



facility 149017
project 10243

Radium-224/226

Case Narrative

COGCC

PW NORM 2017 – 10048

Work Order Number: 1705158

1. This report consists of the analytical results and supporting documentation for one water sample received by ALS on 05/08/2017.
2. This sample was prepared according to the current revision of SOP 701. Modifications were made to the method as described on QASS 472112.
3. The sample was analyzed for the presence of ^{224}Ra and ^{226}Ra according to the current revision of SOP 714. The analyses were completed on 05/23/2017.
4. The analysis results for this sample are reported on an "As Received" basis in units of pCi/L. The water sample was not filtered prior to analysis.
5. Sample 1705158-1 contained a significant concentration of Ba, which required a reduced aliquant to be analyzed. For further information regarding this occurrence, please refer to QASS 472112 in section 6 of this report.
6. The requested MDC for Ra-224 and Ra-226 for sample 1705158-1 was not achieved due to a reduced aliquot of the sample taken for analysis. This sample was counted for a maximum count time of 1000 minutes and results are reported without further qualification. The results are flagged with an "M" and/or "M3" qualifier on the final reports. The reported activity with an "M3" qualifier exceeds the achieved MDC.
7. No further anomalous situations were encountered during the preparation or analysis of this sample. All remaining quality control criteria were met.



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

Pik Yee Yuen
Radiochemistry Primary Data Reviewer

5/25/17
Date

Radiochemistry Final Data Reviewer

5/25/17
Date

Section 1

CHAIN OF CUSTODY

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 1705158

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
149017 Wellington Rapid Infiltrati	1705158-1		WATER	08-May-17	10:40
149017 Wellington Rapid Infiltrati	1705158-2		WATER	08-May-17	10:40









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

Chain-of-Custody

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

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

[illegible]

"Time Zone (Circle):	MST	Matrix:	O = oil	S = soil	NS = non-soil solid	W = water	L = liquid	E = extract	F = filter																														
		NOTES																																					
GAB prepped (coprecip) and counted within 4 days of sampling	<div style="float: right; text-align: right;">Form 202-9</div> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>RELINQUISHED BY</th><th>SIGNATURE</th><th>PRINTED NAME</th><th>DATE</th><th>TIME</th></tr> </thead> <tbody> <tr> <td>RECEIVED BY</td><td></td><td>R. A. Brown</td><td>5/18/17</td><td>11:00</td></tr> <tr> <td>RELINQUISHED BY</td><td></td><td>C. Trimble</td><td>5-8-17</td><td>1110</td></tr> <tr> <td>RECEIVED BY</td><td></td><td></td><td></td><td></td></tr> <tr> <td>RELINQUISHED BY</td><td></td><td></td><td></td><td></td></tr> <tr> <td>RECEIVED BY</td><td></td><td></td><td></td><td></td></tr> </tbody> </table>									RELINQUISHED BY	SIGNATURE	PRINTED NAME	DATE	TIME	RECEIVED BY		R. A. Brown	5/18/17	11:00	RELINQUISHED BY		C. Trimble	5-8-17	1110	RECEIVED BY					RELINQUISHED BY					RECEIVED BY				
RELINQUISHED BY										SIGNATURE	PRINTED NAME	DATE	TIME																										
RECEIVED BY											R. A. Brown	5/18/17	11:00																										
RELINQUISHED BY											C. Trimble	5-8-17	1110																										
RECEIVED BY																																							
RELINQUISHED BY																																							
RECEIVED BY																																							
224Ra prepped and counted within 4 days of sampling																																							
*Iso U only if 6020 "total" U > 3µg/l																																							
*Iso Th only if 6020 "total" Th > 3µg/l																																							
X	LEVEL IV (Sig OC + forms + raw data)																																						
PRESERVATION KEY	1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaOHzAcetate 6-HatSO4 7-4°C 8-Other																																						



TF: (800) 443-1511 PH: (870) 480-1511 FX: (970) 480-1522

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

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

Time Zone (Circle):		MST	Matrix:	O = oil	S = soil	NS = non-soil solid	W = water	L = liquid	E = extract	F = filter	Form 2029e			
NOTES														
6010 total = B, Be, Ca, Cr, Fe, K, Li, Mg, Na, Ni, P, S, Si, V														
6020 total = Al, Ag, As, Ba, Cd, Co, Cu, Mo, Mn, Na, Pb, Se, Sr, Th, Ti, U, Zn														
class. 6010 = Ba, Ca, Fe, K, Mg, Na, Si, Sr														
Dissolved ≠ filter and preserve upon receipt at lab														
PRESERVATION KEY		1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaOH/ZnAcetate 6-NaHSO4 7-4°C 8-Other												

REPORT LEVEL / QC REQUIRED	SIGNATURE	PRINTED NAME	DATE	TIME
Summary (Standard QC)	<i>[Signature]</i>	RACEN	5/8/17	11:10
LEVEL II (Standard QC)				
LEVEL III (Std QC + forms)				
LEVEL IV (Std QC + forms + new data)				
X				
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				



ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: COGCC

Workorder No: 1705158

Project Manager: SS

Initials: EDT Date: 5-8-17

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

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

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

Project Manager Signature / Date: Shiloh Lemay

Section 2



SAMPLE RESULTS SUMMARY

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: 1705158

Page: 1 of 1

Reported on: Thursday, May 25, 2017

9:24:46 AM

Lab Sample ID	Client Sample ID	Sample Type	Nuclide	Result +/- 2 s TPU	MDC	DL	Units	Matrix	Prep Batch	Date Analyze	Flags
1705158-1	149017 Wellington Rapid Infiltration Basin	Sample	Ra-224	-2.5E+00 +/- 4.7E+00	2.1E+01	NA	pCi/l	WATER	RAS170511-1	5/12/2017	U,M
1705158-1	149017 Wellington Rapid Infiltration Basin	Sample	Ra-226	3.9E+00 +/- 1E+00	2.3E+00	NA	pCi/l	WATER	RAS170511-1	5/12/2017	M3

Comments:

Data Package ID: RAS1705158-1

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: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: RAS170511-1MB

Sample Matrix: WATER

Prep SOP: PAI 701 Rev 1

Date Collected: 11-May-17

Date Prepared: 11-May-17

Date Analyzed: 12-May-17

Prep Batch: RAS170511-1

QCBatchID: RAS170511-1-1

Run ID: RAS170511-1

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	-2E-03 +/- 4.2E-02	1.85E-01	1E+00	NA	U
13982-63-3	Ra-226	-7E-03 +/- 1.2E-02	5.2E-02	1E+00	NA	U

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	1.080E+01	9.650E+00	pCi/l	89.4	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: RAS1705158-1

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13
Laboratory Control Sample(s)

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

Lab ID: RAS170511-1LCS

Sample Matrix: WATER
Prep SOP: PAI 701 Rev 1
Date Collected: 11-May-17
Date Prepared: 11-May-17
Date Analyzed: 12-May-17

Prep Batch: RAS170511-1
QCBatchID: RAS170511-1-1
Run ID: RAS170511-1
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	9.33E+00 +/- 6.4E-01	2E-01	8.950E+00	104	75 - 125	P
13982-63-3	Ra-226	9.5E+00 +/- 6.5E-01	6E-02	9.210E+00	103	75 - 125	P

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	1.080E+01	9.550E+00	pCi/l	88.5	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: RAS1705158-1

Section 4

INDIVIDUAL SAMPLE RESULTS



Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

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

Sample Matrix: WATER

Prep SOP: PAI 701 Rev 1

Date Collected: 08-May-17

Date Prepared: 11-May-17

Date Analyzed: 12-May-17

Prep Batch: RAS170511-1

QCBatchID: RAS170511-1-1

Run ID: RAS170511-1

Count Time: 1000 minutes

Report Basis: As Received

Final Aliquot: 10.0 ml

Prep Basis: As Received

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 +/- 4.7E+00	2.1E+01	1E+00	NA	U,M
13982-63-3	Ra-226	3.9E+00 +/- 1E+00	2.3E+00	1E+00	NA	M3

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	5.400E+02	4.760E+02	pCi/l	88.2	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.

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: RAS1705158-1

Section 5

RAW DATA

5

Isotopic Radium by Alpha Spectroscopy Raw Data Report

Laboratory Name: ALS -- Fort Collins

Prep SOP: PAI 701

Reported on: Wednesday, May 24, 2017

PAI Work Order: 1705158

Analytical SOP: PAI 714_Ra226

1:14:14 PM

Sample ID QC Type	Nuclide Type	Sample Date/Time	Prep Batch QC Batch ID	Ingrowth Date /Time	Decay Date/Time	Matrix %Moist.	Samp Aliq Analy Aliq	Inst ID Det ID	AntRunID File Name	Count Date/Time	Net Cnts Bkg Cnts	BaseEff Bkg(min)	CndDur(min) Yield	Activity +/- 2 s TPU	MDC DeclEv	ReportUnits ReportBasis	DER RPD	%Spk. Recov Flags
1705158-1	Ra-224 Trg. Analyte	5/8/2017 10:40:00 AM	RAS170511-1	NA	NA	WATER	10 ml 10 ml	AlphaSpec2 83	RAS170511-1 Spectrum #1	5/12/2017 1:44 PM	52,000 37,000	30.46% 1000	1000 88.2%	-2.5E+00 4.7E+00	2.1E+01	pCi/l As Received	NA	NA
1705158-1	Ra-226 Trg. Analyte	5/8/2017 10:40:00 AM	RAS170511-1	NA	NA	WATER	10 ml 10 ml	AlphaSpec2 83	RAS170511-1 Spectrum #1	5/12/2017 1:44 PM	22,000 4,000	30.46% 1000	1000 88.2%	3.9E+00 1E+00	2.3E+00	pCi/l As Received	NA	M3
RAS170511-1	Ra-224 Trg. Analyte	5/11/2017 12:00:00 PM	RAS170511-1	NA	NA	WATER	500 ml 500 ml	AlphaSpec2 81	RAS170511-1 Spectrum #1	5/12/2017 1:44 PM	46,000 28,000	28.35% 1000	1000 89.4%	-2E-03 4.2E-02	1.85E-01	pCi/l As Received	NA	U
RAS170511-1	Ra-226 Trg. Analyte	5/11/2017 12:00:00 PM	RAS170511-1	NA	NA	WATER	500 ml 500 ml	AlphaSpec2 81	RAS170511-1 Spectrum #1	5/12/2017 1:44 PM	-2,000 5,000	28.35% 1000	1000 89.4%	-7E-03 1.2E-02	5.2E-02	pCi/l As Received	NA	U
RAS170511-1	Ra-224 Trg. Analyte	5/11/2017 12:00:00 PM	RAS170511-1	NA	NA	WATER	500 ml 500 ml	AlphaSpec2 82	RAS170511-1 Spectrum #1	5/12/2017 1:44 PM	2382,000 21,000	28.92% 1000	1000 88.5%	9.33E+00 6.4E-01	2E-01	pCi/l As Received	NA	104 P
RAS170511-1	Ra-226 Trg. Analyte	5/11/2017 12:00:00 PM	RAS170511-1	NA	NA	WATER	500 ml 500 ml	AlphaSpec2 82	RAS170511-1 Spectrum #1	5/12/2017 1:44 PM	2565,000 9,000	28.92% 1000	1000 88.5%	9.5E+00 6.5E-01	6E-02	pCi/l As Received	NA	103 P

Comments:

Data Package ID: RAS1705158-1

Qualifiers/Flags:

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

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

- L - LCS Recovery below lower control limit.
- H - LCS Recovery above upper control limit.
- P - LCS, Matrix Spike Recovery within control limits.
- N - Matrix Spike Recovery outside control limits
- NC - Not Calculated for duplicate results less than 5 times MDC
- B - Analyte concentration greater than MDC.
- B3 - Analyte concentration greater than MDC but less than Requested MDC.

Notes:

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

Abbreviations:

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

Date Printed: Thursday, May 25, 2017

ALS -- Fort Collins

LIMS Version: 6.842

Page 1 of 1

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample: 1705158-1
Spectrum #1 Analysis #1

Sample Size : 0.50

Detector: 83
Batch Name: RAS170511-1_A
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition

Acquisition Start Date: 5/12/2017 1:44:57PM
Live Time: 1,000.00 min.
Real Time: 1,000.12 min.
Dead Time: 0.01 %

Calibration

Bkgd Info: Sample: B17051083; Det: 83; Spectrum #1; 5/10/2017 10:45:36 AM

Calibration Date: 5/10/2017 10:11:37AM

Efficiency Calibration: C17051083

Efficiency: 30.46% +/- 0.18% TPU(2 sigma)

Energy Calibration: C17051083

Energy Cal: Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

Quadratic = 0.0000 keV / Ch²

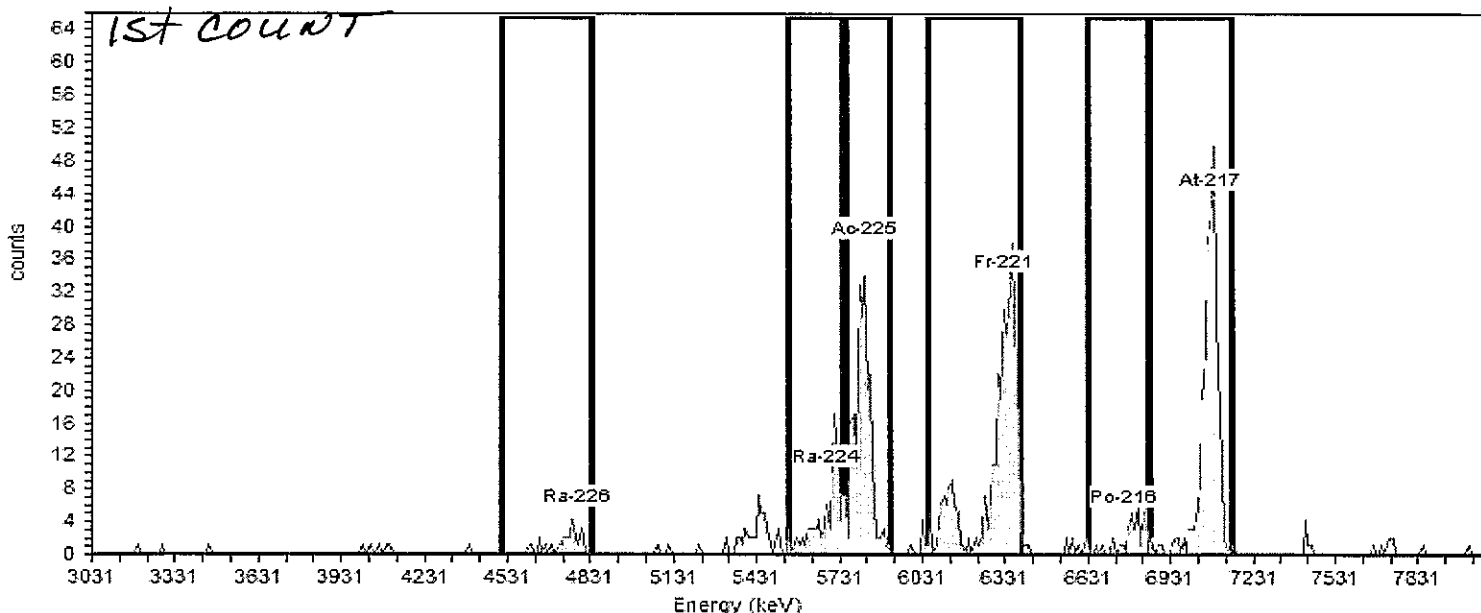
Tracer

Tracer Name: At-217

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

Tracer Nuclide: At-217

Tracer Recovery: 4.26%



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	50.5	100.1	26.00	4.00	22.00	1.5E+000	4.0E-001	3.2E-001	8.3E-001
Ra-224	5684.5	5545.9	5743.9	26.2	95.1	89.00	37.00	52.00	3.8E+000	8.8E-001	1.0E+000	2.3E+000
Ac-225	5823.1	5753.8	5912.2	55.0	78.3	213.00	18.00	195.00	1.7E+001	2.0E+000	8.8E-001	2.0E+000
Fr-221	6328.0	6050.8	6387.4	46.0	100.0	317.00	48.00	269.00	1.2E+002	1.4E+001	7.4E+000	1.6E+001
Po-216	6763.6	6634.9	6852.7	17.9	100.0	34.00	20.00	14.00	9.7E-001	5.2E-001	7.2E-001	1.6E+000
At-217	7080.4	6862.6	7159.6	51.9	99.9	270.00	11.00	259.00	7.7E-001	5.0E-002	5.4E-001	1.3E+000

JA

JM

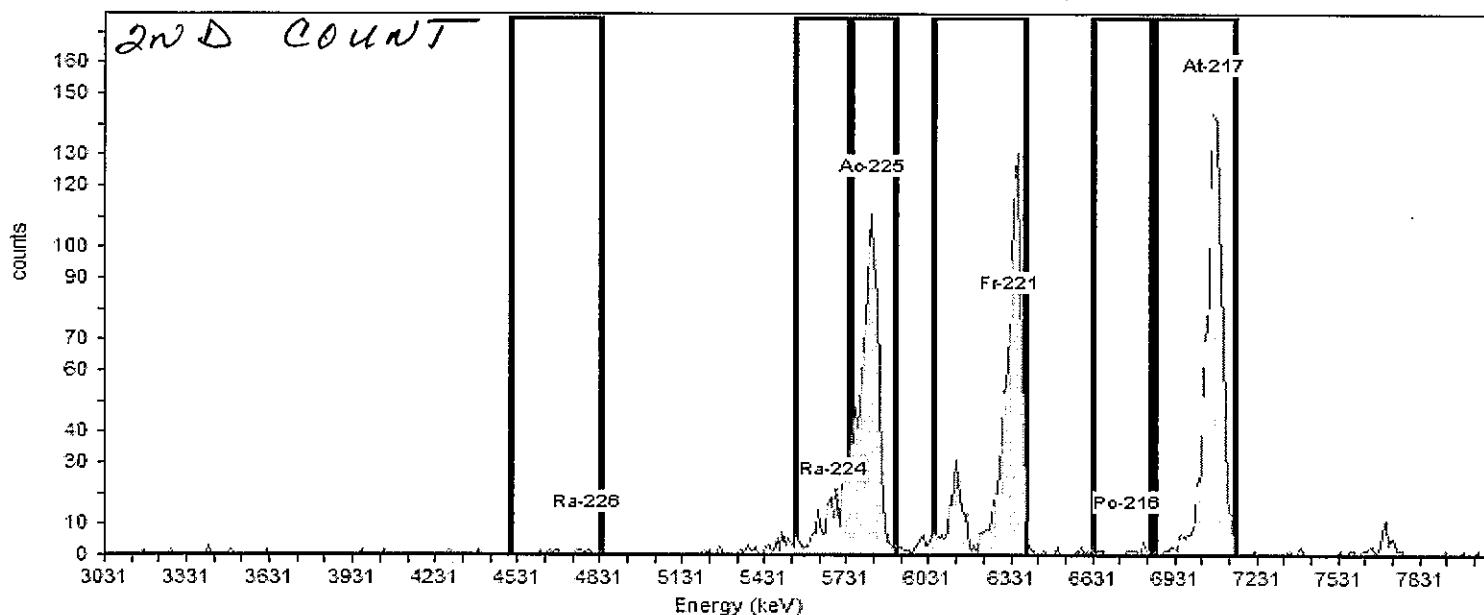
ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample		Sample Size : 0.01
Sample: 1705158-1		
Spectrum #1	Analysis #1	
Acquisition		
Detector: 83		Acquisition Start Date: 5/23/2017 6:44:22AM
Batch Name: RAS170511-1_B		Live Time: 300.00 min.
Nuclide Library: Radium		Real Time: 300.05 min.
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226		Dead Time: 0.02 %
ROI Set: Ra224/Ra226		

Calibration	
Bkgd Info: Sample: B17051083; Det: 83; Spectrum #1; 5/10/2017 10:45:36 AM	
Calibration Date: 5/10/2017 10:11:37AM	Energy Calibration: C17051083
Efficiency Calibration: C17051083	Energy Cal: Gain = 9.9003 keV / Ch
Efficiency: 30.46% +/- 0.18% 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: 52.89%



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	23.4	100.1	10.00	1.20	8.80	8.2E+000	3.2E+000	1.9E+000	6.3E+000
Ra-224	5684.5	5545.9	5743.9	.0	95.1	252.00	11.10	240.90	2.4E+002	2.1E+001	6.1E+000	1.5E+001
Ac-225	5823.1	5753.8	5912.2	69.2	78.3	816.00	5.40	810.60	9.7E+002	6.7E+001	5.2E+000	1.4E+001
Fr-221	6328.0	6050.8	6387.4	42.7	100.0	977.00	14.40	962.60	1.8E+003	1.2E+002	1.3E+001	3.1E+001
Po-216	6763.6	6634.9	6852.7	25.0	100.0	15.00	6.00	9.00	8.4E+000	4.3E+000	4.3E+000	1.1E+001
At-217	7080.4	6862.6	7159.6	56.8	99.9	969.00	3.30	965.70	4.8E+002	1.5E+001	3.2E+000	8.9E+000

JA

JM

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample: RAS170511-1MB
Spectrum #1 Analysis #1

Sample Size : 0.50

Detector: 81
Batch Name: RAS170511-1_A
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition

Acquisition Start Date: 5/12/2017 1:44:56PM
Live Time: 1,000.00 min.
Real Time: 1,000.01 min.
Dead Time: 0.00 %

Calibration

Bkgd Info: Sample: B17051081; Det: 81; Spectrum #1; 5/10/2017 10:45:36 AM

Calibration Date: 5/10/2017 10:11:19AM

Efficiency Calibration: C17051081

Efficiency: 28.35% +/- 0.16% TPU(2 sigma)

Energy Calibration: C17051081

Energy Cal: Gain = 9.7851 keV / Ch

Offset = 3,042.97 keV

Quadratic = 0.0000 keV / Ch²

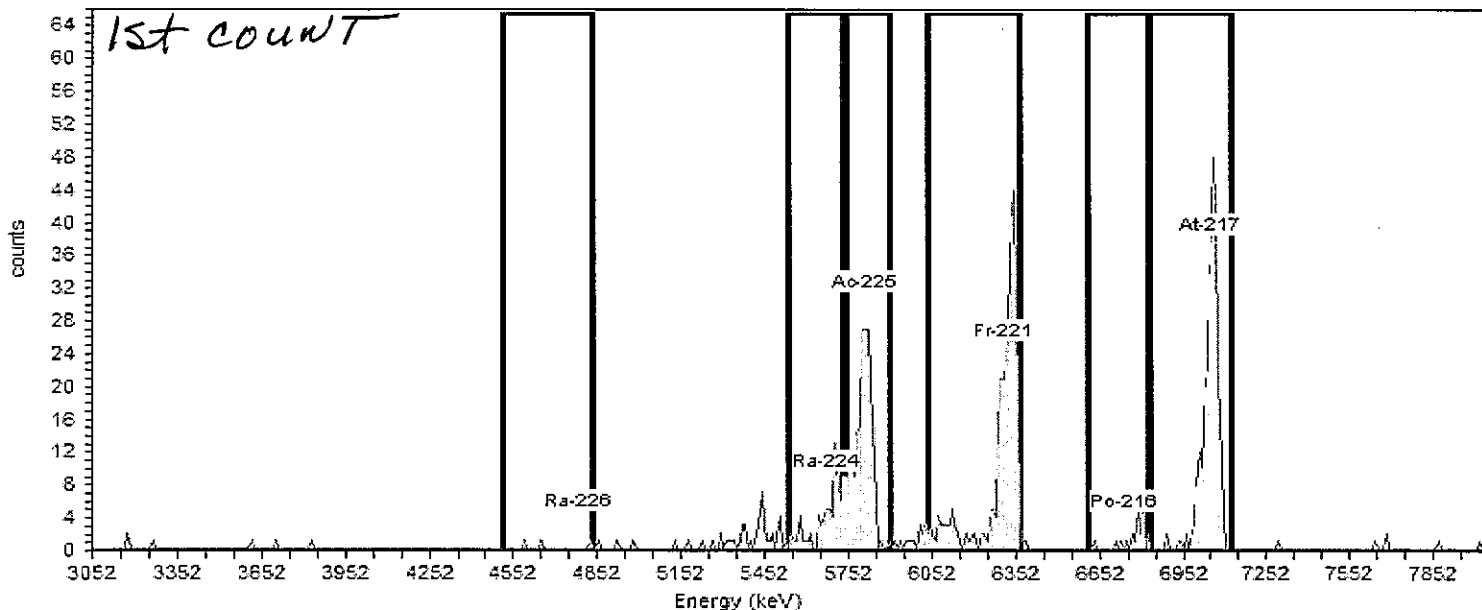
Tracer

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	4784.7	4510.7	4833.6	13.5	100.1	3.00	5.00	-2.00	-1.6E-001	2.2E-001	4.0E-001	1.0E+000
Ra-224	5675.2	5538.2	5733.9	.0	95.1	74.00	28.00	46.00	3.8E+000	8.9E-001	1.0E+000	2.2E+000
Ac-225	5812.2	5743.7	5900.2	54.3	78.3	193.00	19.00	174.00	1.7E+001	2.1E+000	1.0E+000	2.3E+000
Fr-221	6311.2	6037.2	6369.9	43.9	100.0	275.00	37.00	238.00	1.2E+002	1.4E+001	7.2E+000	1.6E+001
Po-216	6741.7	6614.5	6829.8	17.2	100.0	22.00	17.00	5.00	3.9E-001	4.9E-001	7.4E-001	1.7E+000
At-217	7054.9	6839.6	7133.2	41.0	99.9	243.00	11.00	232.00	7.4E-001	5.1E-002	6.0E-001	1.4E+000

JA

JP

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample: RAS170511-1MB
Spectrum #1 Analysis #1

Sample Size : 0.50

Detector: 81
Batch Name: RAS170511-1_B
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition

Acquisition Start Date: 5/23/2017 6:44:22AM
Live Time: 300.00 min.
Real Time: 300.00 min.
Dead Time: 0.00 %

Calibration

Bkgd Info: Sample: B17051081; Det: 81; Spectrum #1; 5/10/2017 10:45:36 AM

Calibration Date: 5/10/2017 10:11:19AM

Efficiency Calibration: C17051081

Efficiency: 28.35% +/- 0.16% TPU(2 sigma)

Energy Calibration: C17051081

Energy Cal: Gain = 9.7851 keV / Ch

Offset = 3,042.97 keV

Quadratic = 0.0000 keV / Ch²

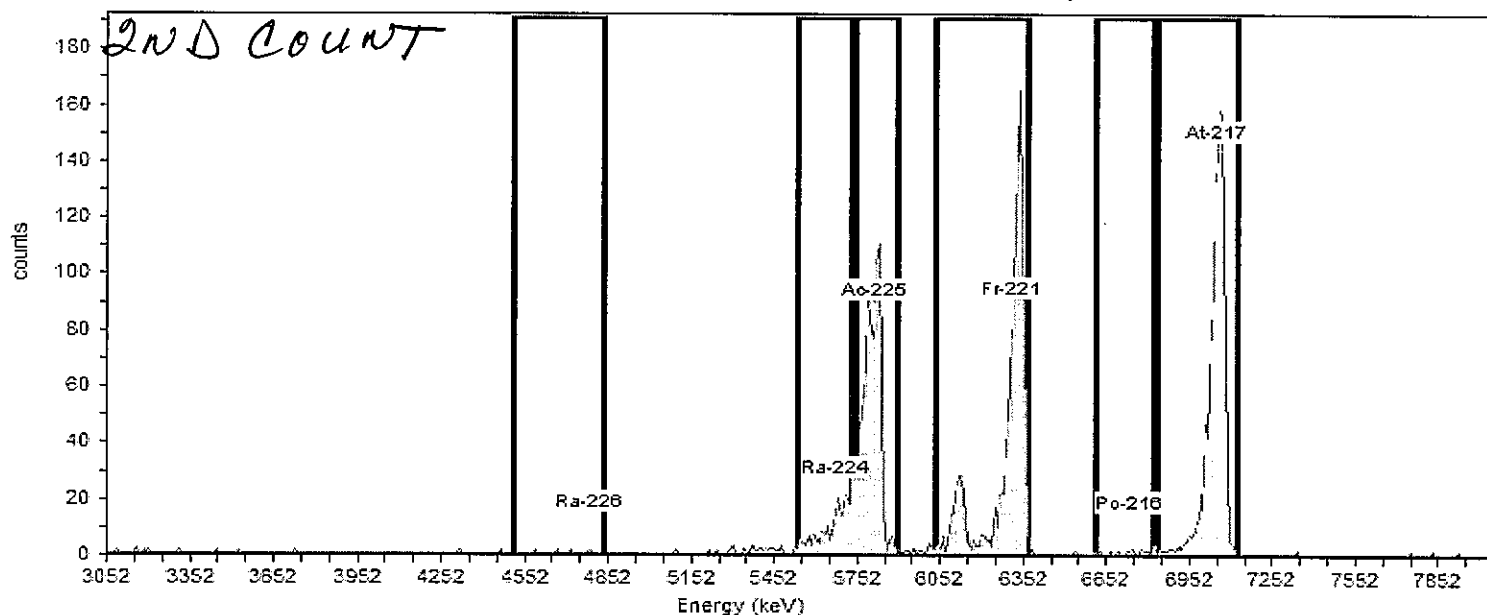
Tracer

Tracer Name: At-217

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

Tracer Nuclide: At-217

Tracer Recovery: 53.60%



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
At-217	7054.9	6839.6	7133.2	44.8	99.9	914.00	3.30	910.70	9.7E+000	3.2E-001	6.7E-002	1.9E-001
Ra-226	4784.7	4510.7	4833.6	12.8	100.1	4.00	1.50	2.50	4.9E-002	4.6E-002	4.5E-002	1.4E-001
Ra-224	5675.2	5538.2	5733.9	13.5	95.1	213.00	8.40	204.60	4.3E+000	4.0E-001	1.1E-001	2.8E-001
Ac-225	5812.2	5743.7	5900.2	71.1	78.3	775.00	5.70	769.30	1.9E+001	1.4E+000	1.1E-001	2.9E-001
Fr-221	6311.2	6037.2	6369.9	40.1	100.0	986.00	11.10	974.90	3.8E+001	2.7E+000	2.4E-001	5.9E-001
Po-216	6741.7	6614.5	6829.8	.6	100.0	17.00	5.10	11.90	2.4E-001	9.4E-002	8.4E-002	2.2E-001

JA

DP

ALS Laboratory Group - Fort Collins

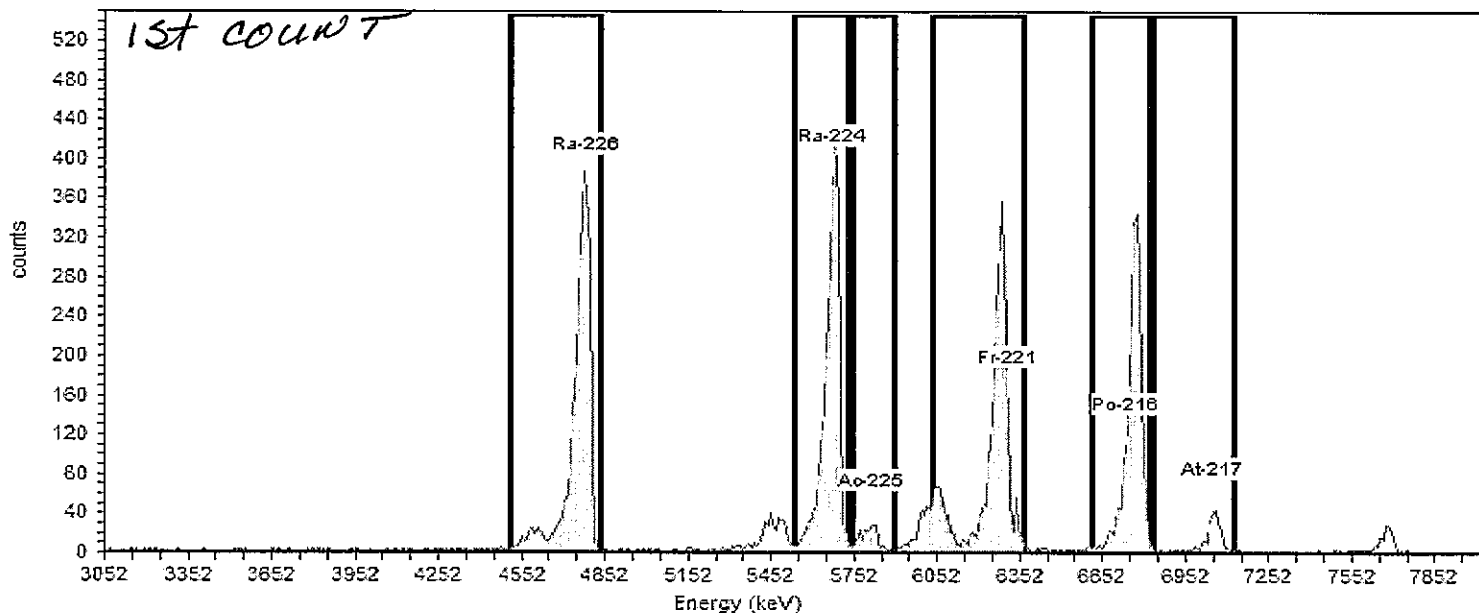
Alpha-Spectroscopy Analysis Report

Sample: RAS170511-1LCS Sample Size : 0.50
Spectrum #1 Analysis #1

Detector: 82 Acquisition Start Date: 5/12/2017 1:44:56PM
Batch Name: RAS170511-1_A Live Time: 1,000.00 min.
Nuclide Library: Radium Real Time: 1,000.01 min.
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226 Dead Time: 0.00 %
ROI Set: Ra224/Ra226

Bkgd Info: Sample: B17051082; Det: 82; Spectrum #1; 5/10/2017 10:45:36 AM
Calibration Date: 5/10/2017 10:11:28AM Energy Calibration: C17051082
Efficiency Calibration: C17051082 Energy Cal: Gain = 9.7851 keV / Ch
Efficiency: 28.92% +/- 0.20% TPU(2 sigma) Offset = 3,042.97 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: 3.67%



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
Fr-221	6311.2	6037.2	6369.9	72.4	100.0	2,573.00	43.00	2,530.00	1.4E+003	1.4E+002	8.5E+000	1.8E+001
Po-216	6741.7	6614.5	6829.8	46.0	100.0	1,990.00	15.00	1,975.00	1.7E+002	1.5E+001	7.7E-001	1.8E+000
At-217	7054.9	6839.6	7133.2	44.7	99.9	226.00	14.00	212.00	6.6E-001	4.8E-002	7.4E-001	1.7E+000
Ra-226	4784.7	4510.7	4833.6	25.5	100.1	2,574.00	9.00	2,565.00	2.2E+002	2.0E+001	5.9E-001	1.4E+000
Ra-224	5675.2	5538.2	5733.9	45.5	95.1	2,403.00	21.00	2,382.00	2.1E+002	1.9E+001	9.5E-001	2.1E+000
Ac-225	5812.2	5743.7	5900.2	77.9	78.3	199.00	15.00	184.00	2.0E+001	2.4E+000	9.8E-001	2.2E+000

JA

[Signature]

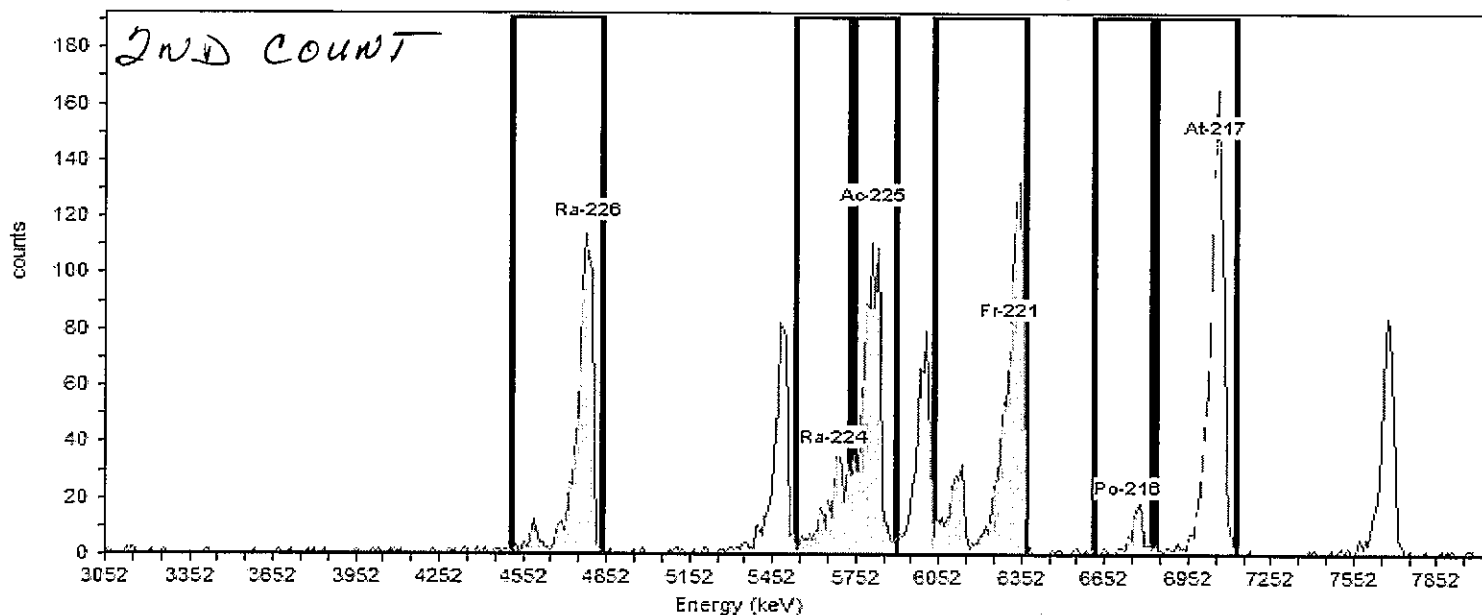
ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample: RAS170511-1LCS Spectrum #1 Analysis #1	Sample Size : 0.50
Detector: 82 Batch Name: RAS170511-1_B Nuclide Library: Radium Analysis Method: ROI Analysis, Set Name = Ra224/Ra226 ROI Set: Ra224/Ra226	Acquisition Acquisition Start Date: 5/23/2017 6:44:22AM Live Time: 300.00 min. Real Time: 300.00 min. Dead Time: 0.00 %

Bkgd Info: Sample: B17051082; Det: 82; Spectrum #1; 5/10/2017 10:45:36 AM Calibration Date: 5/10/2017 10:11:28AM Efficiency Calibration: C17051082 Efficiency: 28.92% +/- 0.20% TPU(2 sigma)	Calibration Energy Calibration: C17051082 Energy Cal: Gain = 9.7851 keV / Ch Offset = 3,042.97 keV Quadratic = 0.0000 keV / Ch ²
---	---

Tracer Name: At-217 Tracer Activity: 20.00 DPM/mL x (Vol.)1.00 mL = 20.00 DPM	Tracer Tracer Nuclide: At-217 Tracer Recovery: 53.07%
--	---



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	4784.7	4510.7	4833.6	26.3	100.1	755.00	2.70	752.30	1.5E+001	1.0E+000	6.0E-002	1.7E-001
Ra-224	5675.2	5538.2	5733.9	130.4	95.1	318.00	6.30	311.70	6.4E+000	5.4E-001	9.7E-002	2.5E-001
Ac-225	5812.2	5743.7	5900.2	71.2	78.3	827.00	4.50	822.50	2.1E+001	1.4E+000	9.9E-002	2.7E-001
Fr-221	6311.2	6037.2	6369.9	46.1	100.0	1,138.00	12.90	1,125.10	4.3E+001	3.0E+000	2.6E-001	6.2E-001
Po-216	6741.7	6614.5	6829.8	39.8	100.0	93.00	4.50	88.50	1.7E+000	2.2E-001	7.8E-002	2.1E-001
At-217	7054.9	6839.6	7133.2	46.4	99.9	924.00	4.20	919.80	9.6E+000	3.2E-001	7.5E-002	2.0E-001

JA

JP

ALS

Alpha Spectrometer Instrument Run Log

Date: 5/11/17 5/12/17

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
105	PAS170506-1A	1704493-12	Pu/F	1000	JA
106		-13			
107		-14			
108		-15			
109		-16			
110		-17			
111		-18			
112		-19			
113		-20			
114		AS170506-1MB			
115		PMB			
116		LS			
128	UAS170506-4A	1704504-1	U/F	420	JA
129		-2			
130		-3			
131		1705057-1			
132		-2			
165	PAS170506-1B	AS170506-1MB	Pu/F	1000	JA
117	UAS170508-2B	1704505-19	U/F	360	JA
118		-20			
119		-20			
120		-21			
121		-22			
122		-23			

5/11/17

5/12/17

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
123	UAS170508-2B	1704505-24	U/F	360	JA
124		1704605-3			
125		-4			
126		AS170508-2MB			
127		-25			
81	PAS170511-1A	PAS170511-1MB	Pu/F	1000	JA
82		-105			
83		1705158-1			
84		1705177-1			
85		-2			
86		-3			
87		1705181-1			
88		1705202-1			
89		-10			
90		1705203-1			
91		1705214-1			
92		-2			
93		-20			
94		-4			
95		1705237-1			
115	UAS170506-2A	1704493-21	U/F	1000	JA
116		-22	AM/F		
		5/12/17			
		5/12/17			

Notes:

JMA 5/12/17

Reviewed by: JMA

Date: 5/12/17

471137

ALS

Alpha Spectrometer Instrument Run Log

5/24/17
Date: 5/22/17 5/23/17

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
81	RAS170519-1-A	RAS170519-1-A	Ra/W	1000	JA
82		↓ -11CS			
83		1705415-3			
84		↓ -4			
85		↓ -5			
86		↓ -6			
87		↓ -7			
88		↓ -70			↓
81	RAS170511-1-B	RAS170511-1-B	Ra/W	300	JA
82		↓ -11CS			
83		1705158-1			
84		1705177-1			
85		↓ -2			
86		↓ -3			
87		1705181-1			
88		1705202-1			
89		↓ -10			
90		1705203-1			
91		1705214-1			
92		↓ -2			
93		↓ -20			
94		↓ -4			
95		1705237-1			↓

5/22/17

5/23/17

jmt. 5/23/17

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
81	UAS170522-1-A	1705137	Ur/W	360	JA
82		↓ -2			
83		↓ -3			
84		↓ -4			
85		↓ -40			
86		↓ -5			
87		↓ -6			
88		↓ -7			
89		↓ -8			
90		↓ -11			
91		1705261-1			
92		↓ -2			
93		↓ -3			
94		↓ -4			
95		↓ -5			↓
117	UAS170522-1-B	1705261-1	Ur/W	360	JA
118		↓ -7			
119		↓ -8			
120		↓ -11			
121		1705389-1			
122		AS170522-1MB			
123		↓ -11CS			↓

jmt. 5/24/17

Notes:

Section 6

QUALITY ASSURANCE SUMMARY REPORTS

6

QUALITY ASSURANCE SUMMARY SHEET

ALS W.O. #/ BATCH 1705181
1705158 1705203
1705177 1705214
1705202 1705237 / RAS 1705111TEST Ra224/226METHOD 2 SPECSOP/REV (PREP) 701SOP/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:

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 1705158-1, 1705202-1, and 1705203-1 contained significant concentrations of Ba. Aliquant volumes were 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. The aliquant volumes used for these samples (6 to 15 ml) were much smaller than the typically used volume of 500ml. The small sample volumes resulted in much higher ssMDCs for these samples.

The duplicate error ratio (DER) for sample 1705214-2 and -2Dup (DER=2.6) was higher than acceptable. The spectral quality for the sample aliquant was not as good as the spectral quality for the duplicate. It appears that scattered alpha counts raised the background in the Ra-226 ROI for the sample causing an overestimation of Ra-226 activity. Ra-226 activity in both aliquants was found to be less than 1pCi/L.

TECHNICIAN/ANALYST

DATE

DEPARTMENT MANAGER

DATE

Sample Preparation	RAS170511-1	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	RAS170511-1
Analyte	RAS170511-1MB	RAS170511-ILCS	1705168-1	1705177-1	1705177-2	1705177-3		
Sampling Date:	5/12/17 11:25 AM	5/12/17 11:25 AM	5/8/17 10:46 AM	5/8/17 9:45 AM	5/8/17 10:42 AM	5/8/17 10:47 AM		
Sample Size (L):	0.5	0.5	0.01	0.5	0.5	0.5		
Spike Added (mL):	0	1	0	0	0	0		
Tracer Added (mL):	0.4	0.4	0.4	0.4	0.4	0.4		
Separation Date:	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17		
Separation Time:	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM		
Sample Analysis								
1st count Detector ID:	81	82	83	84	85	86		
2nd count Detector ID:	81	82	83	84	85	86		
1st Count Start Date:	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17		
1st Count Start Time:	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM		
1st Count Duration(min):	1000	1000	1000	1000	1000	1000		
2nd Count Start Date:	5/23/17	5/23/17	5/23/17	5/23/17	5/23/17	5/23/17		
2nd Count Start Time:	6:44 AM	6:44 AM	6:44 AM	6:44 AM	6:44 AM	6:44 AM		
2nd Count Duration(min):	300	300	300	300	300	300		
1st count Detector Efficiency:	0.2835	0.2892	0.3046	0.3044	0.2983	0.2867		
2nd count Detector Efficiency:	0.2835	0.2892	0.3046	0.3044	0.2983	0.2867		
Bkg. Cal. Ct. Dur. (min):	1000	1000	1000	1000	1000	1000		
1st count Ra-224 Gross Cts:	74	2403	89	3974	4697	4658		
1st count Ac-225 Gross Cts:	28	21	28	34	31	16		
1st count Ac-225 Bkg Cts (per sample ct duration):	193	199	213	1301	1454	758		
2nd count At-217 Gross Cts:	914	924	969	759	891	793		
2nd count At-217 Bkg Cts (per sample ct duration):	3.3	4.2	3.3	6.6	3.3	6.3		
2nd count Ra-224 net counts	205	312	241	732	826	517		
2nd count Ac-225 net counts	769	823	811	935	1202	844		
Calculations								
Tracer Added (dpm@sep date):	29.8	29.8	29.8	29.8	29.8	29.8		
1st count Elapsed Time, sep. to ct.midpt., (hrs):	10.67	10.67	10.67	10.67	10.67	10.67		
2nd count Elapsed Time, sep. to ct.midpt., (hrs):	261.82	261.82	261.82	261.82	261.82	261.82		
1st count At-217 Ingrowth factor:	0.030022	0.030022	0.030022	0.030022	0.030022	0.030022		
2nd count At-217 Ingrowth factor:	0.402307	0.402307	0.402307	0.402307	0.402307	0.402307		
Expected At-217, at mid pt of 1st count (dpm):	0.8940	0.8940	0.8940	0.8940	0.8940	0.8940		
Expected At-217, at mid pt of 2nd count (dpm):	11.9795	11.9795	11.9795	11.9795	11.9795	11.9795		
Chemical Yield (2nd count):	0.89384	0.88498	0.88217	0.68777	0.82804	0.76352		
Ra-224 decay factor, sampling to 1st ct.midpt.:	0.9187	0.9187	0.4260	0.4225	0.4258	0.4260		
Standard Denominator:	0.2455	0.2479	0.0024	0.0933	0.1109	0.0983		
Sample Activity Conc. (pCi/L):	-0.00157	9.32591	-2.46349	31.51903	33.17127	42.60556		
Std. Uncert., Ra-224 (pCi/L):	0.0415	0.1987	4.6886	0.6788	0.6202	0.6953		
Std. Uncert., At-217 (rel):	0.0332	0.0331	0.0323	0.0367	0.0337	0.0359		
Std. Uncert., Ra-225-229 act. (rel):	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561		
Std. Uncert., Sample Volume (rel):	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060		
Combined Std Uncertainty (pCi/L):	0.04154	0.64184	4.68935	2.22829	2.26705	2.93344		
Critical Level (pCi/L):	0.08758	0.09517	9.98383	0.81769	0.68284	0.52654		
MDC (pCi/L):	0.18541	0.20049	21.01032	1.86068	1.38699	1.07799		
LCS Recovery:		103.5%						
		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			

Section 7

LABORATORY BENCH SHEETS



Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: RAS170511-1

Prep Procedure: RalSO

Analytical QASS / NCR? Y / N

472112

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	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
1	1705158-1	SMP	10	10	ml	pCi/l	_51581	83 JPEJA	83 JPEJA	_51581	83 JPEJA	83 JPEJA	_51581			AB
1	1705177-1	SMP	500	500	ml	pCi/l	_51771	84	84	_51771	84	84	_51771			
1	1705177-2	SMP	500	500	ml	pCi/l	_51772	85	85	_51772	85	85	_51772			
1	1705177-3	SMP	500	500	ml	pCi/l	_51773	86	86	_51773	86	86	_51773			
1	1705181-1	SMP	500	500	ml	pCi/l	_51811	87	87	_51811	87	87	_51811			
1	1705202-1	SMP	6	6	ml	pCi/l	_52021	88	88	_52021	88	88	_52021			
1	1705202-1	DUP	6	6	ml	pCi/l	_52021D	89	89	_52021D	89	89	_52021D			
1	1705203-1	SMP	15	15	ml	pCi/l	_52031	90	90	_52031	90	90	_52031			
1	1705214-1	SMP	500	500	ml	pCi/l	_52141	91	91	_52141	91	91	_52141			
1	1705214-2	SMP	300	300	ml	pCi/l	_52142	92	92	_52142	92	92	_52142			
1	1705214-2	DUP	300	300	ml	pCi/l	_52142D	93	93	_52142D	93	93	_52142D			
1	1705214-4	SMP	500	500	ml	pCi/l	_52144	94	94	_52144	94	94	_52144			
1	1705237-1	SMP	500	500	ml	pCi/l	_52371	95	95	_52371	95	95	_52371			
1	RAS170511-1	MB	500	500	ml	pCi/l	_S17051B	81	81	_S17051B	81	81	_S17051B			
1	RAS170511-1	LCS	500	500	ml	pCi/l	_S17051L	82	82	_S17051L	82	82	_S17051L			

Handwritten signature/initials

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	DPW/ml	05/11/17	1	ml	RS-005
S1	Ra-226	1026.4095.84		10.219	DPW/ml	05/11/17	1	ml	RS-005
S1	Rn-222	1026.4095.84		10.219	DPW/ml	05/11/17	1	ml	RS-005
S1	Th-232	1026.4095.84		9.930	DPW/ml	05/11/17	1	ml	RS-005

Sample Barcodes

1705158-1 RAS170511-1PS1	1705177-1 RAS170511-1PS2	1705177-2 RAS170511-1PS3
1705177-3 RAS170511-1PS4	1705181-1 RAS170511-1PS5	1705202-1 RAS170511-1PS7
1705202-1DUP RAS170511-1PS6	1705203-1 RAS170511-1PS8	1705214-1 RAS170511-1PS9
1705214-2 RAS170511-1PS10	1705214-2DUP RAS170511-1PS11	1705214-4 RAS170511-1PS12

Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: RAS170511-1

Prep Procedure: RaISO

Analytical QASS / NCR? Y / N 472112

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Cnt 1 File	Cnt 1 Ins/Det	Cnt 1 Pos Chk By	Cnt 2 File	Cnt 2 Ins/Det	Cnt 2 Pos Chk By	Cnt 3 File	Cnt 3 Ins/Det	Cnt 3 Pos Chk By	Notes
1705237-1	RAS170511-1PS13															

Reporting Units

LabID:	TstGrpName:	RptUnits:
1705237-1	Ra226_224_USGS	pCi/l
1705214-1	Ra226_224_USGS	pCi/l
1705203-1	Ra226_224_COGCC	pCi/l
1705202-1	Ra226_224_COGCC	pCi/l
1705181-1	Ra226_224_USGS	pCi/l
1705177-1	Ra226_224_COGCC	pCi/l
1705158-1	Ra226_224_COGCC	pCi/l
1705214-2	Ra226_224_USGS	pCi/l
1705177-2	Ra226_224_COGCC	pCi/l
1705177-3	Ra226_224_COGCC	pCi/l
1705214-4	Ra226_224_USGS	pCi/l

Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: RAS170511-1

Prep Procedure: RALSO

Reviewed By: sdw

Review Date: 5/11/2017

Non-Routine Pre-Treatment? Y / N

Batch: NA

Re-Prep? Y / N

Batch: NA

Prep QASS / NCR? Y / N

Prep SOP: PAI 701 Rev: 1

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Steven D. White

Prep Date: 5/11/2017

Prep Dept: RS

Balance: na

Balance: na

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Ingrowth Date/Time	Micro Init	Micro Date	Standards	Prep Notes
1	1	1705158-1	SMP		10	10	As Received		SW	5/12/17		
2	1	1705177-1	SMP		500	500	Filtered					
3	1	1705177-2	SMP		500	500	Filtered					
4	1	1705177-3	SMP		500	500	Filtered					
5	1	1705181-1	SMP		500	500	As Received					
6	1	1705202-1	SMP		6	6	Filtered					
7	1	1705202-1	DUP		6	6	Filtered					
8	1	1705203-1	SMP		15	15	Filtered					
9	1	1705214-1	SMP		500	500	As Received					
10	1	1705214-2	SMP		300	300	As Received					
11	1	1705214-2	DUP		300	300	As Received					
12	1	1705214-4	SMP		500	500	As Received					
13	1	1705237-1	SMP		500	500	As Received					
14	1	RAS170511-1	MB		500	500	As Received					
15	1	RAS170511-1	LCS		500	500	As Received					

Comments

Spiked By: Steven D. White Date: 5/11/2017

Witnessed By: Steven D. White Date: 5/11/2017

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	05/11/17	1	ml	RS-005
S1	Ra-226	1026.4095.84		10.219	DPM/ml	05/11/17	1	ml	RS-005
S1	Rn-222	1026.4095.84		10.219	DPM/ml	05/11/17	1	ml	RS-005
S1	Th-232	1026.4095.84		9.930	DPM/ml	05/11/17	1	ml	RS-005

ALS -- Fort Collins

LIMS Version: 6.840

Supersedes:

Page 1 of 1 RALSO Bench Sheet

Date Printed: 5/11/2017 13:05

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

Prep Batch ID: RA5170511-1

Analyst: Steen D. White

Diphonix Resin lot #: 033111DPM

Ra-225 Tracer: C 4-14-17

Ra-224 QC Spike: 5W 5-27-2016

Ra-226 QC Spike: 916, 4095.68

For LIMS purposes ONLY: QC Spike: 1026.4095.84 (1.0ml)
1000ppm Ba ID:

1st Count Date: 5-12-17
Duration (minutes): 1,000

2nd Count Date: 5-23-17
Duration (minutes): 300

Diphonix Column Separation & Collection Date/Time: 5-12-17 @ 11:25

Refrigeration or Sonication Date/Time Start: 1 @ 12:07
End: 1 @ 12:07

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	0.140	--na--	0.09	81 JA	81 JA	
na	na	na	na	LCS	2	500		0.10	1	82	82	
5-8-17	1046	2.2	Client	1705158-1	3	10		--na--	0	83	83	
5-8-17	0945		ALS	1705177-1	4	500		--na--	0.09	84	84	
	1042			-2	5			--na--	1	85	85	
	1047			-3	6			--na--	0.06	86	86	
5-8-17	1315		Client	1705181-1	7			--na--	0.09	87	87	
5-9-17	1250		ALS	1705202-1	8	6		--na--	0	88	88	
	1			-1 Dup	9			--na--	1	89	89	
5-9-17	0930			1705203-1	10	15		--na--	1	90	90	
5-9-17	1100		Client	1705214-1	11	500		--na--	0.08	91	91	
	1415			-2	12	300		--na--	0	92	92	
	1			-2 Dup	13			--na--	1	93	93	
	1100			-4	14	500		--na--	0.05	94	94	
5-10-17	1100			1705237-1	15			--na--	0.09	95	95	
					16			--na--				
					17			--na--				
					18			--na--				
					19			--na--				
					20			--na--				
					21			--na--				
					22			--na--				
					23			--na--				

filtered due to oil layer

filtered due to oil layer

Screens

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	52.7205	20.6546	50.1670	51.7807	50.6940	0.5043	1.0243	5.1356	50.7704	1.0175	1.0391	1.0504
CCB	0.0423	-0.0064	0.1311	0.0405	0.1289	-0.0007	-0.0001	0.0082	0.0158	0.0018	0.0123	-0.0003
1705181-1	11.5155	0.4934	0.6060	4.6103	6.3420	0.0230	0.0052	1.7790	-0.0665	0.0240	-0.0007	-0.0012
1705214-1	18.8821	-0.0355	0.3036	10.0319	28.1694	0.0230	-0.0005	4.9137	-0.0551	0.0395	-0.0006	0.0012
1705214-2	23.4482	0.4378	1.7482	9.8005	7.6707	0.1172	0.0768	1.7790	-0.0709	0.3105	-0.0017	0.0000
1705214-4	34.7681	-0.0464	0.5358	6.2576	8.1792	0.0826	-0.0012	2.3747	-0.0652	0.0834	0.0008	0.0000
1705237-1	9.2568	-0.0475	1.1080	2.0864	14.4965	0.0736	0.0067	2.8143	-0.0519	0.0274	-0.0019	-0.0003
CCV	52.3190	20.5589	50.1920	51.5398	50.4979	0.5063	1.0193	5.1684	50.7141	1.0226	1.0265	1.0471
CCB	0.0513	-0.0040	0.1235	0.0417	0.1406	-0.0005	0.0003	0.0041	0.0234	0.0020	0.0155	-0.0006

Sample vol (ml) ml 1000g in Ba

181-1 500 0.09

214-1 500 0.08

-2 300 0

-4 500 0.05

237-1 500 0.09

1st count 5/12 1000min (due to reduced vol.)

2nd count ~ 5/23 300min

tracer: 0.4ml

Screens

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	51.7633	20.3585	49.9543	51.5826	50.2073	0.5023	1.0101	5.0575	50.7350	1.0156	1.0270	1.0174
CCB	-0.0253	-0.0389	0.0368	-0.0236	0.0377	-0.0012	-0.0009	-0.0041	-0.0507	-0.0008	0.0020	0.0006
100X 1705095-1	180.8864	0.5234	16.2659	22.8274	206.1871	5.9668	0.0216	1.2777	-0.0715	0.0724	-0.0018	-0.0013
100X 1705158-1	0.0456	-0.0521	0.0884	-0.0501	8.5924	0.0119	-0.0013	0.0452	-0.0785	0.0926	0.0005	-0.0010
100X 1705177-1	8.7786	-0.0517	1.7423	2.8498	91.9193	0.2324	-0.0013	35.2547	-0.0829	-0.0013	0.0017	0.0003
100X 1705177-2	8.8470	-0.0437	1.7491	2.8515	90.9329	0.2315	0.0001	35.7025	-0.0715	-0.0012	-0.0008	0.0014
100X 1705177-3	9.6090	0.0342	1.1591	1.4981	48.4507	0.2672	0.0003	6.0682	-0.0766	-0.0005	-0.0015	-0.0004
100X 1705202-1	1.0769	0.4599	0.3328	0.2168	50.1114	0.1023	0.0056	0.0575	-0.0823	0.1577	-0.0025	0.0024
100X 1705203-1	0.0436	0.1595	0.7088	0.0586	43.1160	0.0488	0.0022	0.0657	-0.0811	0.0645	-0.0027	0.0001
CCV	52.1421	20.3762	49.6325	51.6225	49.8078	0.5006	1.0114	5.0863	50.3481	1.0049	1.0345	1.0217
CCB	-0.0297	-0.0394	0.0694	-0.0265	0.0445	-0.0012	-0.0008	0.0205	-0.0513	-0.0007	-0.0011	0.0000

Sample vol. (ml) est Ba to add (ml 1000 ppm)

158-1 ~ 9.3 ug/ml Ba

10

0

177-1 ~ 900mg/L Ca low Ba

250 500

0.09

-2

-3

202-1 ~ 16 ug/ml Ba

6

0

203-1 ~ 6.5 ug/ml Ba

15

0

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	52.3190	20.5589	50.1920	51.5398	50.4979	0.5063	1.0193	5.1684	50.7141	1.0226	1.0265	1.0471
CCB	0.0513	-0.0040	0.1235	0.0417	0.1406	-0.0005	0.0003	0.0041	0.0234	0.0020	0.0155	-0.0006
1705177-1	525.9361	0.0811	215.9052	183.3913	176.9344	13.7658	0.0219	1219.4988	0.2965	0.0099	-0.0018	0.0282
1705177-2	508.7043	0.3012	218.3355	180.2003	172.8211	13.7265	0.1088	1179.5974	0.8728	0.0117	-0.0009	0.0624
1705177-3	625.8498	4.3457	178.0348	113.7966	214.7379	16.9502	0.1122	578.2457	-0.0437	0.0859	0.0192	0.0196
CCV	52.2157	20.6384	51.3507	51.9980	39.1053	0.5153	1.0251	40.4930	51.7387	1.0401	1.0384	1.0365
CCB	0.0916	0.0026	0.1252	0.0602	1.0741	0.0003	0.0003	21.5078	0.0285	0.0022	0.0127	0.0020
1705158-1	6.1817	0.0310	10.9358	1.3940	270.7578	0.9008	0.0281	6.7707	0.0070	8.4460	-0.0011	-0.0018
1705202-1	76.7521	41.7307	62.9640	19.0554	226.3697	7.4105	0.6951	9.4084	0.1024	12.3435	0.0009	0.3839
1705203-1	8.1529	160.7713	117.7244	7.8548	231.2136	3.6469	1.4557	1121.2366	-0.0222	5.3439	0.0091	0.0191

Section 8

STANDARDS TRACEABILITY DOCUMENTS



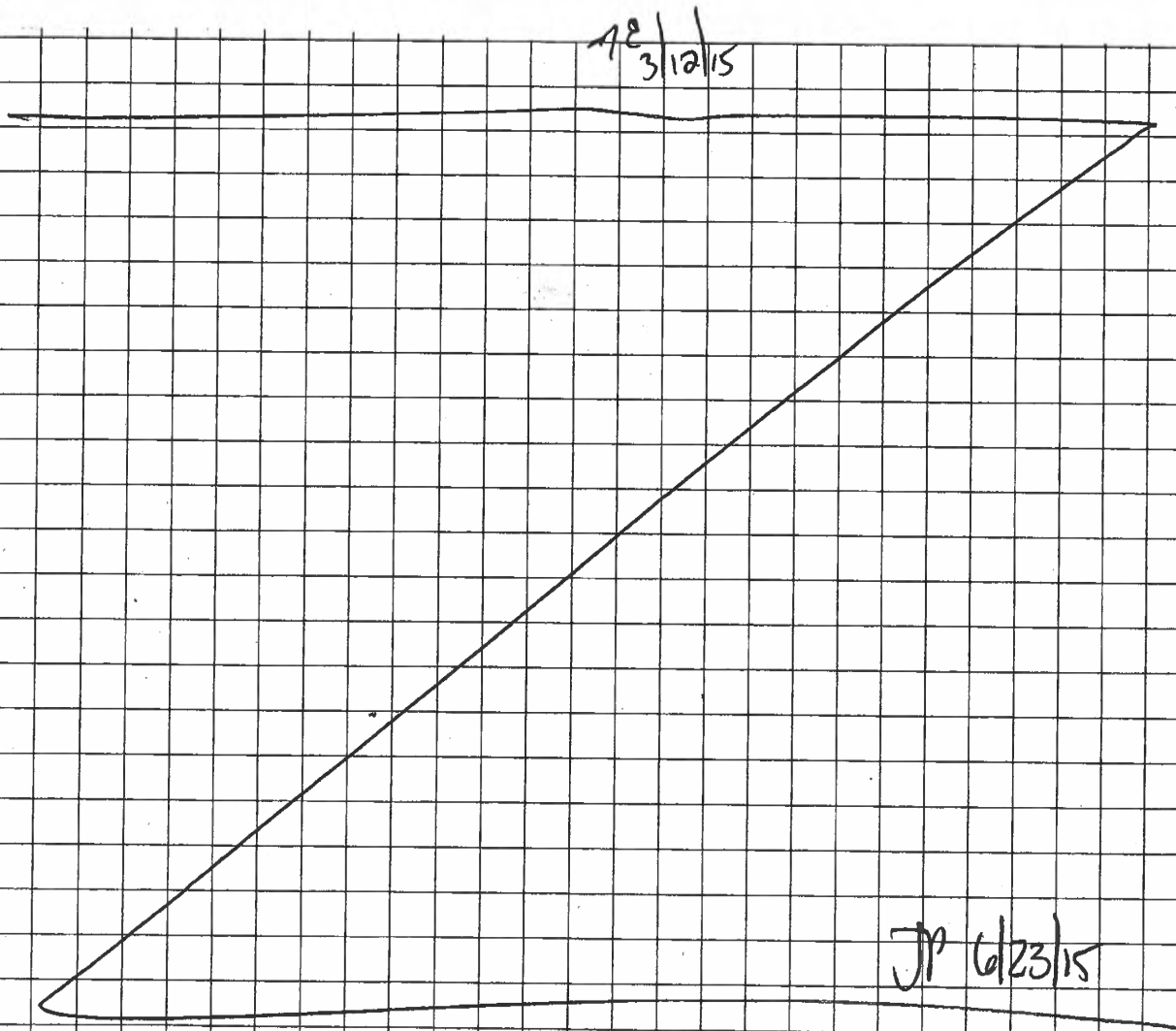
Project 1026.4095.84 Ra224/226 working standard
Continued from Page _____

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 _____

Signed

Date

Read and Understood By

Signed

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 # H45A12

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 (Vial, Std, + diluent)

57.7016 g

1

Net

36.5045 g

Activity, C/L

100 9/27/10

$\frac{1}{4} (1860 \text{ D. } R_0) (10 \text{ dpm}) \cdot 4.9831 \text{ g}$

$\frac{1}{36.5045 \text{ g}}$

$= 30.156 \text{ dpm/g}$

30.156

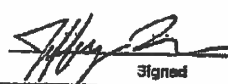
Jan 9/27/10

Continued on Page _____

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: 1705158

Prep SOP: PAI 701
Analytical SOP: PAI 714_Ra226

Reported on: Wednesday, May 24, 2017
1:14:14 PM

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
1705158-1 Spectrum #1 5/12/2017	SMP	RAS170511-1 RAS170511-1	RaISO	83	C17051083 B17051083 C17051083	5/10/2017 5/10/2017 5/10/2017	30.46 0.2180 5555.8	Pass Pass Pass	29.72 0.0000 5505.8	30.25 0.0500 5515.8	32.31 0.5000 5595.8	32.84 0.7500 5605.8
RAS170511-1 Spectrum #1 5/12/2017	MB	RAS170511-1 RAS170511-1	RaISO	81	C17051081 B17051081 C17051081	5/10/2017 5/10/2017 5/10/2017	28.35 0.1830 5548.0	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
RAS170511-1 Spectrum #1 5/12/2017	LCS	RAS170511-1 RAS170511-1	RaISO	82	C17051082 B17051082 C17051082	5/10/2017 5/10/2017 5/10/2017	28.92 0.2730 5548.0	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: RAS1705158-1

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

Date Printed: Thursday, May 25, 2017

ALS -- Fort Collins

LIMS Version: 6.842

Page 1 of 1

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	79837	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	15387.15	15982.35	-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	0.83	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

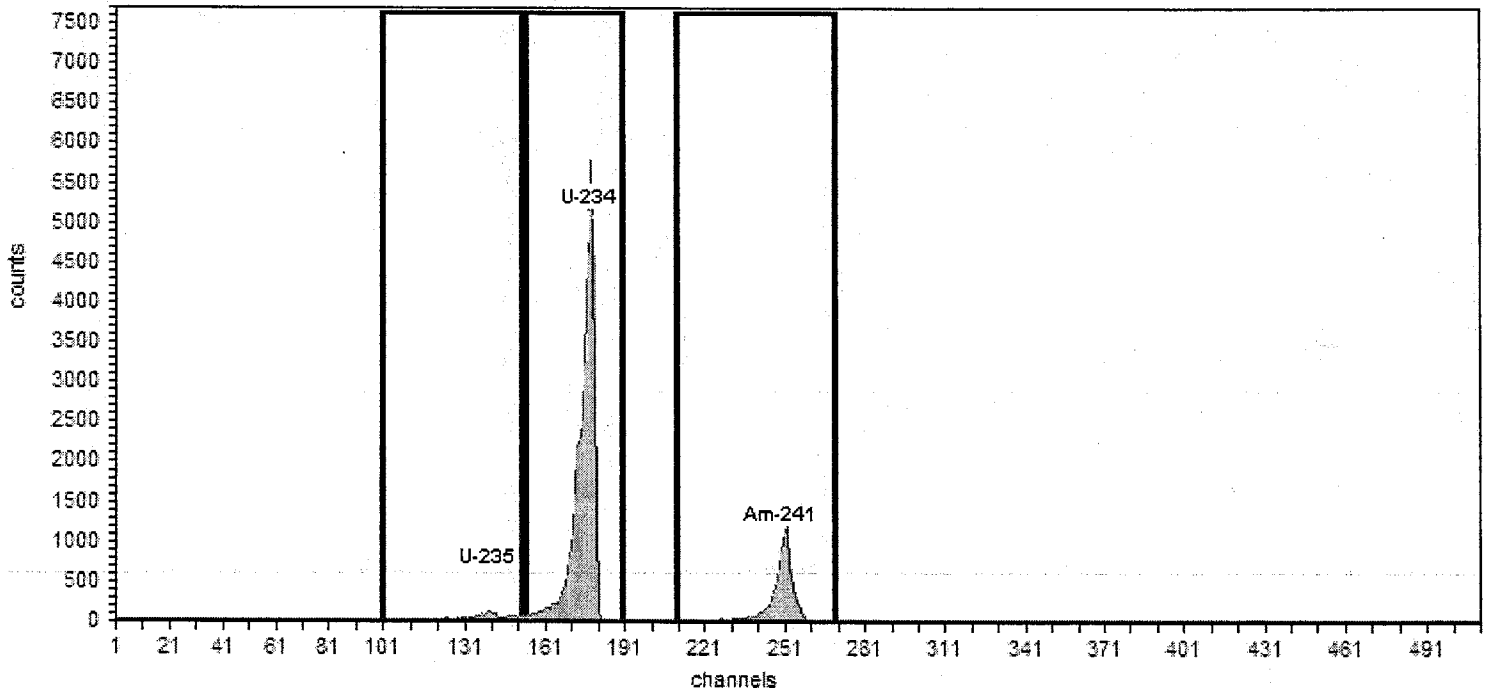
Offset = 3,021.28 keV

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:

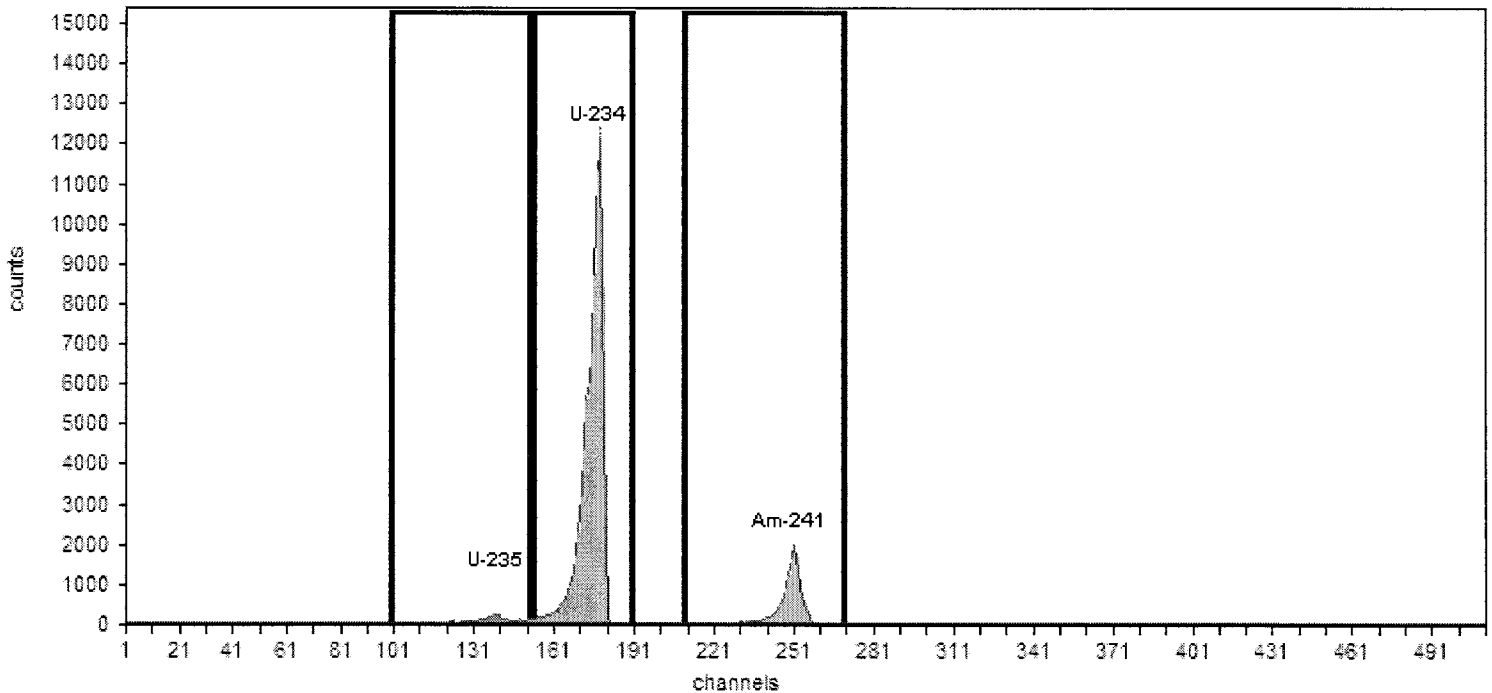
Gain = 9.9003 keV / Ch

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:

CalibrationAnalysis 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:

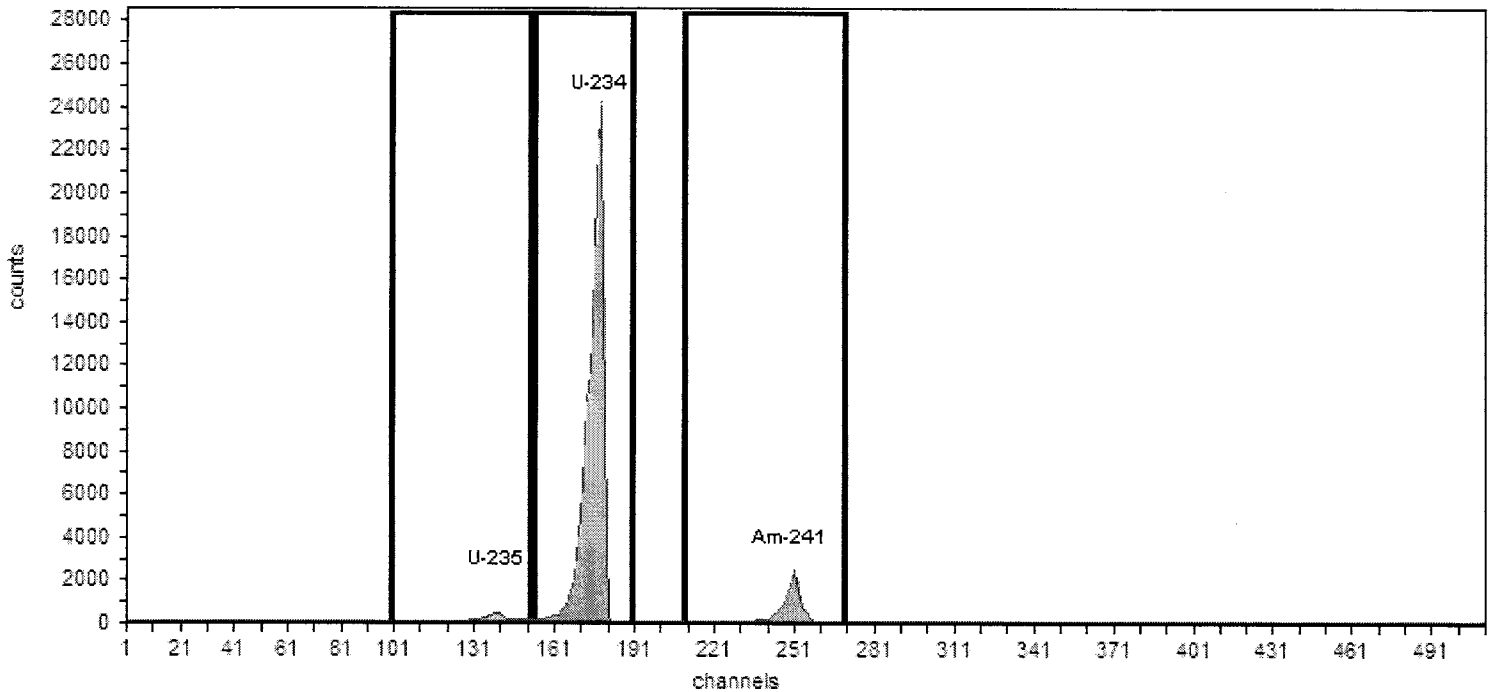
Gain = 9.9003 keV / Ch

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:

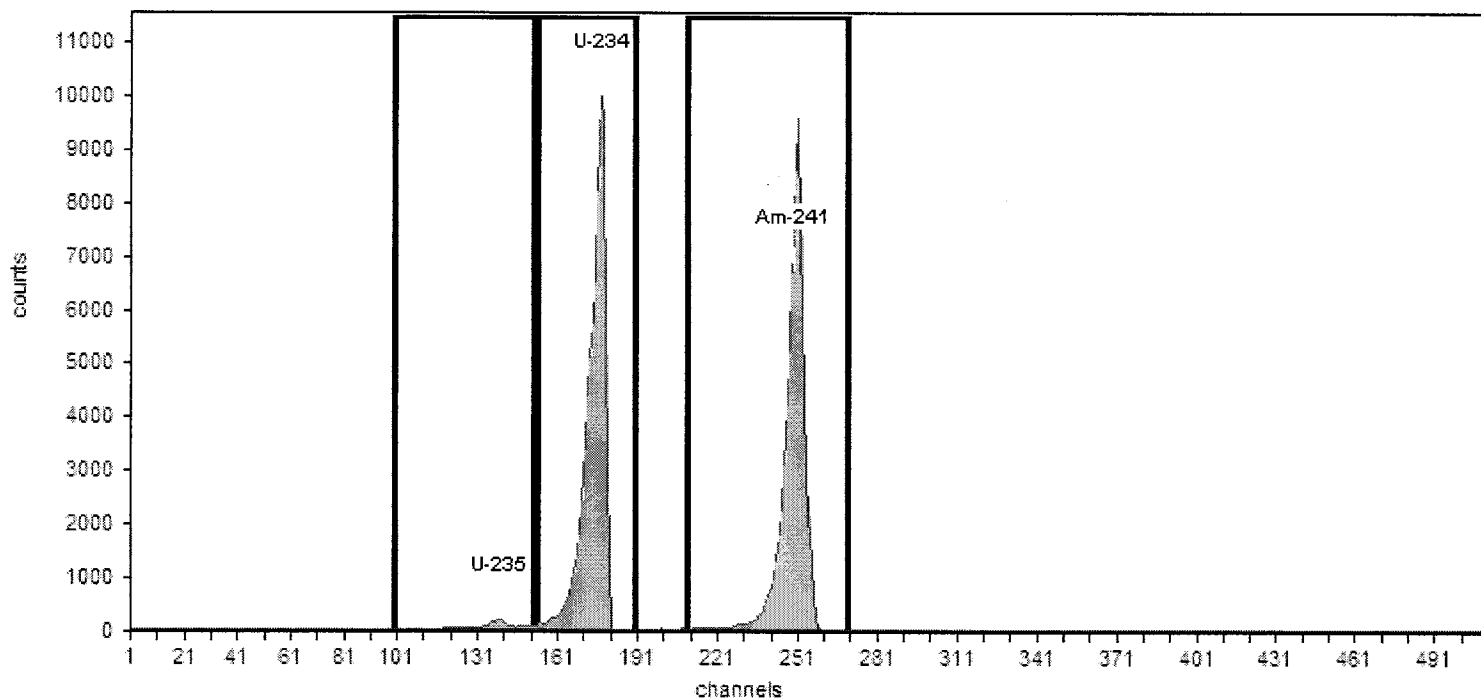
Gain = 9.9003 keV / Ch

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:

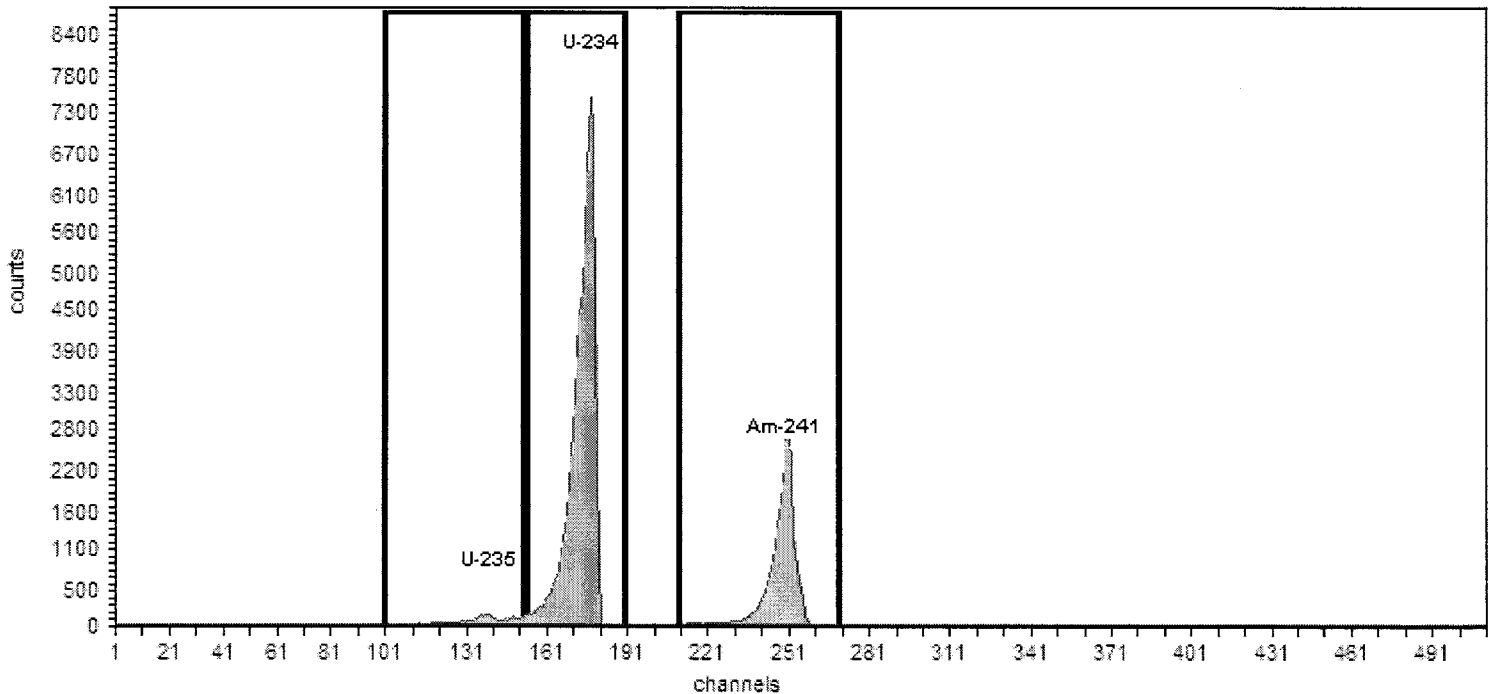
Gain = 9.9003 keV / Ch

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

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:

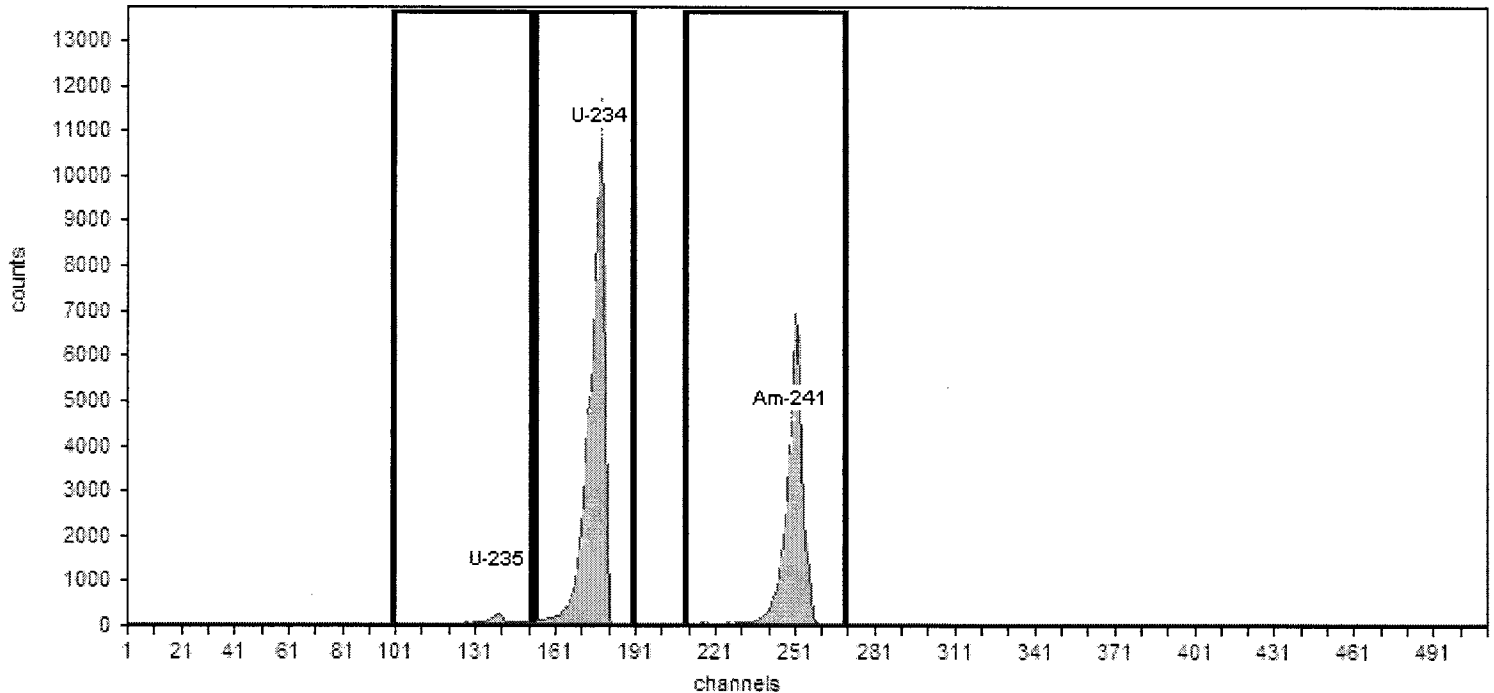
Gain = 9.9003 keV / Ch

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:

CalibrationAnalysis 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:

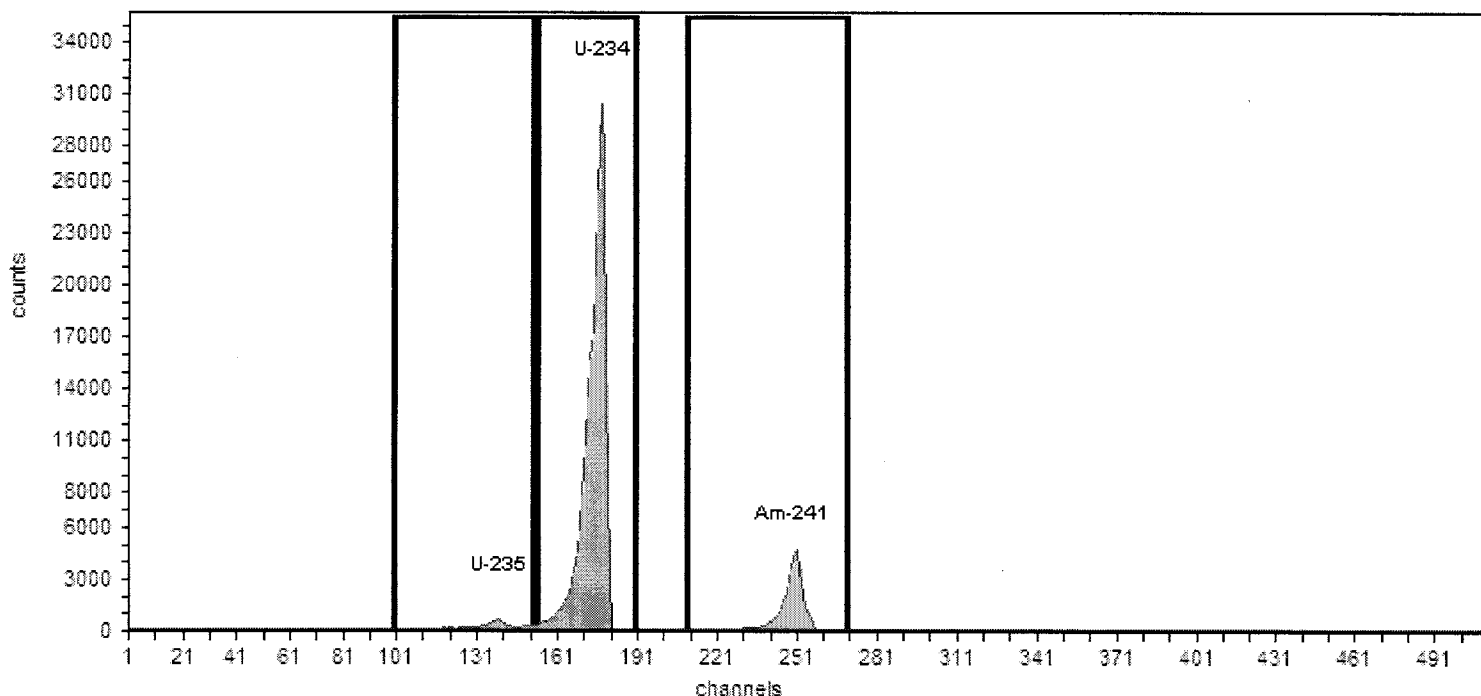
Gain = 9.9003 keV / Ch

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

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 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: 10/5/2016 7:45:09AM

Live Time: 35.00 min.

Real Time: 35.01 min.

Energy Calibration Equation:

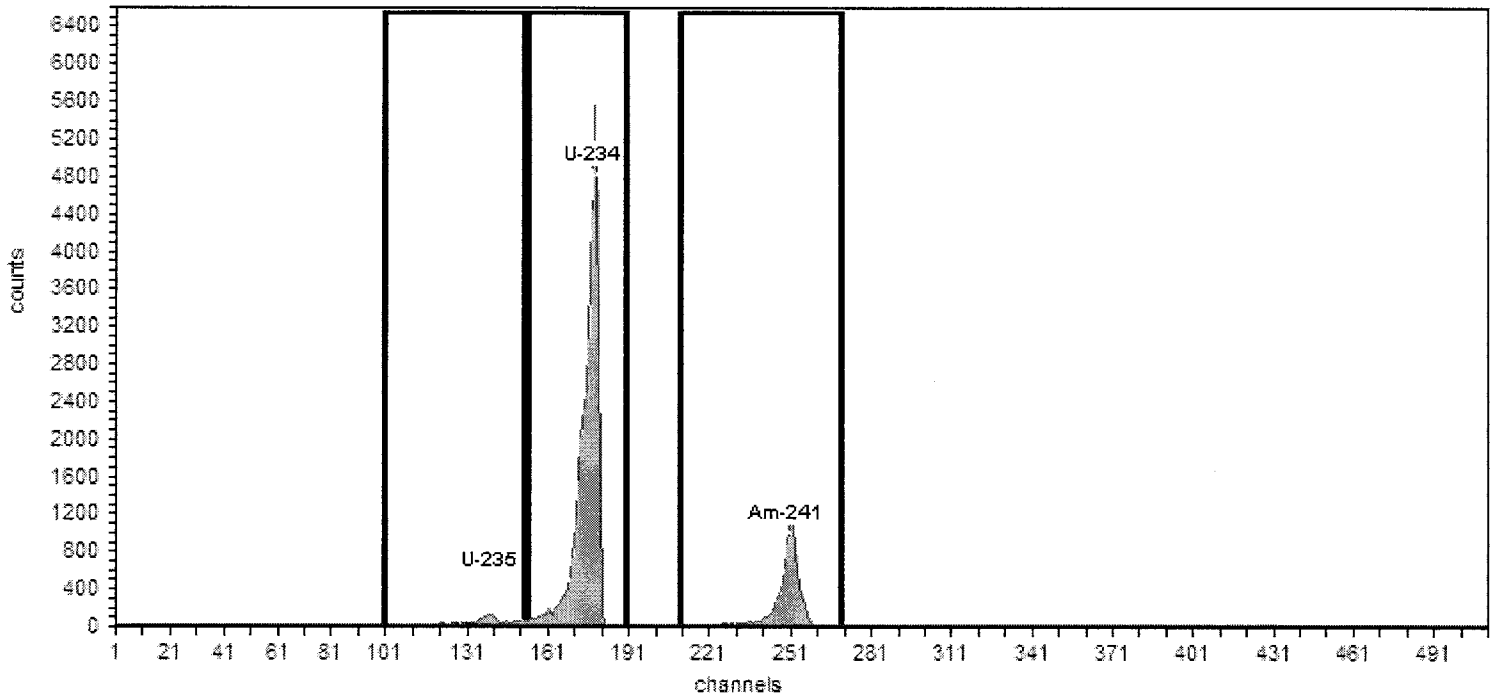
Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV

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)

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	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



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
PAT 1875
recalibrated 4-15-03
T1015/16

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)
U-235: 0.06566 nCi (2.429 Bq)

Am-241: 0.5793 nCi (21.43 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

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

PAT 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

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

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
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 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

24937 Avenue Tibbitts
Valencia, California 91355

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

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
24937 Avenue Tibbitts Valencia, California 91355

ISO 9001 CERTIFIED

Industrial Gauging Laboratory
1800 North Keystone Street Burbank, California 91504



**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
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

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

24937 Avenue Tibbitts
Valencia, California 91355

Tel 661-309-1010

Fax 661-257-8303

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

Medical Imaging Laboratory
24937 Avenue Tibbitts Valencia, California 91355

ISO 9001 CERTIFIED

Industrial Gauging Laboratory
1800 North Keystone Street Burbank, California 91504