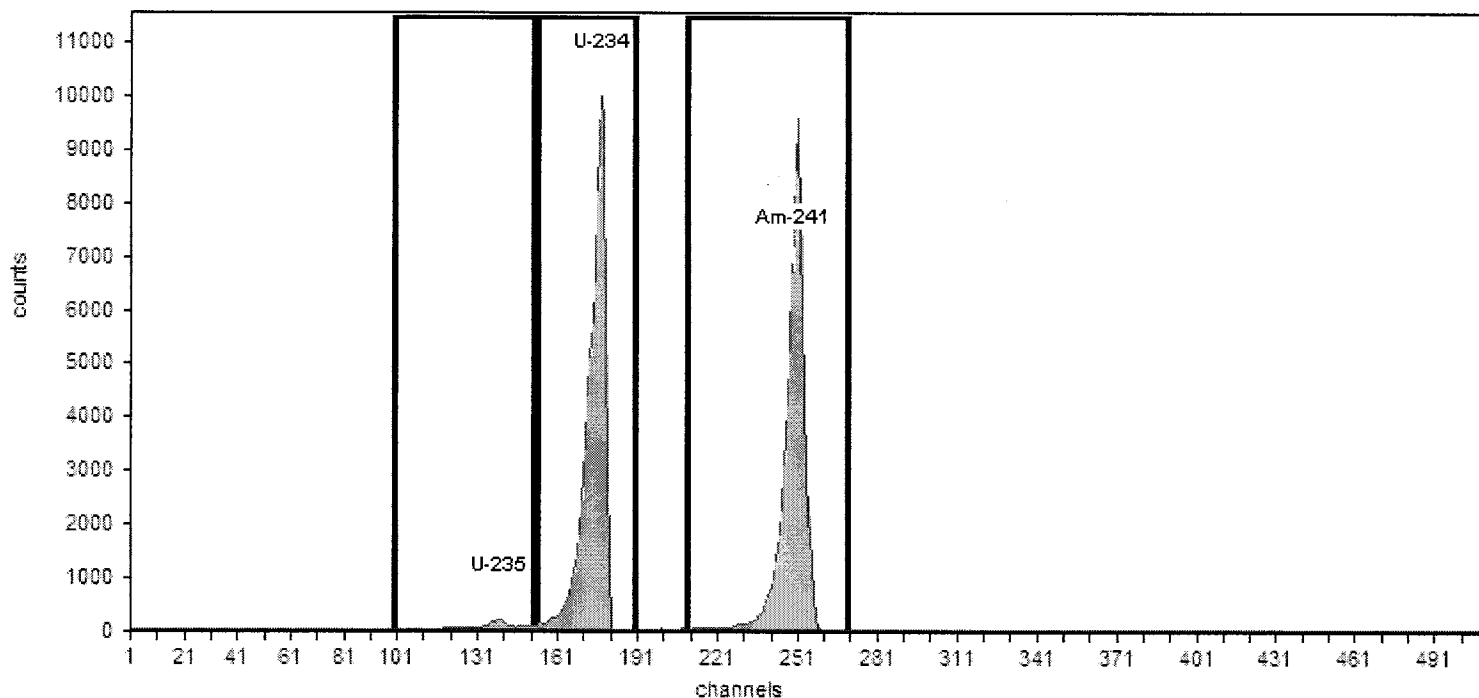
Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

Efficiency Calibration Name: SOURCE184_10.04.16 (#3)

Efficiency: 31.83% +/- 1.26% TPU(2 sigma)

**General Analysis**

Method: Manual (ROI)

Algorithm: Linear

Initial Calibration: Yes

Shelf: 0

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-235	139	4,396.00	100	152	0.00	2,608.00	74.51
U-234	177	4,775.80	153	190	74.20	70,483.00	2,013.80
Am-241	249	5,485.70	210	270	74.76	67,474.00	1,927.83

JP 10/4/16

Analyst: ORTEC

Detector: 129

9:00:58AM 10/5/2016

Energy Calibration: SOURCE185_10.04.16 (#4)

Description:

CalibrationAnalysis Date: 10/4/2016 2:53:33PM
Calibration Type: Energy And Efficiency

Certificate ID: A4 RSO#185

Prepared by: Isotope Product Laboratories

Description:

Source Info

Certification Date: 4/1/2003 10:38:09AM

Acquisition

Detector: 129, SN:5505430, ID: 129

Acquisition Start Date: 10/4/2016 2:18:14PM

Live Time: 35.00 min.

Real Time: 35.02 min.

Energy Calibration Equation:

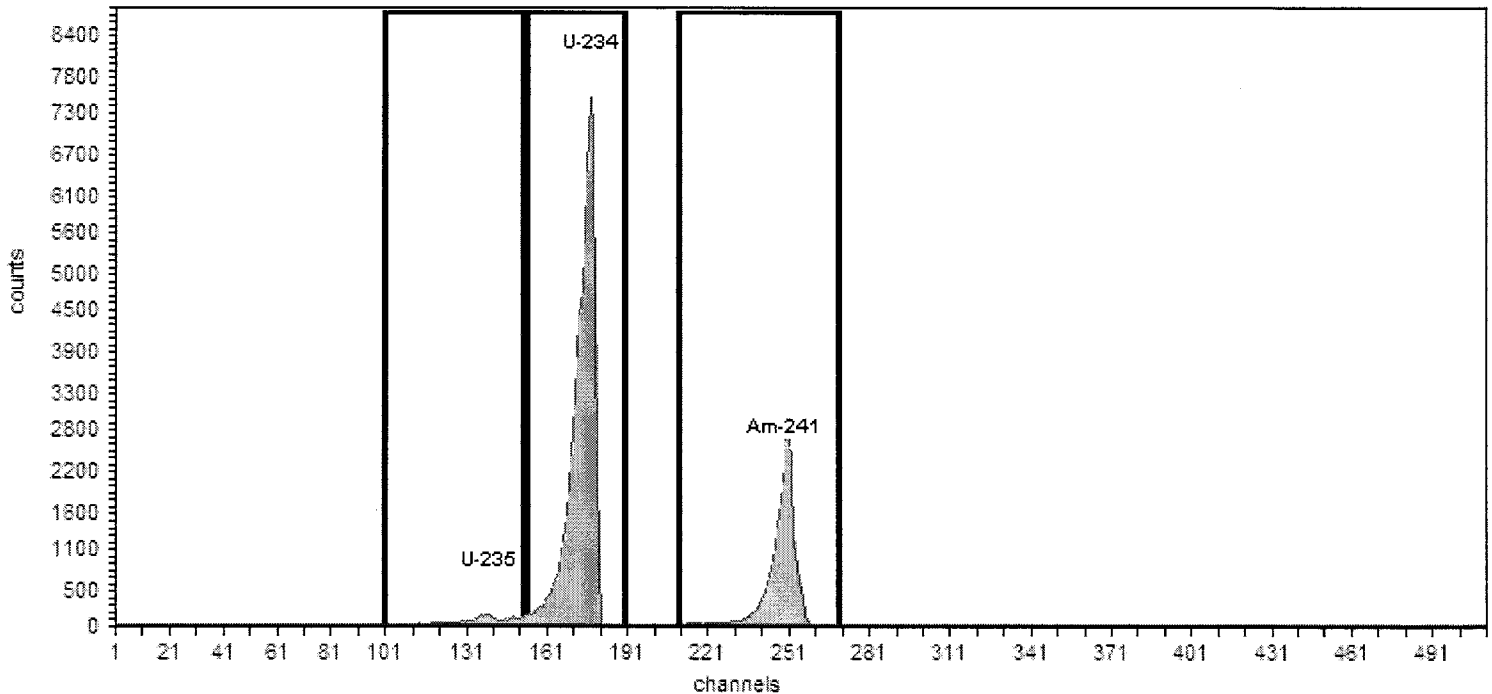
Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

Efficiency Calibration Name: SOURCE185_10.04.16 (#4)

Efficiency: 31.73% +/- 1.30% TPU(2 sigma)

**General Analysis**

Method: Manual (ROI)

Algorithm: Linear

Initial Calibration: Yes

Shelf: 0

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-235	139	4,396.00	100	152	79.20	2,557.00	73.06
U-234	177	4,775.80	153	190	80.97	60,440.00	1,726.86
Am-241	249	5,485.70	210	270	77.99	21,961.00	627.46

Handwritten signature: Jp 10/4/16

Analyst: ORTEC

Detector: 129

7:04:12AM 10/5/2016

Energy Calibration: SOURCE188_10.04.16 (#7)

Description:

CalibrationAnalysis Date: 10/5/2016 7:03:07AM
Calibration Type: Energy And Efficiency

Certificate ID: A7 RSO#188

Prepared by: Isotope Product Laboratories

Description:

Source Info

Certification Date: 4/1/2003 10:42:01AM

Acquisition

Detector: 129, SN:5505430, ID: 129

Acquisition Start Date: 10/5/2016 6:13:44AM

Live Time: 35.00 min.

Real Time: 35.02 min.

Energy Calibration Equation:

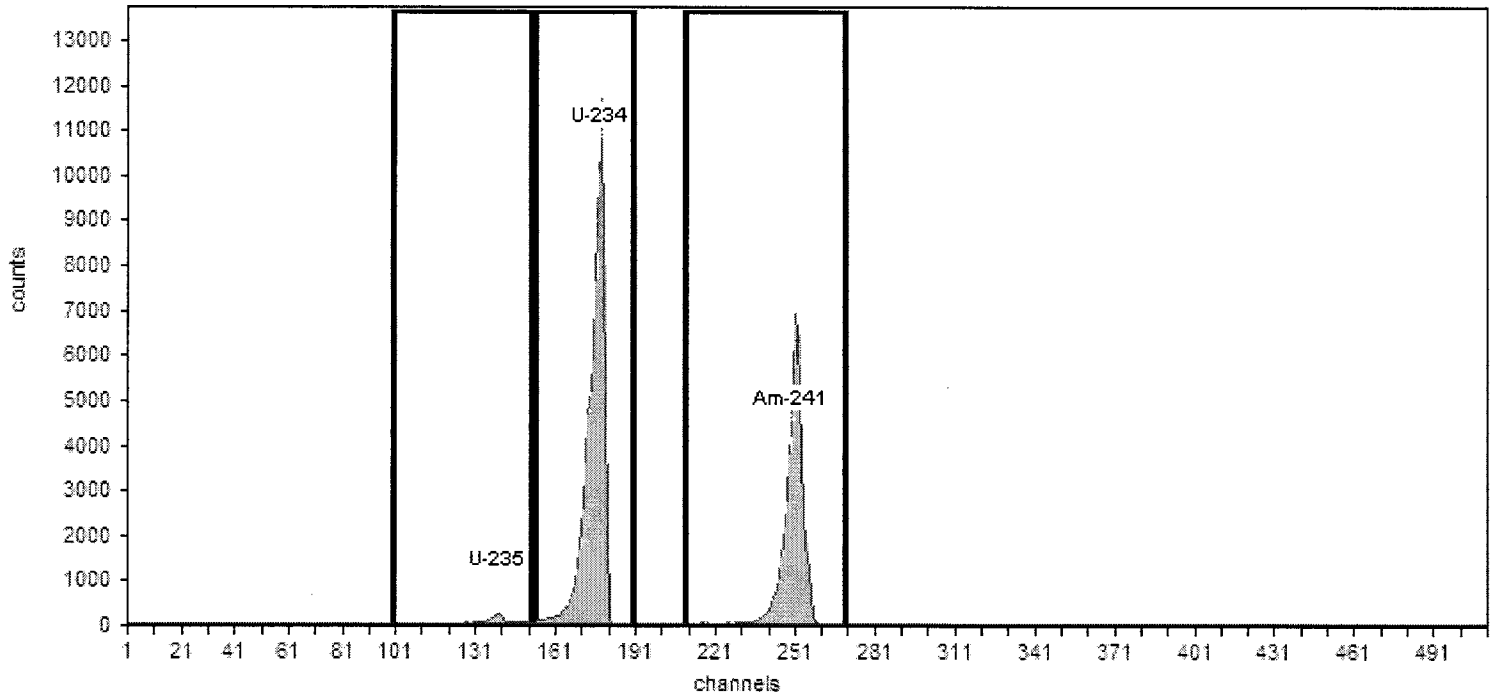
Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

Efficiency Calibration Name: SOURCE188_10.04.16 (#7)

Efficiency: 31.88% +/- 1.31% TPU(2 sigma)

**General Analysis**

Method: Manual (ROI)

Algorithm: Linear

Initial Calibration: Yes

Shelf: 0

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-235	139	4,396.00	100	152	77.73	2,043.00	58.37
U-234	177	4,775.80	153	190	69.01	68,953.00	1,970.09
Am-241	249	5,485.70	210	270	71.83	43,617.00	1,246.20

Analyst: ORTEC

Detector: 129

7:44:05AM 10/5/2016

Energy Calibration: SOURCE189_10.04.16 (#8)

Description:

Calibration

Analysis Date: 10/5/2016 7:43:56AM
Calibration Type: Energy And Efficiency

Certificate ID: A8 RSO#189

Prepared by: Isotope Product Laboratories

Description:

Source Info

Certification Date: 5/1/2003 10:43:18AM

Acquisition

Detector: 129, SN:5505430, ID: 129

Acquisition Start Date: 10/5/2016 7:04:08AM

Live Time: 35.00 min.

Real Time: 35.05 min.

Energy Calibration Equation:

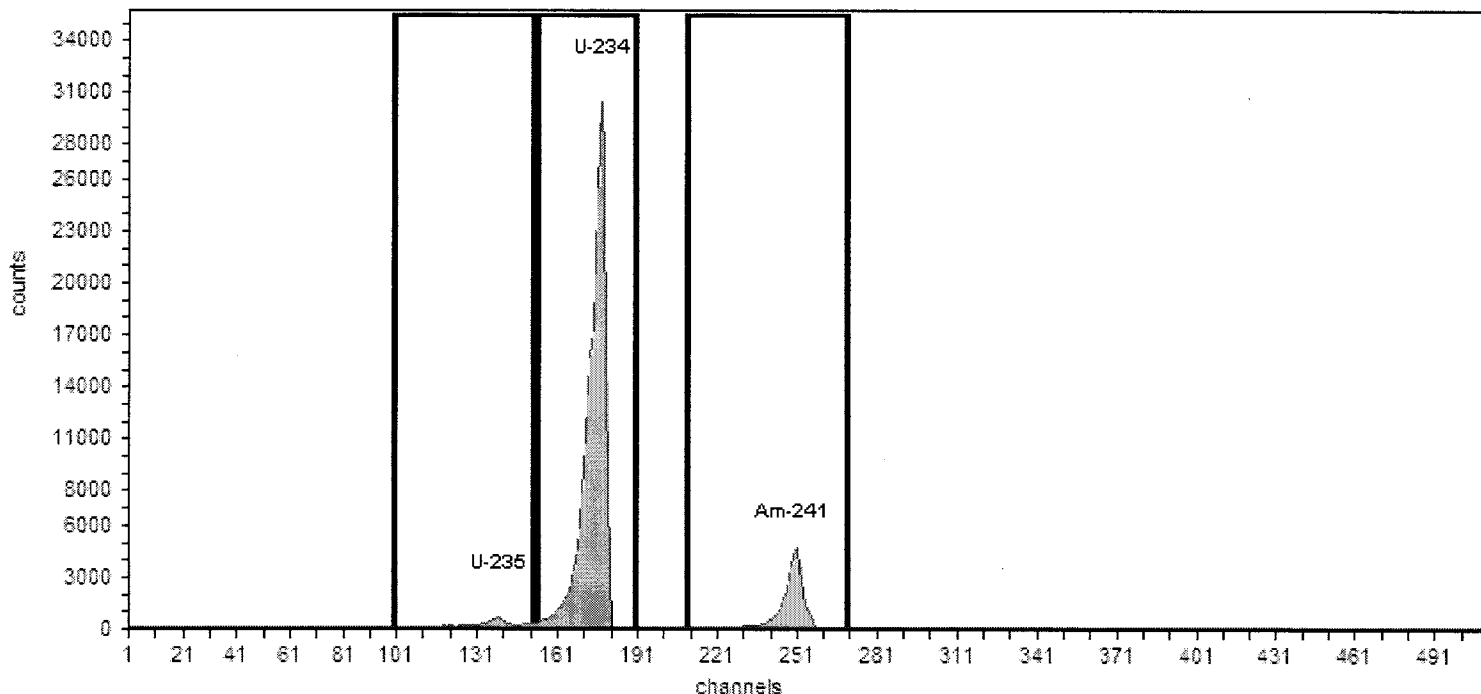
Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

Efficiency Calibration Name: SOURCE189_10.04.16 (#8)

Efficiency: 33.82% +/- 1.28% TPU(2 sigma)



General Analysis

Method: Manual (ROI)

Algorithm: Linear

Initial Calibration: Yes

Shelf: 0

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-235	139	4,396.00	100	152	87.84	7,195.00	205.57
U-234	177	4,775.80	153	190	74.72	214,074.00	6,116.40
Am-241	249	5,485.70	210	270	74.87	33,966.00	970.46

10/4/16

Analyst: ORTEC

Detector: 129

8:36:03AM 10/5/2016

Energy Calibration: SOURCE190A_10.04.16 (#9)
Description:

Calibration

Analysis Date: 10/5/2016 8:35:09AM
Calibration Type: Energy And EfficiencyCertificate ID: A9 RSO#190
Prepared by: Isotope Product Laboratories
Description:

Source Info

Certification Date: 10/15/2013 10:44:40AM

Acquisition

Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/5/2016 7:45:09AM

Energy Calibration Equation:

Gain = 9.9003 keV / Ch

Live Time: 35.00 min.

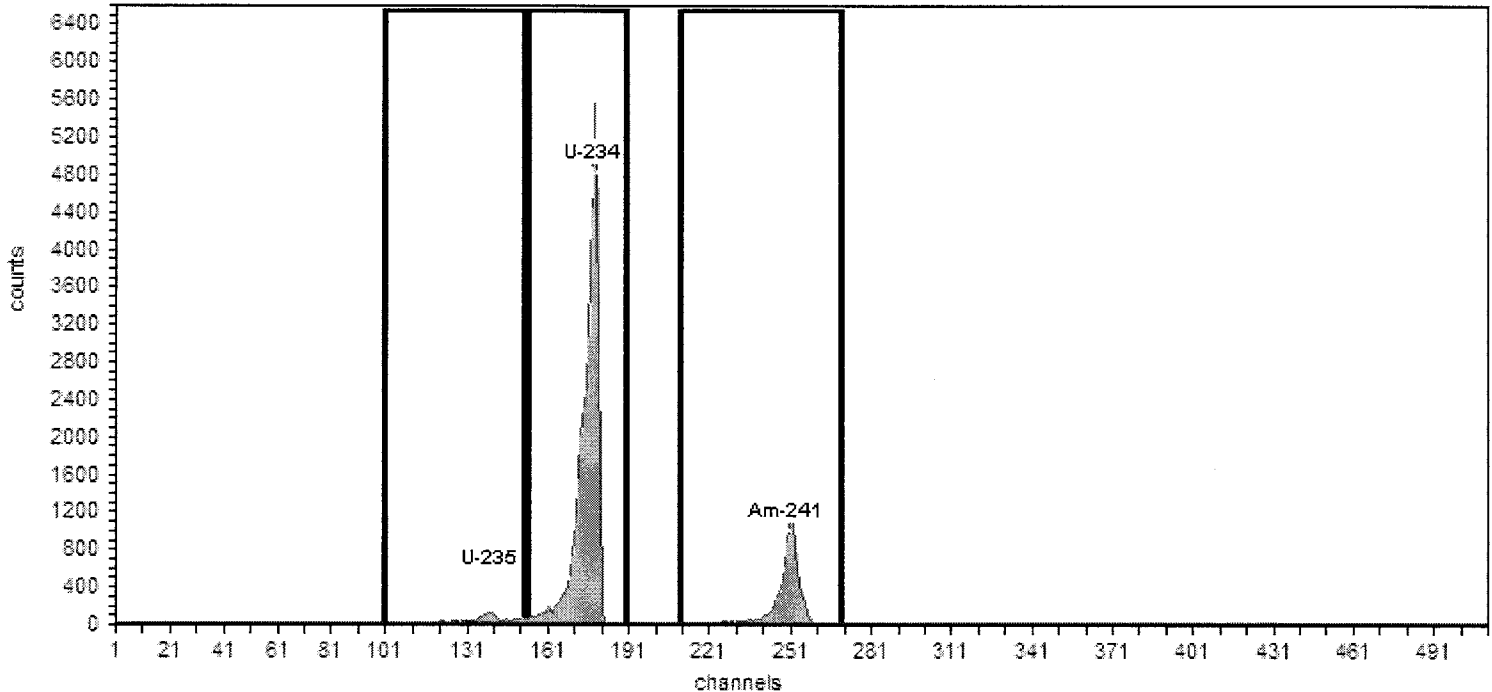
Offset = 3,021.28 keV

Real Time: 35.01 min.

Quadratic = 0.0000 keV / Ch²

Efficiency Calibration Name: SOURCE190A_10.04.16 (#9)

Efficiency: 33.67% +/- 1.38% TPU(2 sigma)



General Analysis

Method: Manual (ROI)

Initial Calibration: Yes

Algorithm: Linear

Shelf: 0

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-235	139	4,396.00	100	152	0.00	1,278.00	36.51
U-234	177	4,775.80	153	190	68.47	32,611.00	931.74
Am-241	249	5,485.70	210	270	71.17	7,807.00	223.06



Eckert & Ziegler

Isotope Products

24937 Avenue Tibbitts
Valencia, California 91355

Tel 661-309-1010

Fax 661-257-8303

#190
Received 10/18/13

CERTIFICATE OF CALIBRATION MIXED ALPHA STANDARD SOURCE

Radionuclide:	U-234	Customer:	ALS LABORATORY
Radionuclide:	U-235	P.O. No.:	FC 3595 / R5576
Radionuclide:	Am-241	Catalog No.:	*SOURCE-RECAL-STD
Half-life (U-234):	(2.454 ± 0.006)E+05 years	Reference Date:	15-Oct-13 12:00 PST
Half-life (U-235):	(7.037 ± 0.011)E+08 years	Source No.:	92MIX223027
Half-life (Am-241):	432.17 ± 0.66 years		

Contained Radioactivity:

U-234:	1.339	nCi,	49.54	Bq	Am-241:	0.3187	nCi,	11.79	Bq
U-235:	0.02954	nCi,	1.093	Bq	Total Activity:	1.687	nCi,	62.42	Bq

Physical Description:

A. Capsule type:	Disk (22 mm OD x 0.79 mm THK)
B. Nature of active deposit:	Electrodeposited and diffusion bonded oxide
C. Active diameter/volume:	19 mm
D. Backing:	Stainless steel
E. Cover:	None

Radioimpurities: Not determined

Method of Calibration:

This source was assayed using a windowless internal gas flow proportional counter for total alpha activity. Individual nuclide ratios were taken from those determined in May 2001.

Uncertainty of Measurement:

A. Type A (random) uncertainty:	± 0.5 %
B. Type B (systematic) uncertainty:	± 3.0 %
C. Uncertainty in aliquot weighing:	± 0.0 %
D. Total uncertainty at the 99% confidence level:	± 3.0 %

Notes:

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (as in NRC Regulatory Guide 4.15).
- Nuclear data was taken from "Table of Radioactive Isotopes", edited by Virginia Shirley, 1986.
- This source has a working life of 2 years.
- This source had a total alpha surface emission rate of 1893 α/min in 2π on 20-Sep-13.


Quality Control

2-OCT-13
Date

IPL Ref. No.: 987-28

ISO 9001 CERTIFIED

Medical Imaging Laboratory

24937 Avenue Tibbitts Valencia, California 91355

Industrial Gauging Laboratory

1800 North Keystone Street Burbank, California 91504

74 of 80



**Isotope Products
Laboratories**

An Eckert & Ziegler Company

24937 Avenue Tibbitts
Valencia, California 91355

Tel 661•309•1010
Fax 661•257•8303

Re Calibrated 10/4/16

New Exp Date 10/4/2017

PAI 1875
recalibrated 4-15-03

10/15/16

CERTIFICATE OF CALIBRATION MIXED ALPHA STANDARD SOURCE

Radionuclide A: U-234
Radionuclide B: U-235
Radionuclide C: Am-241
Half Life (U-234): $(2.454 \pm 0.006)E+05$ years
Half Life (U-235): $(7.037 \pm 0.011)E+08$ years
Half Life (Am-241): 432.17 ± 0.66 years

Customer: PARAGON ANALYTICS, INC.
P.O. No.: EW040203/R2193
Catalog No.: MISC-STD
Reference Date: 1-May-03 12:00 PST
Source No.: 92MIX2203026

Contained Radioactivity:

U-234:	3.354 nCi (124.1 Bq)	Am-241:	0.5793 nCi (21.43 Bq)
U-235:	0.06566 nCi (2.429 Bq)	Total Activity:	3.999 nCi (148.0 Bq)

Physical description:

A. Capsule type:	Disk (22 mm OD X 0.79 mm THK)
B. Nature of active deposit:	Electrodeposited and diffusion bonded oxides
C. Active Diameter:	19 mm
D. Backing:	Stainless steel
E. Cover:	None

Radioimpurities:

Not determined

Method of Calibration:

This source was assayed using a windowless internal gas flow proportional counter for total alpha activity. Individual nuclide ratios were taken from those determined in Mar 1998.

Uncertainty of Measurement:

A. Type A (random) uncertainty:	$\pm 0.7\%$
B. Type B (systematic) uncertainty:	$\pm 3.0\%$
C. Uncertainty in aliquot weighing:	$\pm 0.0\%$
D. Total uncertainty at the 99% confidence level:	$\pm 3.1\%$

Notes:

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Nuclear data was taken from "Table of Radioactive Isotopes", edited by Virginia Shirley, 1986.
- This source has a working life of 2 years.
- This source had a total alpha surface emission rate of 4483 α /min in 2 π on 11 Apr 03.

Daniel James Van Dalsem
Quality Control

15-Apr-03
Date Signed

IPL Ref. No.: 987-7

ISO 9001 CERTIFIED

Medical Imaging Laboratory
24937 Avenue Tibbitts Valencia, California 91355

Industrial Gauging Laboratory
1800 North Keystone Street Burbank, California 91504



**Isotope Products
Laboratories**

An Eckert & Ziegler Company

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Valencia, California 91355

Tel 661-309-1010
Fax 661-257-8303

Re-Calibrated 10/4/16
New Exp Date 10/4/2017

PAI 183
Recalibrated 4-15-03

CERTIFICATE OF CALIBRATION MIXED ALPHA STANDARD SOURCE

Radionuclide A: U-234
Radionuclide B: U-235
Radionuclide C: Am-241
Half Life (U-234): $(2.454 \pm 0.006)E+05$ years
Half Life (U-235): $(7.037 \pm 0.011)E+08$ years
Half Life (Am-241): 432.17 ± 0.66 years

Customer: PARAGON ANALYTICS, INC.
P.O. No.: EW040203/R2193
Catalog No.: MISC-STD
Reference Date: 1-May-03 12:00 PST
Source No.: 92MIX2203028

Contained Radioactivity:

U-234: 6.467 nCi (239.3 Bq)
U-235: 0.1135 nCi (4.200 Bq)

Am-241: 0.6366 nCi (23.55 Bq)
Total Activity: 7.217 nCi (267.1 Bq)

Physical description:

A. Capsule type:	Disk (22 mm OD X 0.79 mm THK)
B. Nature of active deposit:	Electrodeposited and diffusion bonded oxides
C. Active Diameter:	19 mm
D. Backing:	Stainless steel
E. Cover:	None

Radiopurities:

Not determined

Method of Calibration:

This source was assayed using a windowless internal gas flow proportional counter for total alpha activity. Individual nuclide ratios were taken from those determined in Aug 1992.

Uncertainty of Measurement:

A. Type A (random) uncertainty:	$\pm 0.7\%$
B. Type B (systematic) uncertainty:	$\pm 3.0\%$
C. Uncertainty in aliquot weighing:	$\pm 0.0\%$
D. Total uncertainty at the 99% confidence level:	$\pm 3.1\%$

Notes:

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Nuclear data was taken from "Table of Radioactive Isotopes", edited by Virginia Shirley, 1986.
- This source has a working life of 2 years.
- This source had a total alpha surface emission rate of 8091 α /min in 2π on 11 Apr 03.

Daniel James Van Dalsen
Quality Control

15-Apr-03
Date Signed

IPL Ref. No.: 987-7

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Re-Calibrated 10/4/16
New Exp Date 10/4/2017
PAT I.D. 184
recalibrated 4-15-03

CERTIFICATE OF CALIBRATION MIXED ALPHA STANDARD SOURCE

Radionuclide A: U-234
Radionuclide B: U-235
Radionuclide C: Am-241
Half Life (U-234): $(2.454 \pm 0.006)E+05$ years
Half Life (U-235): $(7.037 \pm 0.011)E+08$ years
Half Life (Am-241): 432.17 ± 0.66 years

Customer: PARAGON ANALYTICS, INC.
P.O. No.: EW040203/R2193
Catalog No.: MISC-STD
Reference Date: 1-May-03 12:00 PST
Source No.: 92MIX2203024

Contained Radioactivity:

U-234: 3.227 nCi (119.4 Bq)
U-235: 0.05205 nCi (1.926 Bq)

Am-241: 2.866 nCi (106.0 Bq)
Total Activity: 6.145 nCi (227.3 Bq)

Physical description:

A. Capsule type: Disk (22 mm OD X 0.79 mm THK)
B. Nature of active deposit: Electrodeposited and diffusion bonded oxides
C. Active Diameter: 19 mm
D. Backing: Stainless steel
E. Cover: None

Radioimpurities:

Not determined

Method of Calibration:

This source was assayed using a windowless internal gas flow proportional counter for total alpha activity. Individual nuclide ratios were taken from those determined in Aug 1992.

Uncertainty of Measurement:

A. Type A (random) uncertainty: $\pm 0.6\%$
B. Type B (systematic) uncertainty: $\pm 3.0\%$
C. Uncertainty in aliquot weighing: $\pm 0.0\%$
D. Total uncertainty at the 99% confidence level: $\pm 3.1\%$

Notes:

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Nuclear data was taken from "Table of Radioactive Isotopes", edited by Virginia Shirley, 1986.
- This source has a working life of 2 years.
- This source had a total alpha surface emission rate of 6889 α/min in 2π on 11 Apr 03.

Daniel James Van Dalsem
Quality Control

15-Apr-03
Date Signed

IPL Ref. No.: 987-7

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Recalibrated 10/4/16
New Exp Date 10/4/2017
JP 10/5/16

PAI ID 00185
rec'd from recalibrator
3-28-03

CERTIFICATE OF CALIBRATION ALPHA STANDARD SOURCE

Radionuclide A: U-234
Radionuclide B: U-235
Radionuclide C: Am-241
Half Life (U-234): $(2.454 \pm 0.006)E+05$ years
Half Life (U-235): $(7.037 \pm 0.011)E+08$ years
Half Life (Am-241): 432.17 ± 0.66 years

Customer: PARAGON ANALYTICS, INC.
P.O. No.: EW030603/R2155
Catalog No.: MISC-STD
Reference Date: 1-Apr-03 12:00 PST
Source No.: 92MIX2203021

Contained Radioactivity:

U-234: 2.731 nCi (101.0 Bq)
U-235: 0.03416 nCi (1.264 Bq)

Am-241: 0.9325 nCi (34.50 Bq)
Total Activity: 3.698 nCi (136.8 Bq)

Physical description:

A. Capsule type: Disk (22 mm OD X 0.79 mm THK)
B. Nature of active deposit: Electrodeposited and diffusion bonded oxides
C. Active Diameter: 19 mm
D. Backing: Stainless steel
E. Cover: None

Radioimpurities:

Not determined

Method of Calibration:

This source was assayed using a windowless internal gas flow proportional counter for total alpha activity. Individual nuclide ratios were taken from those determined in Aug 1992.

Uncertainty of Measurement:

A. Type A (random) uncertainty: $\pm 0.8\%$
B. Type B (systematic) uncertainty: $\pm 3.1\%$
C. Uncertainty in aliquot weighing: $\pm 0.0\%$
D. Total uncertainty at the 99% confidence level: $\pm 3.2\%$

Notes:

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Nuclear data was taken from "Table of Radioactive Isotopes", edited by Virginia Shirley, 1986.
- This source has a working life of 2 years.
- This source had a total alpha surface emission rate of 4145 α /min in 2 π on 18 Mar 03.

Daniel James Van Dalsem
Quality Control

19-Mar-03
Date Signed

IPL Ref. No.: 987-2

Medical Imaging Laboratory
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Re Calibrated 10/4/16
New Exp Date 10/4/2017
JP10516
PAID 188
rec'd for recalibration
3-28-03

CERTIFICATE OF CALIBRATION ALPHA STANDARD SOURCE

Radionuclide A: U-234
Radionuclide B: U-235
Radionuclide C: Am-241
Half Life (U-234): $(2.454 \pm 0.006)E+05$ years
Half Life (U-235): $(7.037 \pm 0.011)E+08$ years
Half Life (Am-241): 432.17 ± 0.66 years

Customer: PARAGON ANALYTICS, INC.
P.O. No.: EW030603/R2155
Catalog No.: MISC-STD
Reference Date: 1-Apr-03 12:00 PST
Source No.: 92MIX2203023

Contained Radioactivity:

U-234:	2.895 nCi (107.1 Bq)	Am-241:	1.953 nCi (72.26 Bq)
U-235:	0.02502 nCi (0.9257 Bq)	Total Activity:	4.873 nCi (180.3 Bq)

Physical description:

A. Capsule type:	Disk (22 mm OD X 0.79 mm THK)
B. Nature of active deposit:	Electrodeposited and diffusion bonded oxides
C. Active Diameter:	19 mm
D. Backing:	Stainless steel
E. Cover:	None

Radioimpurities:

Not determined

Method of Calibration:

This source was assayed using a windowless internal gas flow proportional counter for total alpha activity. Individual nuclide ratios were taken from those determined in Aug 1992.

Uncertainty of Measurement:

A. Type A (random) uncertainty:	$\pm 0.8\%$
B. Type B (systematic) uncertainty:	$\pm 3.1\%$
C. Uncertainty in aliquot weighing:	$\pm 0.0\%$
D. Total uncertainty at the 99% confidence level:	$\pm 3.2\%$

Notes:

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Nuclear data was taken from "Table of Radioactive Isotopes", edited by Virginia Shirley, 1986.
- This source has a working life of 2 years.
- This source had a total alpha surface emission rate of 5463 α /min in 2π on 18 Mar 03.

Daniel James Van Dalsem
Quality Control

19-Mar-03
Date Signed

IPL Ref. No.: 987-2

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ReCalibrated 10/4/16
New Exp Date 10/4/2017
JP 10/5/16

PAI ID 189
rec'd 4-21-03
recalibrated 4-15-03

CERTIFICATE OF CALIBRATION MIXED ALPHA STANDARD SOURCE

Radionuclide A: U-234
Radionuclide B: U-235
Radionuclide C: Am-241
Half Life (U-234): $(2.454 \pm 0.006)E+05$ years
Half Life (U-235): $(7.037 \pm 0.011)E+08$ years
Half Life (Am-241): 432.17 ± 0.66 years

Customer: PARAGON ANALYTICS, INC.
P.O. No.: EW040203/R2193
Catalog No.: MISC-STD
Reference Date: 1-May-03 12:00 PST
Source No.: 92MIX2203029

Contained Radioactivity:

U-234: 9.048 nCi (334.8 Bq)
U-235: 0.1771 nCi (6.553 Bq)

Am-241: 1.433 nCi (53.02 Bq)
Total Activity: 10.66 nCi (394.4 Bq)

Physical description:

A. Capsule type:	Disk (22 mm OD X 0.79 mm THK)
B. Nature of active deposit:	Electrodeposited and diffusion bonded oxides
C. Active Diameter:	19 mm
D. Backing:	Stainless steel
E. Cover:	None

Radioimpurities:

Not determined

Method of Calibration:

This source was assayed using a windowless internal gas flow proportional counter for total alpha activity. Individual nuclide ratios were taken from those determined in Mar 1998.

Uncertainty of Measurement:

A. Type A (random) uncertainty:	$\pm 0.5\%$
B. Type B (systematic) uncertainty:	$\pm 3.0\%$
C. Uncertainty in aliquot weighing:	$\pm 0.0\%$
D. Total uncertainty at the 99% confidence level:	$\pm 3.0\%$

Notes:

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Nuclear data was taken from "Table of Radioactive Isotopes", edited by Virginia Shirley, 1986.
- This source has a working life of 2 years.
- This source had a total alpha surface emission rate of $11950 \alpha/\text{min}$ in 2π on 11 Apr 03.

Daniel James Van Dalsem
Quality Control

15-Apr-03
Date Signed

IPL Ref. No.: 987-7

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