facility 439136
project 10243

Radium-224/226

Case Narrative

COGCC

PW NORM 2017 – 10048

Work Order Number: 1705202

1. This report consists of the analytical results and supporting documentation for one water sample received by ALS on 05/09/2017.

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 in units of pCi/L. The water sample was filtered prior to analysis.

5. Sample 1705202-1 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 was not met for samples 1705202-1 and -1D, due to reduced aliquots of the samples taken for analysis. The samples were 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 — 5/25/17

Pik Yee Yuen — Date

Radiochemistry Primary Data Reviewer

5/25/17

Radiochemistry Final Data Reviewer — Date

1

Section 1

CHAIN OF CUSTODY

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 1705202
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
439136	1705202-1		WATER	09-May-17	12:50
439136	1705202-2		WATER	09-May-17	12:50

ALS Environmental

225 Commerce Drive, Fort Collins, Colorado 80524
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.

ALS WORKORDER #	
1705202	
PAGE	of
DISPOSAL	BY LAB or RETURN

PROJECT NAME	PW NORM 2017	TURNAROUND TIME	45 days
PROJECT No.	10048	SITE ID	
		EDD FORMAT	COGCC
COMPANY NAME	COGCC	PURCHASE ORDER	CT 2017-3066
SEND REPORT TO	Peter Cintantas	BILL TO COMPANY	
ADDRESS	1120 Lincoln St., Suite 801	INVOICE ATTN TO	
CITY / STATE / ZIP	Denver, CO 80203	ADDRESS	
PHONE	719-679-1326	CITY / STATE / ZIP	
FAX		PHONE	
E-MAIL		FAX	
		E-MAIL	

SAMPLER: Robert Young

PARAMETER/METHOD REQUEST FOR ANALYSIS

A	total metals SW6010/6020
B	dissolved metals SW6010
C	SW9040A pH
D	SM2510B specific conductance
E	SM2320C total, bicarb & carb alkalinity
F	SM2540C dissolved solids
G	SM2540D suspended solids
H	SW9056 ~~SW9~~ (Br, Cl, F, SO_4)
I	SAR calc.
J	

LAB ID	FIELD ID	MATRIX	SAMPLE DATE	SAMPLE TIME	# OF BOTTLES	PRESERVATIVE	QC	A	B	C	D	E	F	G	H	I	J	SEE NOTES SECTION
1	439136	W	5/9/17	1250	1	2	X	X										
↓	439136	W	↓	↓	2	7	X		X	X	X	X	X	X	X	X		

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract F = filter

NOTES	REPORT LEVEL / QC REQUIRED
	Summary (Standard QC)
	LEVEL II (Standard QC)
	LEVEL III (Std QC + forms)
	LEVEL IV (Std QC + forms + raw)

PRESERVATION KEY: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaOH/ZnAcetate 6-NaHSO4 7-4°C 8-Other

Form 202r9	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY		Robert Young	5/9/17	1642
RECEIVED BY		~~Joshua Griffith~~	5/9/17	1642
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

ALS Environmental

225 Commerce Drive, Fort Collins, Colorado 80524
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.

ALS WORKORDER # 1705202

PAGE of

DISPOSAL BY LAB or RETURN

PROJECT NAME	PW NORM 2017	TURNAROUND TIME	45 day
PROJECT No.	10048	SITE ID	
		EDD FORMAT	COGCC
COMPANY NAME	COGCC	PURCHASE ORDER	CT2017-3066
SEND REPORT TO	Peter Gintautas	BILL TO COMPANY	
ADDRESS		INVOICE ATTN TO	
CITY / STATE / ZIP		ADDRESS	
PHONE	719 6791326	CITY / STATE / ZIP	
FAX		PHONE	
E-MAIL		FAX	
		E-MAIL	
		SAMPLER	Robert Young

PARAMETER/METHOD REQUEST FOR ANALYSIS

A	gross alpha/gross beta
B	210 Pb
C	210 Po
D	222 Rn
E	224 Ra + 226 Ra
F	228 Ra
G	gamma emitters
H	* isotopic U
I	* isotopic Th
J	

LAB ID	FIELD ID	MATRIX	SAMPLE DATE	SAMPLE TIME	# OF BOTTLES	PRESERVATIVE	QC	A	B	C	D	E	F	G	H	I	J	SEE NOTES SECTION
	439136	W	5/9/17	1250	3	2		X	X	X		X	X	X	*	*		
	439136	W	"	"	3	7					X							

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract F = filter

NOTES	REPORT LEVEL / QC REQUIRED
* iso U only if 6020 "total" U > 3 ug/L	Summary (Standard QC)
* " Th " " " " Th > 3 ug/L	LEVEL II (Standard QC)
	LEVEL III (Std QC + forms)
	LEVEL IV (Std QC + forms + raw)

PRESERVATION KEY: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaOH/ZnAcetate 6-NaHSO4 7-4°C 8-Other

Form 202r9

	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY	Robert T. Young	Robert Young	5/8/17	1642
RECEIVED BY		JOSHUA JS	5/9/17	1642
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: COGCC Workorder No: 1705202

Project Manager: SS Initials: CAT Date: 5-10-17

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

Cooler #:	1	2					
Temperature (°C):	6.0	Amb					
No. of custody seals on cooler:	0	0					
DOT Survey/ Acceptance Information — External µR/hr reading:	NA	NA					
Background µR/hr reading:	NA						

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES / NO (NA) (If no, see Form 008.)

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

All RAD Samples in the Amb Cooler.

Added 3.5 ml HNO_3 to EA. RAD and Total metals bottle. Final pH < 2. HNO_3 lot no. 152495.

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

Project Manager Signature / Date: Shiloh Summy

*IR Gun #2: Oakton, SN 29922500201-0066
*IR Gun #4: Oakton, SN 2372220101-0002

Form 201r24.xls (06/04/2012)

Section 2

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: 1705202

Reported on: Thursday, May 25, 2017
9:33:58 AM

Lab Sample ID	Client Sample ID	Sample Type	Nuclide	Result +/- 2 s TPU	MDC	DL	Units	Matrix	Prep Batch	Date Analyze	Flags
1705202-1	439136	Sample	Ra-224	5.1E+00 +/- 6.7E+00	2.81E+01	NA	pCi/l	WATER	RAS170511-1	5/12/2017	U,M
1705202-1	439136	Sample	Ra-226	1.25E+02 +/- 1E+01	3E+00	NA	pCi/l	WATER	RAS170511-1	5/12/2017	M3

Comments:

Data Package ID: *RAS1705202-1*

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 ❸

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Method Blank Results

Lab Name: ALS -- Fort Collins
Work Order Number: 1705202
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: *RAS1705202-1*

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins
Work Order Number: 1705202
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: *RAS1705202-1*

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins
Work Order Number: 1705202
Client Name: COGCC
ClientProject ID: PW NORM 2017 10048

Field ID:	439136
Lab ID:	1705202-1DUP

Sample Matrix: WATER
Prep SOP: PAI 701 Rev 1
Date Collected: 09-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: 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	5.1E+00 +/- 6.7E+00	2.81E+01	U,M	-4E+00 +/- 6.4E+00	2.9E+01	U,M	0.9907	2
13982-63-3	Ra-226	1.25E+02 +/- 1E+01	3E+00	M3	1.12E+02 +/- 9.4E+00	3.1E+00	M3	0.9313	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: *RAS1705202-1*

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: 1705202
Client Name: COGCC
ClientProject ID: PW NORM 2017 10048

Field ID: 439136
Lab ID: 1705202-1

Sample Matrix: WATER
Prep SOP: PAI 701 Rev 1
Date Collected: 09-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: 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	5.1E+00 +/- 6.7E+00	2.81E+01	1E+00	NA	U,M
13982-63-3	Ra-226	1.25E+02 +/- 1E+01	3E+00	1E+00	NA	M3

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	8.990E+02	7.760E+02	pCi/l	92.4	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: *RAS1705202-1*

Isotopic Radium by Alpha Spectroscopy

PAI 714_Ra226 Rev 13

Sample Duplicate Results

Lab Name: ALS -- Fort Collins
Work Order Number: 1705202
Client Name: COGCC
ClientProject ID: PW NORM 2017 10048

Field ID: 439136
Lab ID: 1705202-1DUP

Sample Matrix: WATER
Prep SOP: PAI 701 Rev 1
Date Collected: 09-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: 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	-4E+00 +/- 6.4E+00	2.9E+01	1E+00	NA	U,M
13982-63-3	Ra-226	1.12E+02 +/- 9.4E+00	3.1E+00	1E+00	NA	M3

Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
At-217	8.990E+02	8.310E+02	pCi/l	86.3	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: *RAS1705202-1*

Section 5

RAW DATA

5

Isotopic Radium by Alpha Spectroscopy Raw Data Report

Laboratory Name: ALS -- Fort Collins
PAI Work Order: 1705202
Prep SOP: PAI 701
Analytical SOP: PAI 714_Ra226
Reported on: Wednesday, May 24, 2017 1:14:14 PM

Sample ID / QC Type	Nuclide / Type	Sample Date/Time	Prep Batch / QCBatchID	Ingrowth Date /Time	Decay Date/Time	Matrix / %Moist.	Samp Alq / Analy Alq	Inst ID / Det ID	AnRunID / File Name	Count Date/Time	Net Cnts / Bkg Cnts	BaseEff / Bkg(min)	CntDur(min) / Yield	Activity +/- 2 s TPU	MDC / DecLev	ReportUnits / ReportBasis	DER / RPD	%Spk. Recov / Flags
1705202-1	Ra-224	5/9/2017	RAS170511-1	NA	NA	WATER	6 ml	AlphaSpec2	RAS170511-1	5/12/2017	64.000	28.84%	1000	5.1E+00	2.81E+01	pCi/l	NA	
SMP	Trg. Analyte	12:50:00 PM	RAS170511-1-1	NA	NA	NA	6 ml	88	Spectrum #1	1:44 PM	36.000	1000	92.4%	6.7E+00		Filtered	NA	U,M
1705202-1	Ra-226	5/9/2017	RAS170511-1	NA	NA	WATER	6 ml	AlphaSpec2	RAS170511-1	5/12/2017	420.000	28.84%	1000	1.25E+02	3E+00	pCi/l	NA	
SMP	Trg. Analyte	12:50:00 PM	RAS170511-1-1	NA	NA	NA	6 ml	88	Spectrum #1	1:44 PM	2.000	1000	92.4%	1E+01		Filtered	NA	M3
1705202-1	Ra-224	5/9/2017	RAS170511-1	NA	NA	WATER	6 ml	AlphaSpec2	RAS170511-1	5/12/2017	49.000	29.52%	1000	-4E+00	2.9E+01	pCi/l	0.99	
DUP	Trg. Analyte	12:50:00 PM	RAS170511-1-1	NA	NA	NA	6 ml	89	Spectrum #1	1:44 PM	32.000	1000	86.3%	6.4E+00		Filtered	NA	U,M
1705202-1	Ra-226	5/9/2017	RAS170511-1	NA	NA	WATER	6 ml	AlphaSpec2	RAS170511-1	5/12/2017	360.000	29.52%	1000	1.12E+02	3.1E+00	pCi/l	0.93	
DUP	Trg. Analyte	12:50:00 PM	RAS170511-1-1	NA	NA	NA	6 ml	89	Spectrum #1	1:44 PM	2.000	1000	86.3%	9.4E+00		Filtered	NA	M3
RAS170511-1	Ra-224	5/11/2017	RAS170511-1	NA	NA	WATER	500 ml	AlphaSpec2	RAS170511-1	5/12/2017	46.000	28.35%	1000	-2E-03	1.85E-01	pCi/l	NA	
MB	Trg. Analyte	12:00:00 PM	RAS170511-1-1	NA	NA	NA	500 ml	81	Spectrum #1	1:44 PM	28.000	1000	89.4%	4.2E-02		As Received	NA	U
RAS170511-1	Ra-226	5/11/2017	RAS170511-1	NA	NA	WATER	500 ml	AlphaSpec2	RAS170511-1	5/12/2017	-2.000	28.35%	1000	-7E-03	5.2E-02	pCi/l	NA	
MB	Trg. Analyte	12:00:00 PM	RAS170511-1-1	NA	NA	NA	500 ml	81	Spectrum #1	1:44 PM	5.000	1000	89.4%	1.2E-02		As Received	NA	U
RAS170511-1	Ra-224	5/11/2017	RAS170511-1	NA	NA	WATER	500 ml	AlphaSpec2	RAS170511-1	5/12/2017	2382.000	28.92%	1000	9.33E+00	2E-01	pCi/l	NA	104
LCS	Trg. Analyte	12:00:00 PM	RAS170511-1-1	NA	NA	NA	500 ml	82	Spectrum #1	1:44 PM	21.000	1000	88.5%	6.4E-01		As Received	NA	P
RAS170511-1	Ra-226	5/11/2017	RAS170511-1	NA	NA	WATER	500 ml	AlphaSpec2	RAS170511-1	5/12/2017	2565.000	28.92%	1000	9.5E+00	6E-02	pCi/l	NA	103
LCS	Trg. Analyte	12:00:00 PM	RAS170511-1-1	NA	NA	NA	500 ml	82	Spectrum #1	1:44 PM	9.000	1000	88.5%	6.5E-01		As Received	NA	P

Comments:

Data Package ID: *RAS1705202-1*

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

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample

Sample: 1705202-1
Spectrum #1 Analysis #1

Sample Size : 0.01

Acquisition

Detector: 88
Batch Name: RAS170511-1_A
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition Start Date: 5/12/2017 1:44:55PM
Live Time: 1,000.00 min.
Real Time: 1,000.09 min.
Dead Time: 0.01 %

Calibration

Bkgd Info: Sample: B17051088; Det: 88; Spectrum #1; 5/10/2017 10:45:37 AM

Calibration Date: 5/10/2017 10:12:28AM

Efficiency Calibration: C17051088

Efficiency: 28.84% +/- 0.20% TPU(2 sigma)

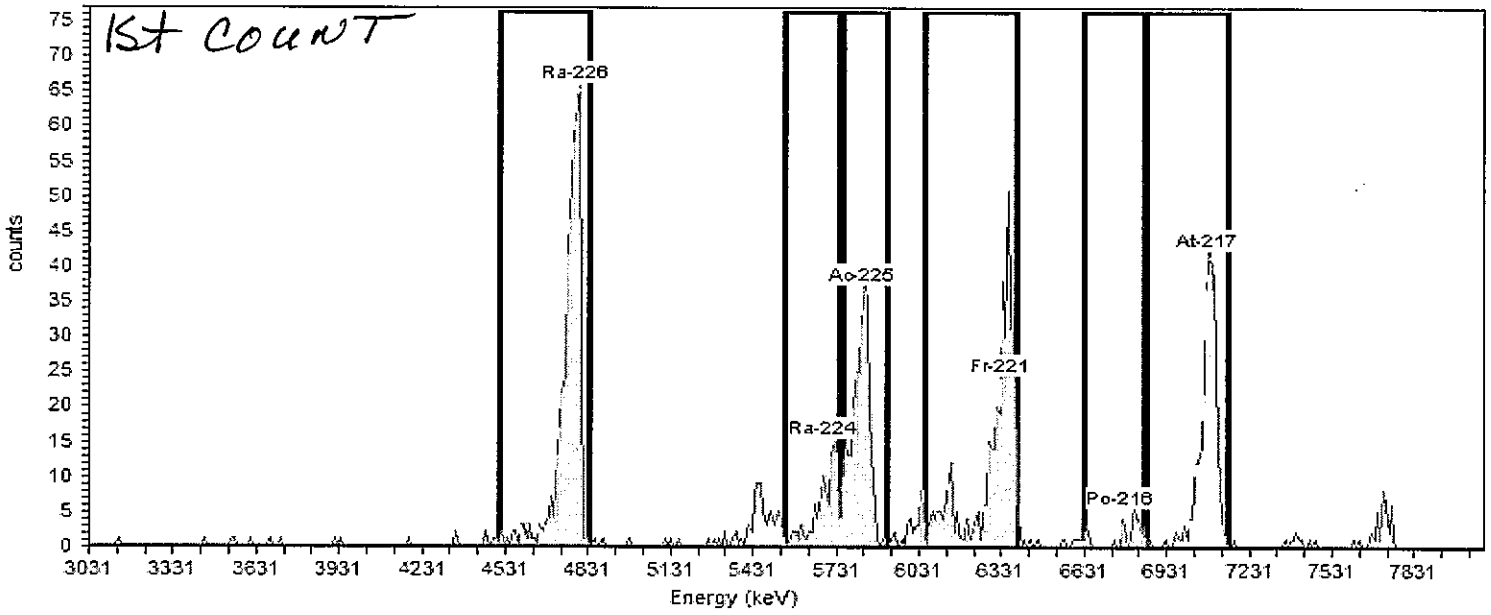
Energy Calibration: C17051088

Energy Cal: Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch^2

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: 3.89%



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	28.0	100.1	422.00	2.00	420.00	2.8E+003	3.0E+002	2.2E+001	6.2E+001
Ra-224	5684.5	5545.9	5743.9	23.2	95.1	100.00	36.00	64.00	4.5E+002	9.2E+001	9.8E+001	2.2E+002
Ac-225	5823.1	5753.8	5912.2	61.4	78.3	262.00	48.00	214.00	1.8E+003	2.3E+002	1.4E+002	3.0E+002
Fr-221	6328.0	6050.8	6387.4	47.4	100.0	361.00	63.00	298.00	1.3E+004	1.6E+003	8.1E+002	1.7E+003
Po-216	6763.6	6634.9	6852.7	81.7	100.0	33.00	25.00	8.00	5.4E+001	5.1E+001	7.8E+001	1.7E+002
At-217	7080.4	6862.6	7159.6	49.4	99.9	265.00	41.00	224.00	5.8E+001	4.6E+000	1.0E+002	2.2E+002

JA

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample

Sample: 1705202-1
Spectrum #1 Analysis #1

Sample Size : 0.01

Acquisition

Detector: 88
Batch Name: RAS170511-1_B
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition Start Date: 5/23/2017 6:44:23AM
Live Time: 300.00 min.
Real Time: 300.17 min.
Dead Time: 0.06 %

Calibration

Bkgd Info: Sample: B17051088; Det: 88; Spectrum #1; 5/10/2017 10:45:37 AM

Calibration Date: 5/10/2017 10:12:28AM

Efficiency Calibration: C17051088

Efficiency: 28.84% +/- 0.20% TPU(2 sigma)

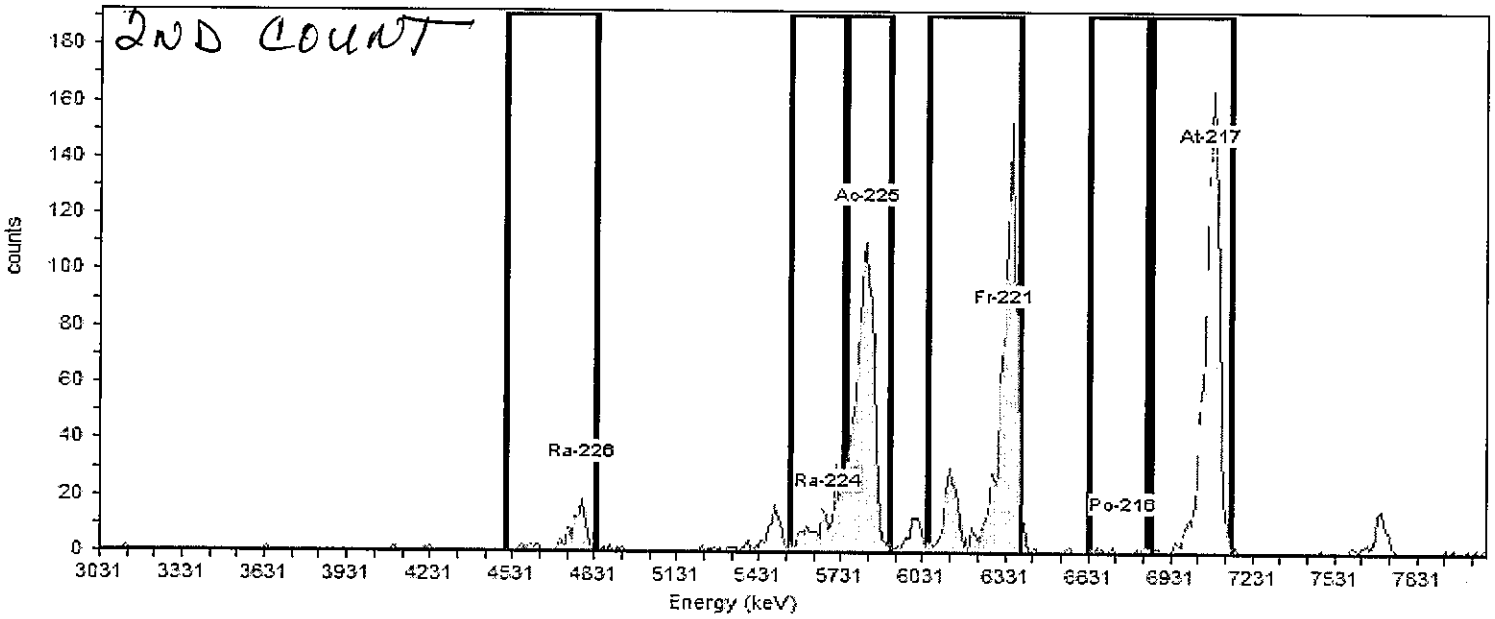
Energy Calibration: C17051088

Energy Cal: Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch^2

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: 55.40%



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	26.0	100.1	109.00	0.60	108.40	1.7E+002	1.9E+001	2.3E+000	8.8E+000
Ra-224	5684.5	5545.9	5743.9	12.0	95.1	225.00	10.80	214.20	3.5E+002	3.3E+001	1.0E+001	2.5E+001
Ac-225	5823.1	5753.8	5912.2	74.9	78.3	848.00	14.40	833.60	1.7E+003	1.2E+002	1.4E+001	3.4E+001
Fr-221	6328.0	6050.8	6387.4	46.3	100.0	1,036.00	18.90	1,017.10	3.1E+003	2.2E+002	2.5E+001	5.9E+001
Po-216	6763.6	6634.9	6852.7	24.1	100.0	13.00	7.50	5.50	8.6E+000	7.1E+000	8.0E+000	2.0E+001
At-217	7080.4	6862.6	7159.6	48.8	99.9	970.00	12.30	957.70	8.3E+002	2.7E+001	1.0E+001	2.5E+001

JA

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample

Sample: 1705202-1D
Spectrum #1 Analysis #1

Sample Size : 0.01

Acquisition

Detector: 89
Batch Name: RAS170511-1_A
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition Start Date: 5/12/2017 1:44:55PM
Live Time: 1,000.00 min.
Real Time: 1,000.01 min.
Dead Time: 0.00 %

Calibration

Bkgd Info: Sample: B17051089; Det: 89; Spectrum #1; 5/10/2017 10:46:22 AM

Calibration Date: 5/10/2017 10:12:37AM

Efficiency Calibration: C17051089

Efficiency: 29.52% +/- 0.18% TPU(2 sigma)

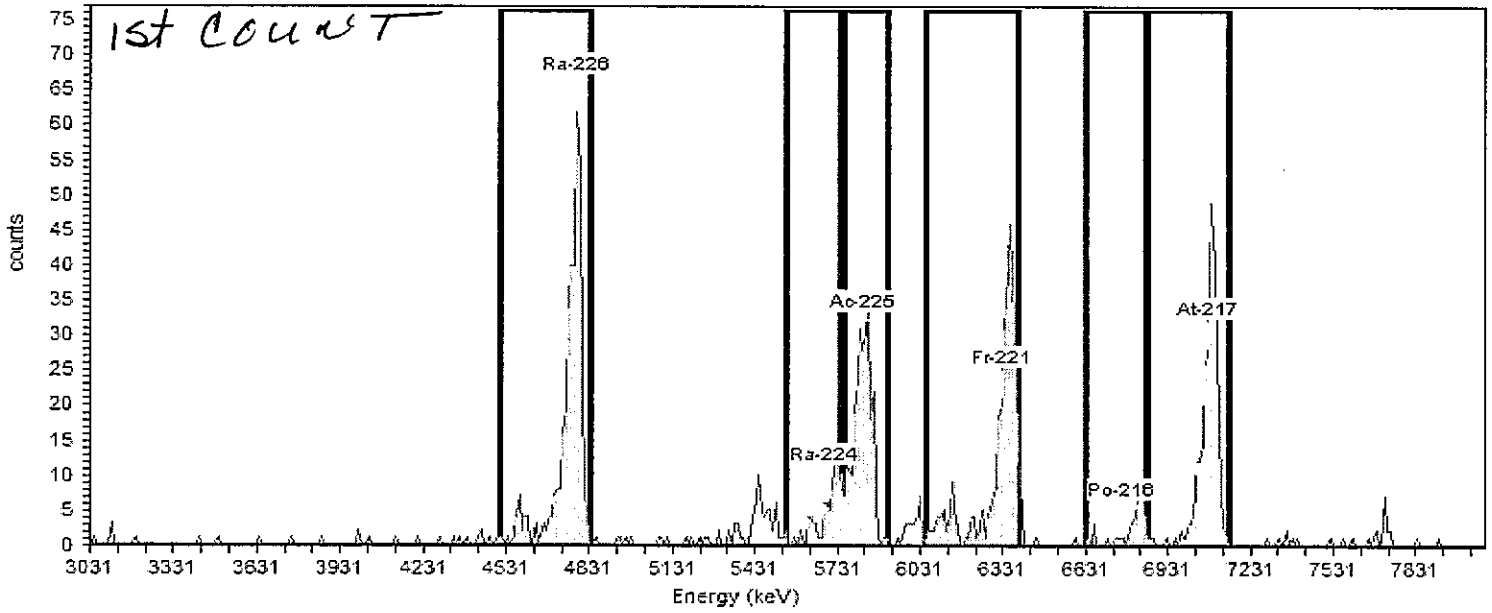
Energy Calibration: C17051089

Energy Cal: Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch^2

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: 4.22%



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	26.9	100.1	362.00	2.00	360.00	2.2E+003	2.2E+002	2.0E+001	5.6E+001
Ra-224	5684.5	5545.9	5743.9	45.0	95.1	81.00	32.00	49.00	3.1E+002	7.3E+001	8.4E+001	1.8E+002
Ac-225	5823.1	5753.8	5912.2	71.0	78.3	255.00	26.00	229.00	1.8E+003	2.0E+002	9.1E+001	2.0E+002
Fr-221	6328.0	6050.8	6387.4	47.8	100.0	313.00	54.00	259.00	1.0E+004	1.2E+003	6.7E+002	1.5E+003
Po-216	6763.6	6634.9	6852.7	23.8	100.0	40.00	22.00	18.00	1.1E+002	4.8E+001	6.6E+001	1.5E+002
At-217	7080.4	6862.6	7159.6	45.3	99.9	273.00	24.00	249.00	6.3E+001	4.4E+000	6.9E+001	1.5E+002

JA

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample

Sample: 1705202-1D
Spectrum #1 Analysis #1

Sample Size : 0.01

Acquisition

Detector: 89
Batch Name: RAS170511-1_B
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

Acquisition Start Date: 5/23/2017 6:44:24AM
Live Time: 300.00 min.
Real Time: 300.10 min.
Dead Time: 0.03 %

Calibration

Bkgd Info: Sample: B17051089; Det: 89; Spectrum #1; 5/10/2017 10:46:22 AM

Calibration Date: 5/10/2017 10:12:37AM

Efficiency Calibration: C17051089

Efficiency: 29.52% +/- 0.18% TPU(2 sigma)

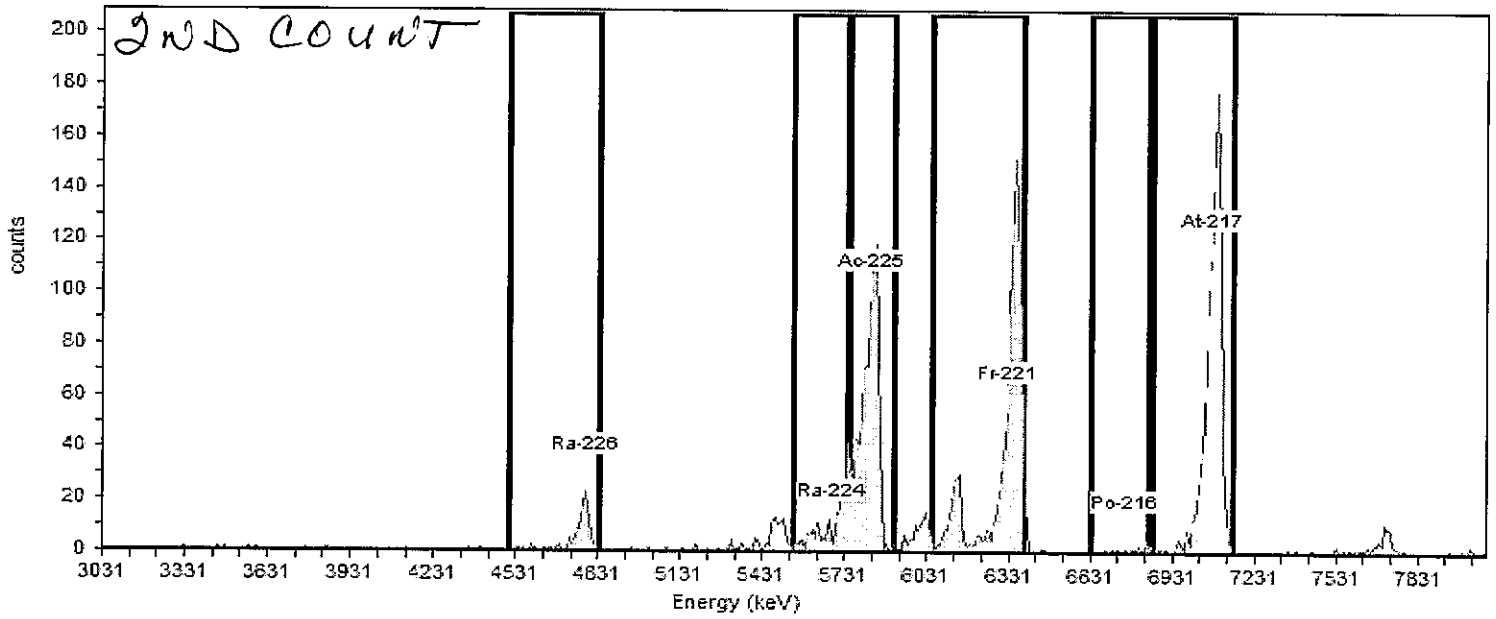
Energy Calibration: C17051089

Energy Cal: Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch^2

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: 51.76%



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	24.4	100.1	103.00	0.60	102.40	1.7E+002	1.9E+001	2.4E+000	9.2E+000
Ra-224	5684.5	5545.9	5743.9	13.0	95.1	200.00	9.60	190.40	3.3E+002	3.2E+001	1.0E+001	2.5E+001
Ac-225	5823.1	5753.8	5912.2	61.5	78.3	789.00	7.80	781.20	1.6E+003	1.1E+002	1.1E+001	2.8E+001
Fr-221	6328.0	6050.8	6387.4	46.4	100.0	976.00	16.20	959.80	3.1E+003	2.2E+002	2.4E+001	5.8E+001
Po-216	6763.6	6634.9	6852.7	18.4	100.0	15.00	6.60	8.40	1.4E+001	7.7E+000	7.9E+000	2.0E+001
At-217	7080.4	6862.6	7159.6	46.6	99.9	923.00	7.20	915.80	7.8E+002	2.6E+001	8.3E+000	2.1E+001

JA

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample

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

Sample Size : 0.50

Acquisition

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

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)

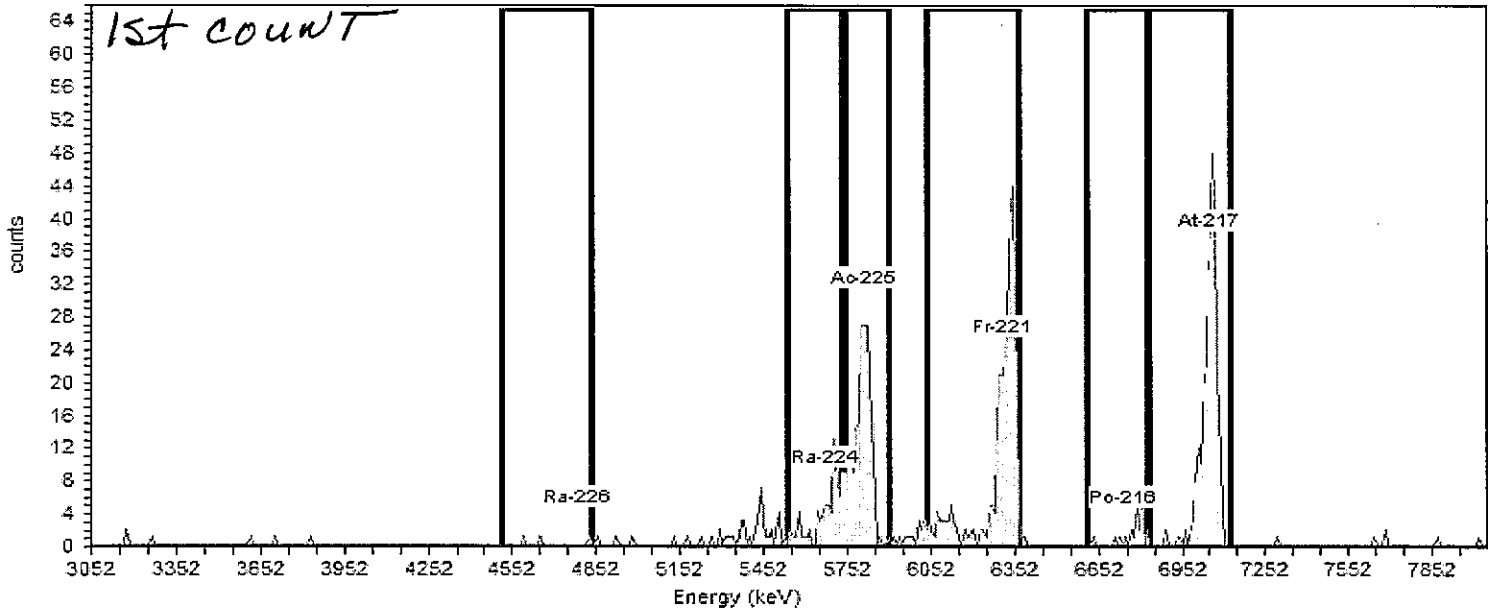
Energy Calibration: C17051081

Energy Cal: Gain = 9.7851 keV / Ch
Offset = 3,042.97 keV
Quadratic = 0.0000 keV / Ch^2

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

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample

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

Sample Size : 0.50

Acquisition

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

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)

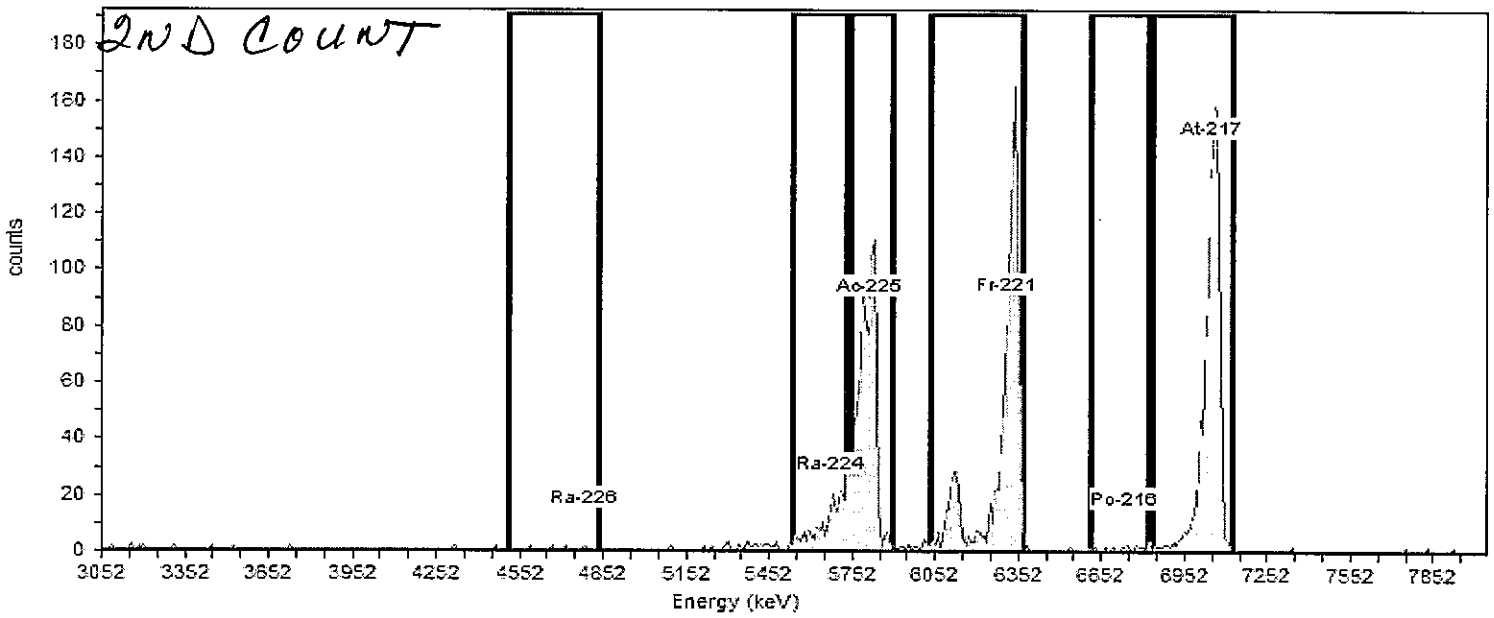
Energy Calibration: C17051081

Energy Cal: Gain = 9.7851 keV / Ch
Offset = 3,042.97 keV
Quadratic = 0.0000 keV / Ch^2

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

JP

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample

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

Sample Size : 0.50

Acquisition

Detector: 82
Batch Name: RAS170511-1_A
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

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: 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)

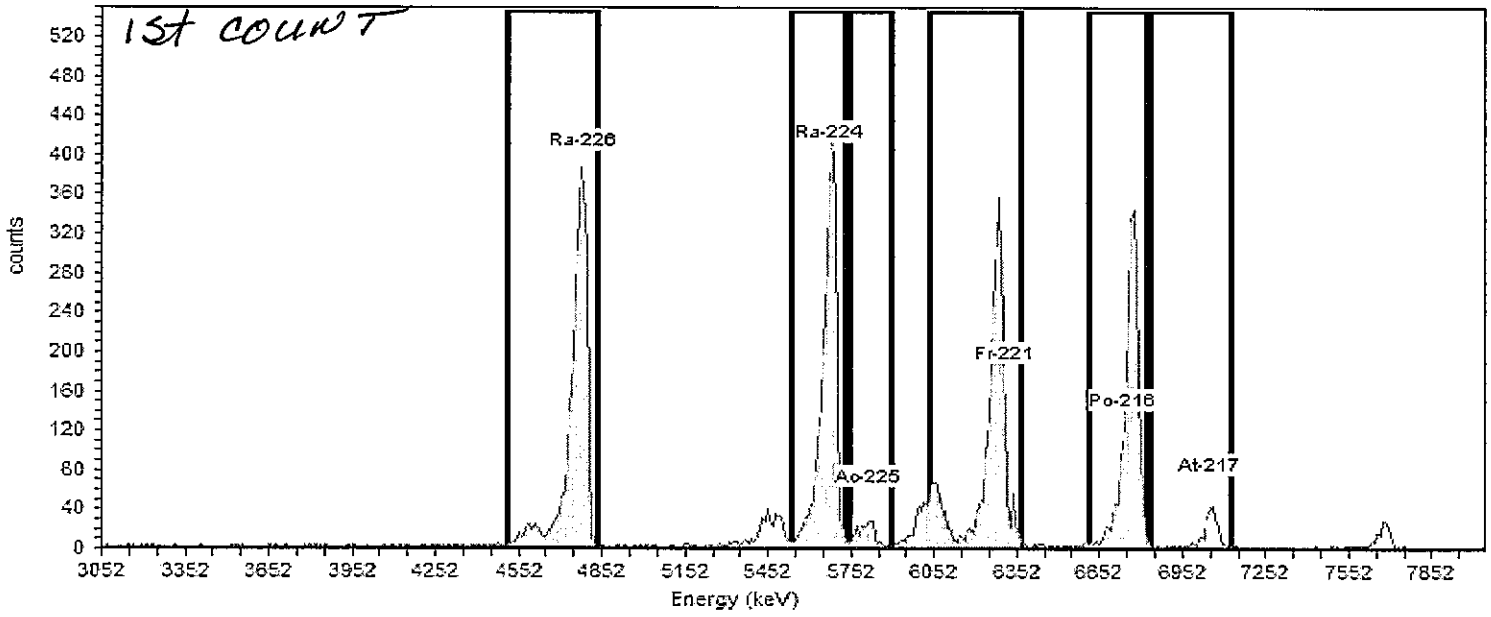
Energy Calibration: C17051082

Energy Cal: Gain = 9.7851 keV / Ch
Offset = 3,042.97 keV
Quadratic = 0.0000 keV / Ch^2

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: 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

JP

ALS Laboratory Group - Fort Collins

Alpha-Spectroscopy Analysis Report

Sample

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

Sample Size : 0.50

Acquisition

Detector: 82
Batch Name: RAS170511-1_B
Nuclide Library: Radium
Analysis Method: ROI Analysis, Set Name = Ra224/Ra226
ROI Set: Ra224/Ra226

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: 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)

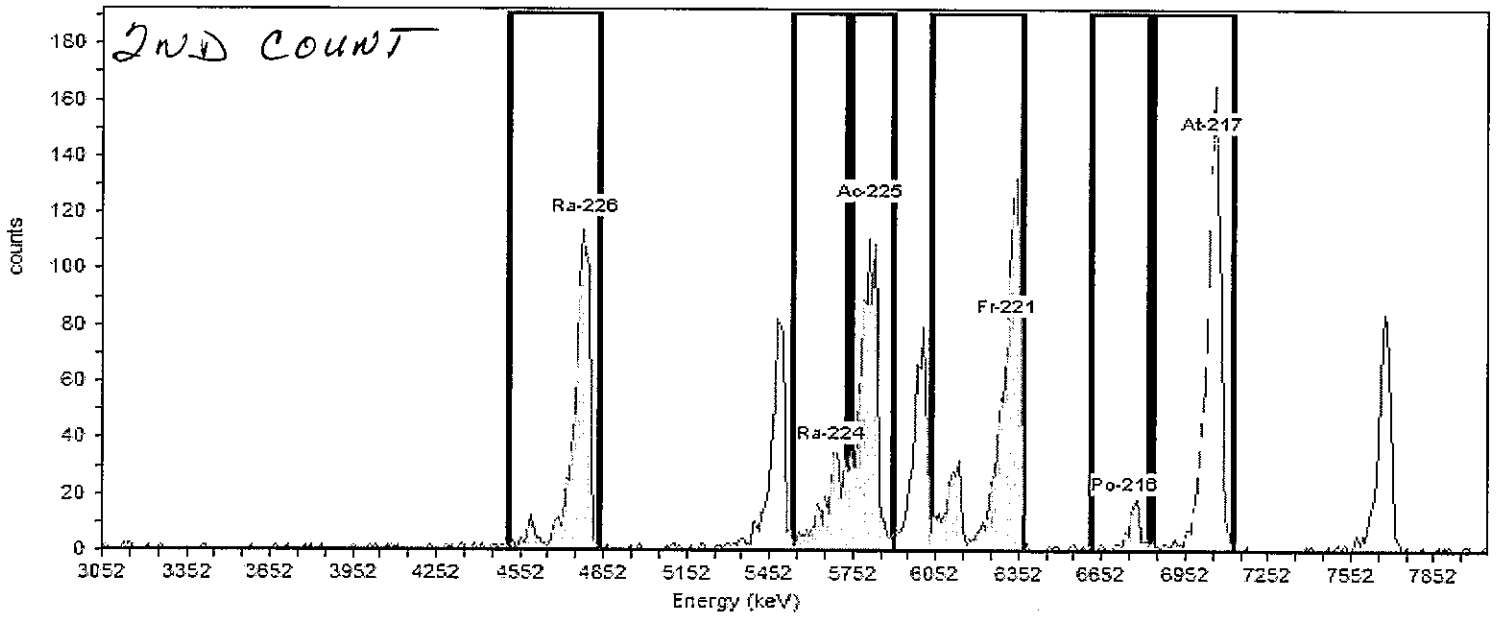
Energy Calibration: C17051082

Energy Cal: Gain = 9.7851 keV / Ch
Offset = 3,042.97 keV
Quadratic = 0.0000 keV / Ch^2

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: 53.07%



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

SOP 714;FORM 746r8.xls (10/2/07)

Alpha Spectrometer Instrument Run Log

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

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
105	PAS170506-1_A	1704493-12	Pu/F	1000	JA
106		-13			
107		-14			
108		-15			
109		-16			
110		-17			
111		-18			
112		-19			
113		-26			
114		AS170506-1MMB			
115		PMB			
116		LCS			
128	UAS170506-4_A	1704564-1	Ur/W	420	JA
129		-2			
130		-3			
131		1705057-1			
132		-2			
65	PAS170506-1_B	AS170506-1LCSD	Pu/F	1000	JA
117	UAS170508-2_B	1704505-19	Ur/S	360	JA
118		-20	JA 5/12/17		
119		-20D			
120		-21			
121		-22			
122		-23			

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
123	UAS170508-2_B	1704505-24	Ur/S	360	JA
124		1704605-3			
125		-4			
126		AS170508-2MB			
127		-LCS			
81	RAS170511-1_A	RAS170511-1MB	Ra/W	1000	JA
82		-LCS			
83		1705158-1			
84		1705177-1			
85		-2			
86		-3			
87		1705181-1			
88		1705202-1			
89		-1D			
90		1705203-1			
91		1705214-1			
92		-2			
93		-2D			
94		-4			
95		1705237-1			
115	AAS170506-2_A	1704493-21	~~AS~~/F	1000	JA
116		-22	AM/F JA 5/12/17		

JMA 5/12/17

Notes:

Reviewed by: JMA
Date: 5/12/17

SOP 714;FORM 746r8.xls (10/2/07)

ALS

Alpha Spectrometer Instrument Run Log

5/22/17 JA

5/24/17

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

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
81	RAS170519-1_A	RAS170519-1MB	Ra/W	1000	JA
82		-1LCS			
83		1705415 - 3			
84		-4			
85		-5			
86		-6			
87		-7			
88		-7D			
81	RAS170511-1_B	RAS170511-1MB	Ra/W	300	JA
82		-1LCS			
83		1705158 - 1			
84		1705177 - 1			
85		-2			
86		-3			
87		1705181 - 1			
88		1705202 - 1			
89		-1D			
90		1705203 - 1			
91		1705214 - 1			
92		-2			
93		-2D			
94		-4			
95		1705237 - 1			

5/22/17

5/23/17

JmA 5/23/17

Detector	Batch ID	Sample ID	Iso/Matrix	Duration	Initial
81	UAS170522-1_A	1705137 - 1	Ur/W	360	JA
82		-2			
83		-3			
84		-4			
86		-4D			
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 - 6	Ur/W	360	JA
118		-7			
119		-8			
120		-11			
121		1705389 - 1			
122		AS170522-1MD			
123		-1LCS			

JmA 5/24/17

Notes:

Reviewed by: JmA
Date: 5/24/17

Section 6

QUALITY ASSURANCE SUMMARY REPORTS

QUALITY ASSURANCE SUMMARY SHEET 1705181 1705158 1705203 1705217 1705214

ALS W.O. # / BATCH 1705202 1705237 / RAS 170511-1

TEST Ra224/226

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.

JMA 5/24/17

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 $Ra/BaSO_4$ 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.

JMA 5/24/17

TECHNICIAN/ANALYST [signature] DATE 5/24/17

DEPARTMENT MANAGER [signature] DATE 5/24/17

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

Sample Preparation	RAS170511-1	Ra-224				RAS170511-1
Analyte	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224
-	RAS170511-1MB	RAS170511-1LCS	1705158-1	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 Ra-224 Bkg Cts (per sample ct duration):	28	21	37	34	31	16
1st count Ac-225 Gross Cts:	193	199	213	1301	1454	758
1st count Ac-225 Bkg Cts (per sample ct duration):	19	15	18	24	17	20
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 A-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	4.6866	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**	**1.66068**	**1.38699**	**1.07799**
LCS Recovery:	#DIV/0!	103.5%	#DIV/0!	#DIV/0!	#DIV/0!	

Ra-224				RAS170511-1	Ra-224			
Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224	Ra-224
1705181-1	1705202-1	1705202-1D	1705203-1	1705214-1	1705214-2	1705214-2D	1705214-4	1705237-1
5/8/17 1:15 PM	5/9/17 12:50 PM	5/9/17 12:50 PM	5/9/17 9:30 AM	5/9/17 11:00 AM	5/9/17 2:15 PM	5/9/17 2:15 PM	5/9/17 11:00 AM	5/10/17 11:00 AM
0.5	0.006	0.006	0.015	0.5	0.3	0.3	0.5	0.5
0	0	0	0	0	0	0	0	0
0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17
11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM
87	88	89	90	91	92	93	94	95
87	88	89	90	91	92	93	94	95
5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17
1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM
1000	1000	1000	1000	1000	1000	1000	1000	1000
5/23/17	5/23/17	5/23/17	5/23/17	5/23/17	5/23/17	5/23/17	5/23/17	5/23/17
6:44 AM	6:44 AM	6:44 AM	6:44 AM	6:44 AM	6:44 AM	6:44 AM	6:44 AM	6:44 AM
300	300	300	300	300	300	300	300	300
0.2871	0.2884	0.2952	0.3009	0.3028	0.2959	0.303	0.3038	0.3026
0.2871	0.2884	0.2952	0.3009	0.3028	0.2959	0.303	0.3038	0.3026
1000	1000	1000	1000	1000	1000	1000	1000	1000
122	100	81	102	129	180	144	103	87
24	36	32	36	49	29	39	47	36
249	262	255	238	219	199	242	238	238
29	48	26	26	21	20	36	23	18
1018	970	923	943	965	1015	1034	954	953
6.6	12.3	7.2	6	4.5	4.2	5.1	4.5	7.2
205	214	190	185	184	345	218	183	227
857	834	781	823	818	692	862	825	801
29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
10.67	10.67	10.67	10.67	10.67	10.67	10.67	10.67	10.67
261.82	261.82	261.82	261.82	261.82	261.82	261.82	261.82	261.82
0.030022	0.030022	0.030022	0.030022	0.030022	0.030022	0.030022	0.030022	0.030022
0.402307	0.402307	0.402307	0.402307	0.402307	0.402307	0.402307	0.402307	0.402307
0.8940	0.8940	0.8940	0.8940	0.8940	0.8940	0.8940	0.8940	0.8940
11.9795	11.9795	11.9795	11.9795	11.9795	11.9795	11.9795	11.9795	11.9795
0.98023	**0.92400**	**0.86322**	**0.86648**	**0.88264**	**0.95052**	**0.94487**	**0.86965**	**0.86970**
0.4345	0.5241	0.5241	0.5104	0.5165	0.5300	0.5300	0.5165	0.6251
0.1289	0.0018	0.0017	0.0042	0.1456	0.0943	0.0960	0.1439	0.1735
0.35192	**5.14279**	**-3.97089**	**4.35789**	**0.24362**	**0.65478**	**0.55102**	**0.05774**	**-0.06541**
0.0944	6.6471	6.3456	2.8107	0.0922	0.1540	0.1417	0.0857	0.0644
0.0316	0.0326	0.0332	0.0328	0.0324	0.0316	0.0313	0.0326	0.0327
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
0.09706	**6.65559**	**6.35094**	**2.82511**	**0.09352**	**0.15972**	**0.14607**	**0.08576**	**0.06459**
0.16907	**13.36224**	**13.74063**	**5.39521**	**0.16441**	**0.28339**	**0.24620**	**0.16728**	**0.14125**
0.35765	**28.14870**	**28.97061**	**11.38827**	**0.34611**	**0.59344**	**0.51862**	**0.35204**	**0.29701**
		#DIV/0!	#DIV/0!					

	Sample Preparation	RAS170511-1	Ra-226				RAS170511-1
	Analyte	Ra-226	Ra-226	Ra-226	Ra-226	Ra-226	Ra-226
	-	RAS170511-1MB	RAS170511-1LCS	1705158-1	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:	5/23/2017	5/23/2017	5/23/2017	5/23/2017	5/23/2017	5/23/2017
	2nd Count Start Time:	06:44	06:44	06:44	06:44	06:44	06:44
	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-226 Gross Cts:	3	2574	26	48545	57000	26474
	1st count Ra-226 Bkg Cts (per sample ct duration):	5	9	4	2	6	1
	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
	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):	**0.8938**	**0.8850**	**0.8822**	**0.6878**	**0.8280**	**0.7635**
	Ra-226 decay factor, sampling to 1st ct.midpt:	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	Standard Denominator:	0.2672	0.2699	0.0057	0.2208	0.2605	0.2308
	Sample Activity Conc. (pCi/L):	**-0.00748**	**9.50403**	**3.88210**	**219.88413**	**218.81594**	**114.68591**
	Std. Uncert., Ra-226 (pCi/L):	0.0118	0.1884	0.9982	0.9981	0.9167	0.7049
	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):	**0.0118**	**0.6499**	**1.0296**	**14.8398**	**14.4135**	**7.7035**
	Critical Level (pCi/L):	**0.025294**	**0.031441**	**1.099846**	**0.022454**	**0.027790**	**0.017786**
	MDC (pCi/L):	**0.052099**	**0.064754**	**2.262797**	**0.045740**	**0.057262**	**0.035397**
	LCS Recovery:	#DIV/0!	102.9%	#DIV/0!	#DIV/0!	#DIV/0!	

Ra-226				RAS170511-1	Ra-226			
Ra-226	Ra-226	Ra-226	Ra-226	Ra-226	Ra-226	Ra-226	Ra-226	Ra-226
1705181-1	1705202-1	1705202-1D	1705203-1	1705214-1	1705214-2	1705214-2D	1705214-4	1705237-1
5/8/17 1:15 PM	5/9/17 12:50 PM	5/9/17 12:50 PM	5/9/17 9:30 AM	5/9/17 11:00 AM	5/9/17 2:15 PM	5/9/17 2:15 PM	5/9/17 11:00 AM	5/10/17 11:00 AM
0.5	0.006	0.006	0.015	0.5	0.3	0.3	0.5	0.5
0	0	0	0	0	0	0	0	0
0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17
11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM	11:25 AM
87	88	89	90	91	92	93	94	95
87	88	89	90	91	92	93	94	95
5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17	5/12/17
1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM	1:45 PM
1000	1000	1000	1000	1000	1000	1000	1000	1000
5/23/2017	5/23/2017	5/23/2017	5/23/2017	5/23/2017	5/23/2017	5/23/2017	5/23/2017	5/23/2017
06:44	06:44	06:44	06:44	06:44	06:44	06:44	06:44	06:44
300	300	300	300	300	300	300	300	300
0.2871	0.2884	0.2952	0.3009	0.3028	0.2959	0.303	0.3038	0.3026
0.2871	0.2884	0.2952	0.3009	0.3028	0.2959	0.3030	0.3038	0.3026
1000	1000	1000	1000	1000	1000	1000	1000	1000
83	422	362	443	45	112	75	15	14
4	2	2	2	6	1	5	2	2
1018	970	923	943	965	1015	1034	954	953
6.6	12.3	7.2	6	4.5	4.2	5.1	4.5	7.2
29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
10.67	10.67	10.67	10.67	10.67	10.67	10.67	10.67	10.67
261.82	261.82	261.82	261.82	261.82	261.82	261.82	261.82	261.82
0.030022	0.030022	0.030022	0.030022	0.030022	0.030022	0.030022	0.030022	0.030022
0.402307	0.402307	0.402307	0.402307	0.402307	0.402307	0.402307	0.402307	0.402307
0.8940	0.8940	0.8940	0.8940	0.8940	0.8940	0.8940	0.8940	0.8940
11.9795	11.9795	11.9795	11.9795	11.9795	11.9795	11.9795	11.9795	11.9795
0.9802	**0.9240**	**0.8632**	**0.8665**	**0.8826**	**0.9505**	**0.9449**	**0.8697**	**0.8697**
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.2968	0.0034	0.0032	0.0082	0.2818	0.1780	0.1811	0.2786	0.2775
0.26621	**124.55295**	**111.64418**	**53.46792**	**0.13838**	**0.62377**	**0.38645**	**0.04666**	**0.04324**
0.0318	6.1208	5.9330	2.5634	0.0258	0.0603	0.0500	0.0156	0.0153
0.0316	0.0328	0.0332	0.0328	0.0324	0.0316	0.0313	0.0326	0.0327
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
0.0362	**10.1690**	**9.4182**	**4.3318**	**0.0274**	**0.0725**	**0.0559**	**0.0159**	**0.0155**
0.021003	**1.470029**	**1.537287**	**0.601002**	**0.025684**	**0.023072**	**0.037314**	**0.017793**	**0.017862**
0.043211	**2.994559**	**3.131567**	**1.224286**	**0.052922**	**0.045915**	**0.076857**	**0.036245**	**0.036387**
		#DIV/0!	#DIV/0!					

Section 7

LABORATORY BENCH SHEETS

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

JP 5/24/17

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

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 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
1705237-1 RAS170511-1PS13								RAS170511-1MB RAS170511-1PS15						RAS170511-1LCS RAS170511-1PS14		

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: RaISO

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) NA

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 Alq ml	Fin Alq 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				S1	

JP 5/12/17

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

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

Prep Batch ID: RA51705111-1

Analyst: Steven D. White

Diphonix Resin lot #: 033111DPM

Ra-225 Tracer: C 4-14-17

Ra-224 QC Spike: SW 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 Seperation & Collection Date/Time: 5-12-17 @ 1125

Refrigiration or Sonication Date/Time — Start: @ 1207 — End: @

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	0.40	-- na --	0.09	81 JA	81 JA	
na	na	na	na	LCS	2	500		0.10	"	82	82	
5-8-17	1046	<2	Client	1705158-1	3	10		-- na --	ø	83	83	
5-8-17	0945		ALS	1705177-1	4	500		-- na --	0.09	84	84	filtered due to oil layer
"	1042		"	-2	5	"		-- na --	"	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 --	ø	88	88	filtered due to oil layer
"	"		"	-1 Dup	9	"		-- na --	"	89	89	"
5-9-17	0930		"	1705203-1	10	15		-- na --	"	90	90	"
5-9-17	1100		Client	1705214-1	11	500		-- na --	0.08	91	91	
"	1415		"	-2	12	300		-- na --	ø	92	92	
"	"		"	-2 Dup	13	"		-- na --	"	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 --				

Screens

Printed 5/11/2017 12:38:15 Page 1

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 1000ppm 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

Printed 5/10/2017 15:44:37 Page 1

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 1000ppm)

158-1 ~9.3 ug/ml Ba — 10 — 0

177-1 ~ 900mg/L Ca low Ba — 250 500 — 0.09 — -2 — -3 — 0.06

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

Ra-225 Tracer Standardization

Tracer Solution ID:	C 04-14-17
Separation date/time:	4/14/2017 09:45

Ra-226 standard: 1026dpm/ml (907.3610.53 ref date: 2/24/10)
Ra-226 standard spike volume: 0.01ml

Additional Physical Constants		
Ra-225 Half-Life:	14.80	days
Ac-225 Half Life:	10.00	days
λ1(Ra-225):	0.046834269	day^-1
λ.2(Ac-225):	0.069314718	day^-1
ROI abun. of At-217:	0.9999	
ROI abun. of Ra-226:	1.0000	

Sample ID:	CAL 1	CAL 2	CAL 3	CAL 4
Ra-226 spiked (dpm):	10.26	10.26	10.26	10.26
Ra-225 tracer vol. (mL):	0.1	0.1	0.1	0.1
Separation Date:	4/14/17	4/14/17	4/14/17	4/14/17
Separation Time:	9:45 AM	9:45 AM	9:45 AM	9:45 AM
Sample Analysis				
Detector ID:	85	86	87	88
Count Start Date:	4/28/17	4/28/17	4/28/17	4/28/17
Count Start Time:	9:13 AM	9:13 AM	9:13 AM	9:13 AM
Count Duration(min.):	1000	1000	1000	1000
Ra-226 Gross Cts:	2317	2111	2319	2220
Ra-226 Bkg Cts (per sample ct duration):	6	5	1	2
At-217 Gross Cts:	2468	2373	2570	2399
At-217 Bkg Cts (per sample ct duration):	16	21	20	16
Calculations				
Elapsed Time, sep. to ct.midpt., (hrs):	343.80	343.80	343.80	343.80
At-217 Ingrowth factor:	0.434008	0.434008	0.434008	0.434008
Ra-225 tracer activity (dpm/mL):	250.8495	264.0412	260.0875	254.0126
Mean:	257.247695			
Standard Deviation of Mean:	5.1386			
% RSD:	1.9975			

Section 8

STANDARDS TRACEABILITY DOCUMENTS

Project 1026.4095.84 Ra224/226 working standard

Continued from Page

1E 3/12/15

10dpm/ml QC Spike Solution

1E 3/12/15

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).

1E 3/12/15

The QC spike solution contains:

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

1E 3/12/15

JP 6/23/15

Continued on Page

Signed — Date: 3/12/15

Read and Understood By

Signed — Date: 03/25/15

Project 916.4095.68 Ra-226 working std.

Continued from Page

TE 12/8/14

Prepare a working dilution of 916.3610.76

1. Density of 0.1M HCl, lot # 000092116
   Mass of 100mL vol. flask: 68.3000g Balance # 12
   Mass of flask & 100mL acid: 168.0372g Balance# 12
   Net Mass: 99.7372g
   Density: 0.9974g/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# ____

TE 12/8/14

TE 12/8/14

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:

$$30{,}156\ \text{dpm/g} \times 0.9974\ \text{g/mL} \times \frac{3.4129\ \text{g}}{1001.5604\ \text{g}} = 102.49\ \text{dpm/mL}$$

TE 12/8/14

JP 1/9/15

Stnd 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

JP 1/9/15

Continued on Page

T Elliot 12/8/14

Signed Date

Read and Understood By

01/09/15

Signed Date

76
PROJECT 916.3610.76 Ra-226

Notebook No. ______

Continued From Page ______

Prepare a intermediate dilution of 226 # 916.

0.1 M HCl diluent lot # 445A12

Density of diluent

Mass of 100 ml vol flask 68.2982 g

Flask + Acid 168.0565 g

Net 99.7583 g

ρ = 0.9976 g/ml

Mass of parent transferred

Mass of Open full Ampule + Beaker 38.2082 g

Mass of Open Empty Ampule + Beaker 33.2251 g

Net 4.9831 g

Dilute to final Vol./Mass

Mass of Open Empty 40 ml Vol Vial 21.3971 g

Mass of Vial, Std, + diluent 57.9016 g

Net 36.5045 g

Activity, Cf.

JDO 9/27/10

$(1860.0 \ Bq)\left(\frac{60 \ dpm}{1 \ Bq}\right)\frac{4.9831 \ g}{5.65176 \ g}\ \frac{1}{36.5045 \ g} = 30,156 \ dpm/g$

30,156.1

JDO 9/27/10

Continued on Page

Read and Understood By

[signature] Signed 9/27/10 Date

[signature] Signed 9/27/10 Date

Eckert & Ziegler
Analytics

RSO# 916

1380 Seaboard Industrial Blvd.
Atlanta, Georgia 30318
Tel 404-352-8677
Fax 404-352-2837
www.analyticsinc.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.: 73625 06-10-10, 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 4.15, Revision 1, February, 1979, and compliance with ANSI N42.22-1995, "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*, % Type u_A	u_B	U	Reference Date (12:00 PM EST)
Ra-226	5.844E+05	1.860E+04	0.5	2.4	4.9	07/01/2010

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

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

Source Prepared by: W. Mao, Radiochemist

QA Approved: J. D. McCorvey, QA Manager Alternate **Date:** 6/30/10

ACCREDITED SOURCE CALIBRATION LABORATORY HEALTH PHYSICS SOCIETY

ANA Form005 Rev. —

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: 1705202

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
1705202-1	SMP	RAS170511-1	RaISO	88	C17051088	5/10/2017	28.84	Warning	28.16	29.07	31.08	31.86
Spectrum #1		RAS170511-1			B17051088	5/10/2017	0.3010	Pass	0.0000	0.0500	0.5000	0.7500
5/12/2017					C17051088	5/10/2017	5555.8	Pass	5505.8	5515.8	5595.8	5605.8
1705202-1	DUP	RAS170511-1	RaISO	89	C17051089	5/10/2017	29.52	Pass	28.26	28.77	30.73	31.24
Spectrum #1		RAS170511-1			B17051089	5/10/2017	0.2310	Pass	0.0000	0.0500	0.5000	0.7500
5/12/2017					C17051089	5/10/2017	5555.8	Pass	5505.8	5515.8	5595.8	5605.8
RAS170511-1	MB	RAS170511-1	RaISO	81	C17051081	5/10/2017	28.35	Warning	28.30	28.86	30.89	31.42
Spectrum #1		RAS170511-1			B17051081	5/10/2017	0.1830	Pass	0.0000	0.0500	0.5000	0.7500
5/12/2017					C17051081	5/10/2017	5548.0	Pass	5505.8	5515.8	5595.8	5605.8
RAS170511-1	LCS	RAS170511-1	RaISO	82	C17051082	5/10/2017	28.92	Pass	27.98	28.49	30.51	31.02
Spectrum #1		RAS170511-1			B17051082	5/10/2017	0.2730	Pass	0.0000	0.0500	0.5000	0.7500
5/12/2017					C17051082	5/10/2017	5548.0	Pass	5496.0	5506.0	5586.0	5596.0

Data Package ID: *RAS1705202-1*

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

Alpha Spec Calibration Source Re-Certification

Recalibration performed by Isotope Products Laboratories

Primary Certified Source

Source PA ID: 190
Planchet Label: 9
Recalibrated on: 10/4/2016
Received by ALS on: 10/18/2013

Values from certificate		
Source ID:	92MIX223027	
Total Activity:	3745.2	dpm
Ref. Date:	10/15/2013	

Nuclide	Act (Bq)	Act (dpm)	Half-Life (yrs)	Decay Corrected
U-234:	49.54	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
92MIX223027	190	97-19-103-09	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**
92MIX2203026	182	97-19-103-01	10/4/16	12981	79837	2777	2100	31.06%	**1193.95**	**7343.17**	**255.42**	**8792.54**
92MIX2203028	183	97-19-103-02	10/4/16	15085	148128	3863	2100	31.06%	**1387.47**	**13624.37**	**355.31**	**15367.15**
92MIX2203024	184	97-19-103-03	10/4/16	67474	70483	2608	2100	31.06%	**6206.06**	**6482.82**	**239.88**	**12928.75**
92MIX2203021	185	97-19-103-04	10/4/16	21961	60440	2557	2100	31.06%	**2019.91**	**5559.09**	**235.19**	**7814.18**
92MIX2203025	186	97-19-103-05	10/4/16	97883	114458	3780	2100	31.06%	**9002.99**	**10527.51**	**347.67**	**19878.16**
92MIX2203022	187	97-19-103-06	10/4/16	72777	79883	2564	2100	31.06%	**6693.81**	**7347.40**	**237.67**	**14278.88**
92MIX2203023	188	97-19-103-07	10/4/16	43617	68953	2043	2100	31.06%	**4011.76**	**6342.09**	**187.91**	**10541.76**
92MIX2203029	189	97-19-103-08	10/4/16	33966	214074	7195	2100	31.06%	**3124.09**	**19689.89**	**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
92MIX223027	190	97-19-103-09	10/5/16	7807	32611	1278	2100	1191.31	3741.99	31.84%	-2.46%	**PASS**

Sources 1 through 8 activity re-verification

Source Serial#	PA ID	Sequential #	Combined Obseved dpm	Combined Certified dpm*	Percent Difference %	Within 5% of Certified value?
92MIX2203026	182	97-19-103-01	8792.54	8849.86	-0.65%	**Yes**
92MIX2203028	183	97-19-103-02	15367.15	15992.35	-3.91%	**Yes**
92MIX2203024	184	97-19-103-03	12928.75	13503.77	-4.26%	**Yes**
92MIX2203021	185	97-19-103-04	7814.18	8161.24	-4.25%	**Yes**
92MIX2203025	186	97-19-103-05	19878.16	20979.95	-5.25%	**No**
92MIX2203022	187	97-19-103-06	14278.88	15285.63	-6.59%	**No**
92MIX2203023	188	97-19-103-07	10541.76	10723.95	-1.70%	**Yes**
92MIX2203029	189	97-19-103-08	23475.75	23593.84	-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	7446.00	2.43	145.74	21.43	1285.80
5/1/2003	239.30	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	4335.60
5/1/2003	334.80	20088.00	6.55	393.18	53.02	3181.20

OK JP 10/5/16

Expires 10/4/2017

AlphaVision v6.0 **Alpha-Spectroscopy Calibration Report**

Analyst: ORTEC

Detector: 129 9:14:40AM 10/5/2016

Calibration

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

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

Source Info

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

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

Acquisition

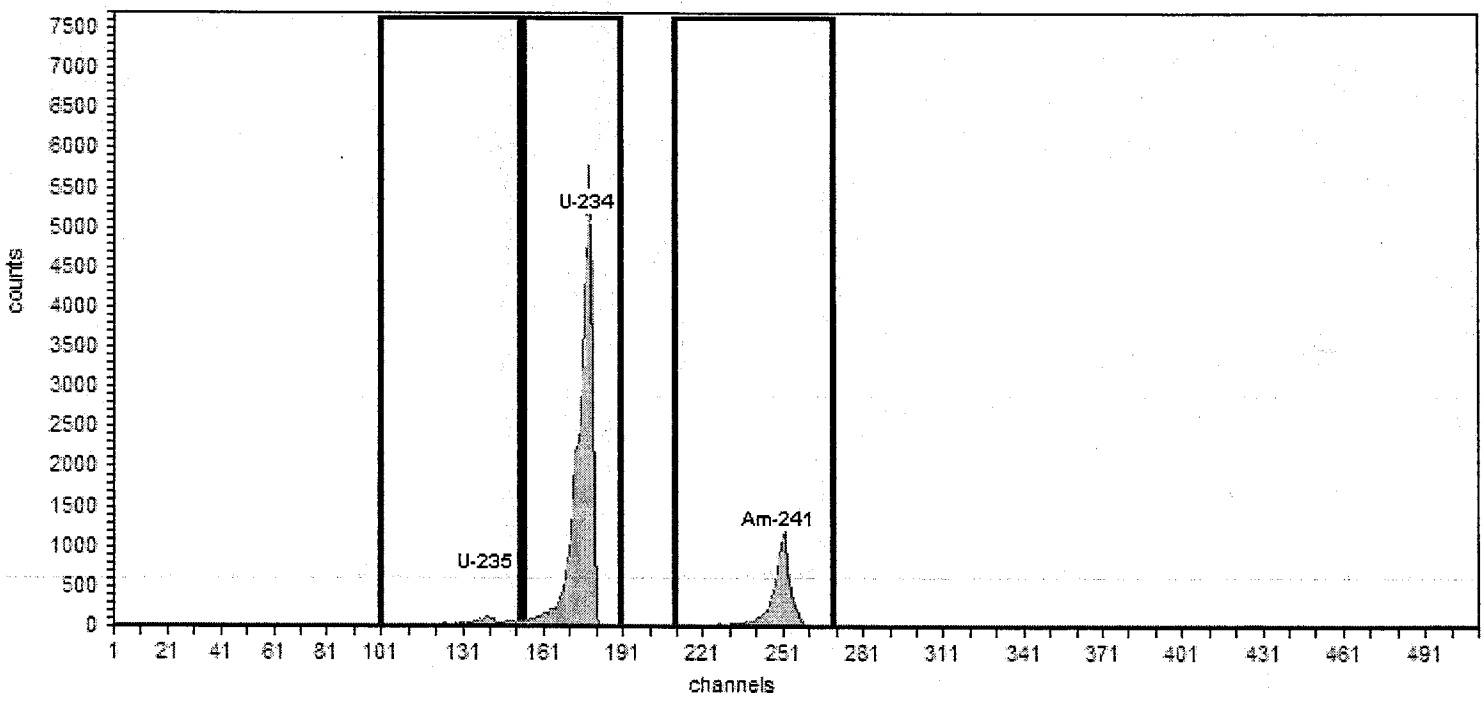
Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/4/2016 11:26:06AM

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

Efficiency Calibration Name: SOURCE190_10.04.16 (#9)

Energy Calibration Equation:
Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch²

Efficiency: 33.86% +/- 1.39% 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	1,070.00	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

AlphaVision v6.0 **Alpha-Spectroscopy Calibration Report**

Analyst: ORTEC

Detector: 129 12:49:08PM 10/4/2016

Calibration

Energy Calibration: SOURCE182_10.04.16 (#1)
Description:

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

Source Info

Certificate ID: A1 RSO#182
Prepared by: Isotope Product Laboratories
Description:

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

Acquisition

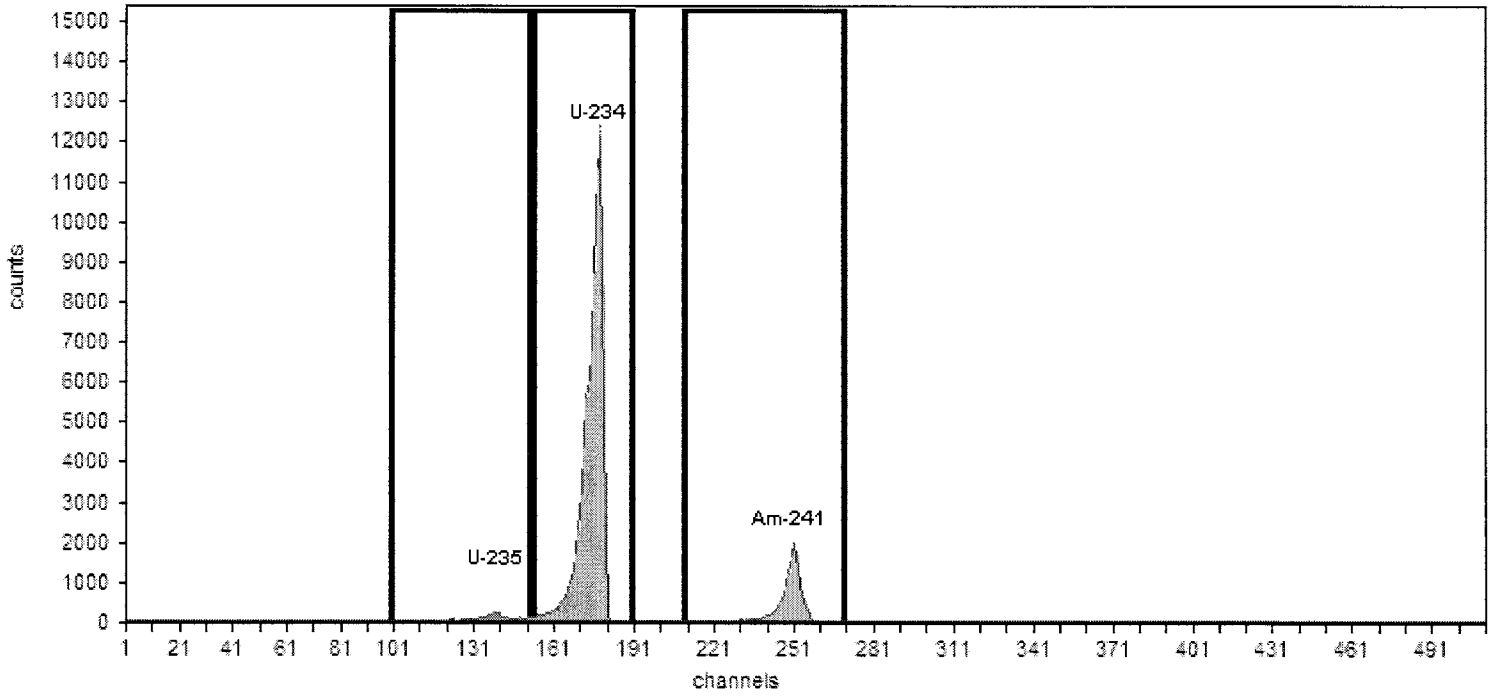
Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/4/2016 12:11:42PM

Live Time: 35.00 min.
Real Time: 35.02 min.

Efficiency Calibration Name: SOURCE182_10.04.16 (#1)

Energy Calibration Equation:
Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch^2

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

JM 10/4/16

AlphaVision v6.0 **Alpha-Spectroscopy Calibration Report**

Analyst: ORTEC

Detector: 129 1:25:35PM 10/4/2016

Calibration

Energy Calibration: SOURCE183_10.04.16 (#2)
Description:

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

Source Info

Certificate ID: A2 RSO#183
Prepared by: Isotope Product Laboratories
Description:

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

Acquisition

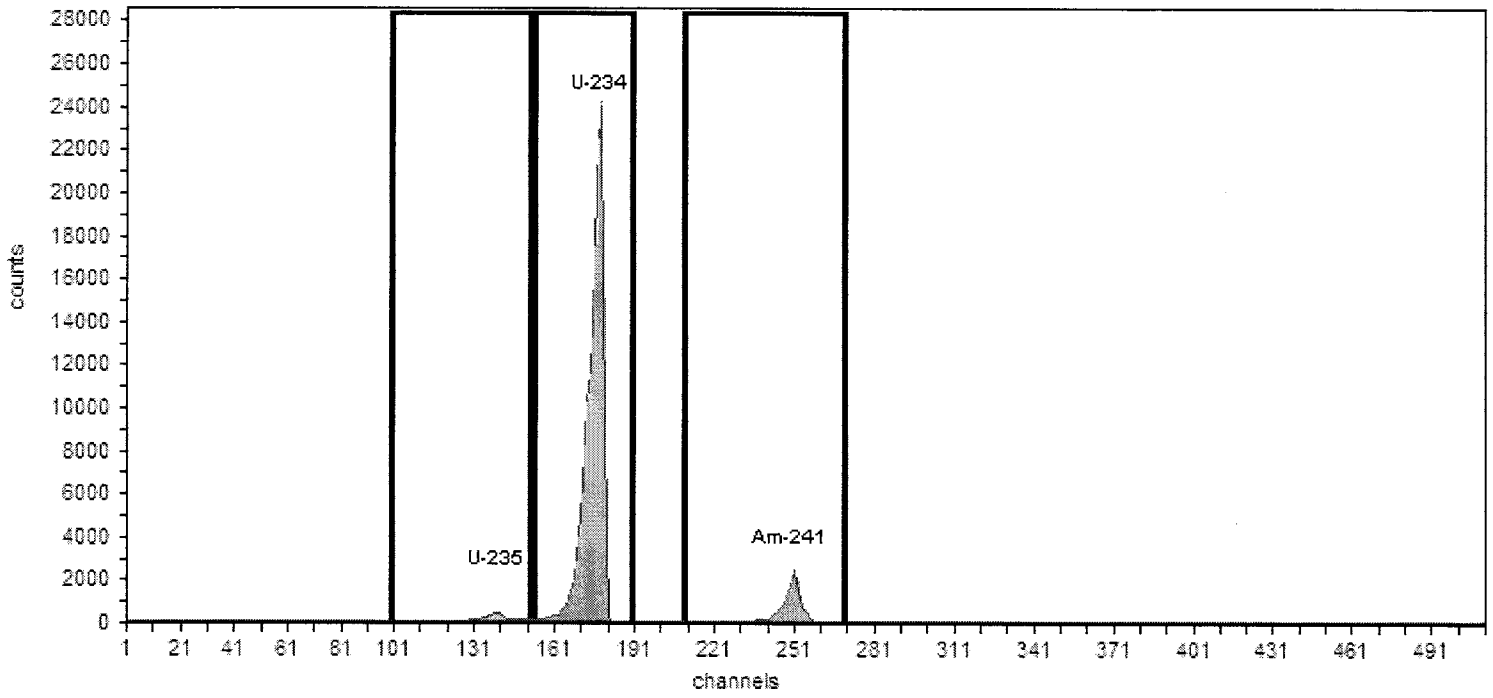
Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/4/2016 12:49:04PM

Live Time: 35.00 min.
Real Time: 35.03 min.

Efficiency Calibration Name: SOURCE183_10.04.16 (#2)

Energy Calibration Equation:
Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch²

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

AlphaVision v6.0 *Alpha-Spectroscopy Calibration Report*

Analyst: ORTEC

Detector: 129 2:17:25PM 10/4/2016

Calibration

Energy Calibration: SOURCE184_10.04.16 (#3)
Description:

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

Source Info

Certificate ID: A3 RSO#184
Prepared by: Isotope Product Laboratories
Description:

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

Acquisition

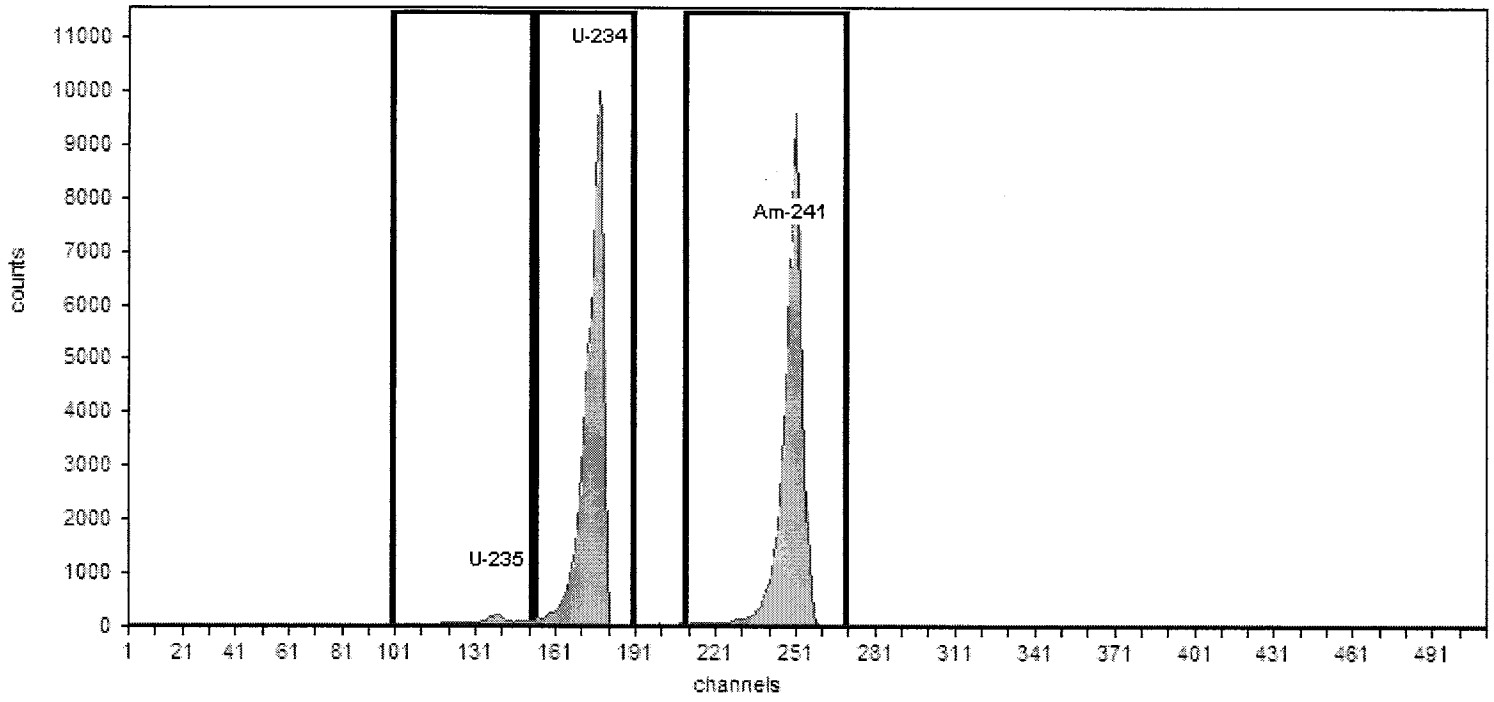
Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/4/2016 1:26:53PM

Live Time: 35.00 min.
Real Time: 35.03 min.

Efficiency Calibration Name: SOURCE184_10.04.16 (#3)

Energy Calibration Equation:
Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch²

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

AlphaVision v6.0 **Alpha-Spectroscopy Calibration Report**

Analyst: ORTEC

Detector: 129 9:00:58AM 10/5/2016

Calibration

Energy Calibration: SOURCE185_10.04.16 (#4)
Description:

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

Source Info

Certificate ID: A4 RSO#185
Prepared by: Isotope Product Laboratories
Description:

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

Acquisition

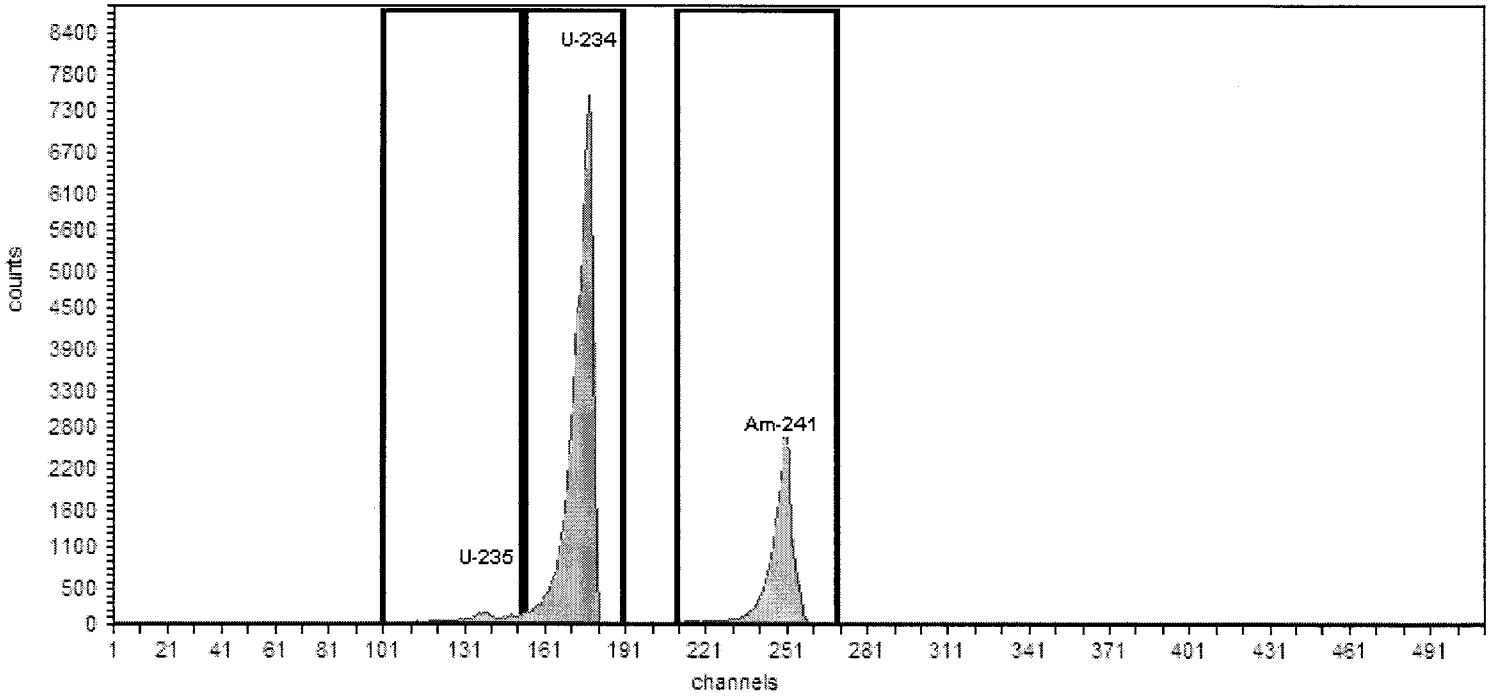
Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/4/2016 2:18:14PM

Live Time: 35.00 min.
Real Time: 35.02 min.

Efficiency Calibration Name: SOURCE185_10.04.16 (#4)

Energy Calibration Equation:
Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch²

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

AlphaVision v6.0 **Alpha-Spectroscopy Calibration Report**

Analyst: ORTEC

Detector: 129 7:04:12AM 10/5/2016

Calibration

Energy Calibration: SOURCE188_10.04.16 (#7)
Description:

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

Source Info

Certificate ID: A7 RSO#188
Prepared by: Isotope Product Laboratories
Description:

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

Acquisition

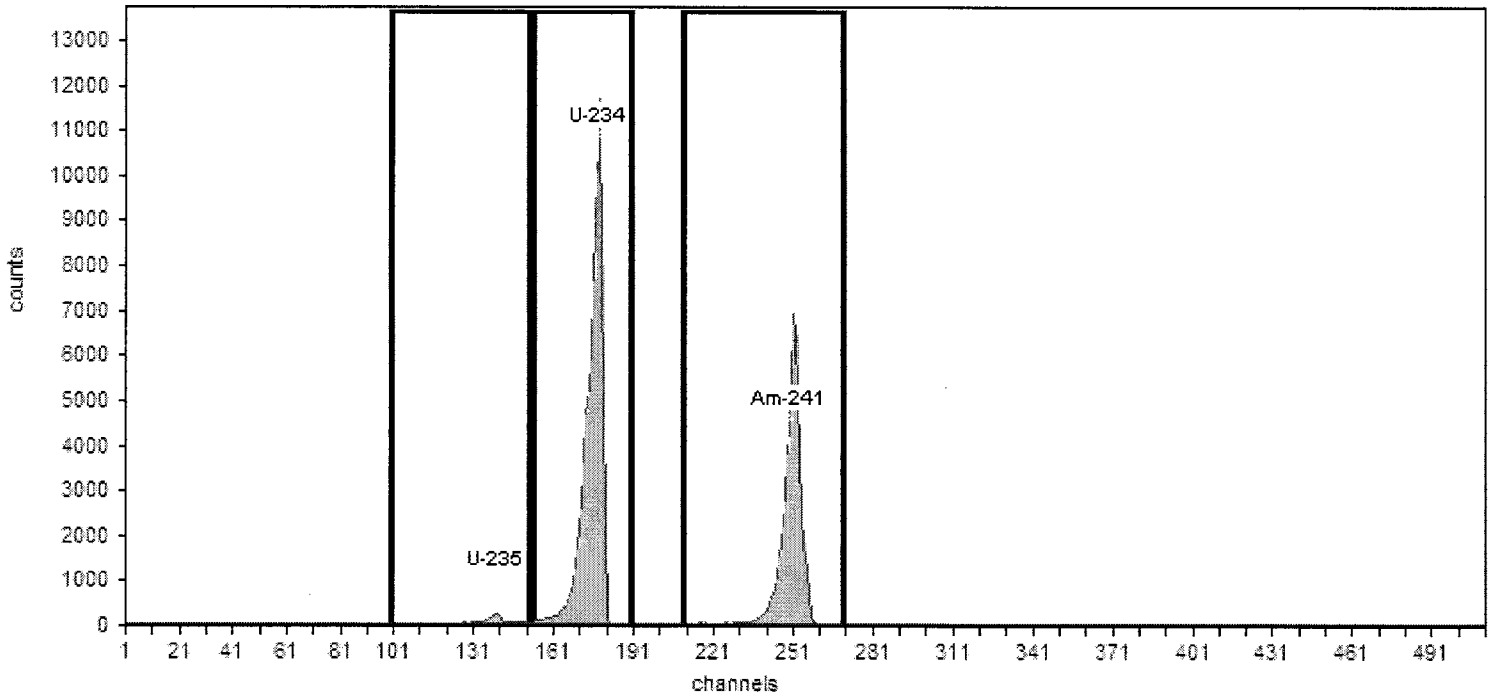
Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/5/2016 6:13:44AM

Live Time: 35.00 min.
Real Time: 35.02 min.

Efficiency Calibration Name: SOURCE188_10.04.16 (#7)

Energy Calibration Equation:
Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch²

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

10/4/16

AlphaVision v6.0 *Alpha-Spectroscopy Calibration Report*

Analyst: ORTEC

Detector: 129 7:44:05AM 10/5/2016

Calibration

Energy Calibration: SOURCE189_10.04.16 (#8)
Description:

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

Source Info

Certificate ID: A8 RSO#189
Prepared by: Isotope Product Laboratories
Description:

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

Acquisition

Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/5/2016 7:04:08AM

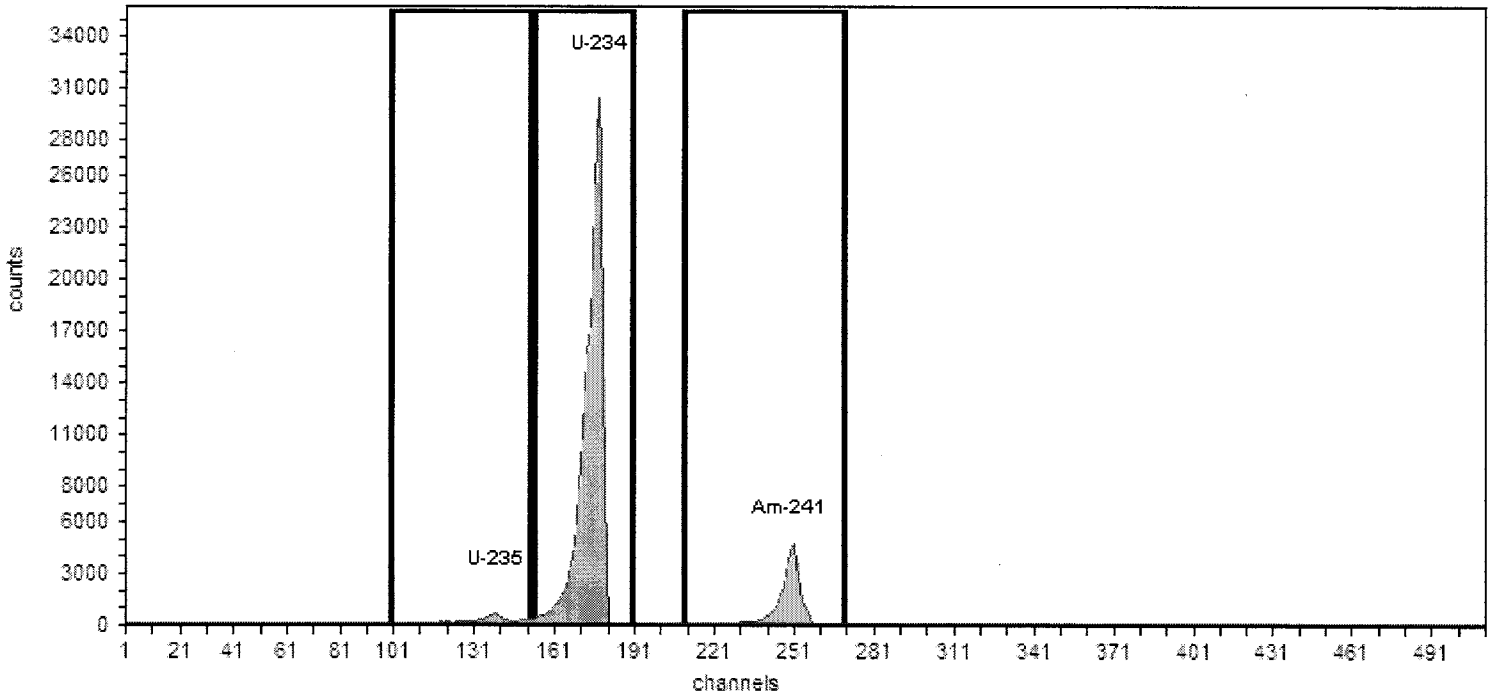
Live Time: 35.00 min.
Real Time: 35.05 min.

Efficiency Calibration Name: SOURCE189_10.04.16 (#8)

Energy Calibration Equation:
Gain = 9.9003 keV / Ch

Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch²

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

AlphaVision v6.0 **Alpha-Spectroscopy Calibration Report**

Analyst: ORTEC

Detector: 129 8:36:03AM 10/5/2016

Calibration

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

Analysis Date: 10/5/2016 8:35:09AM
Calibration Type: Energy And Efficiency

Source Info

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

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

Acquisition

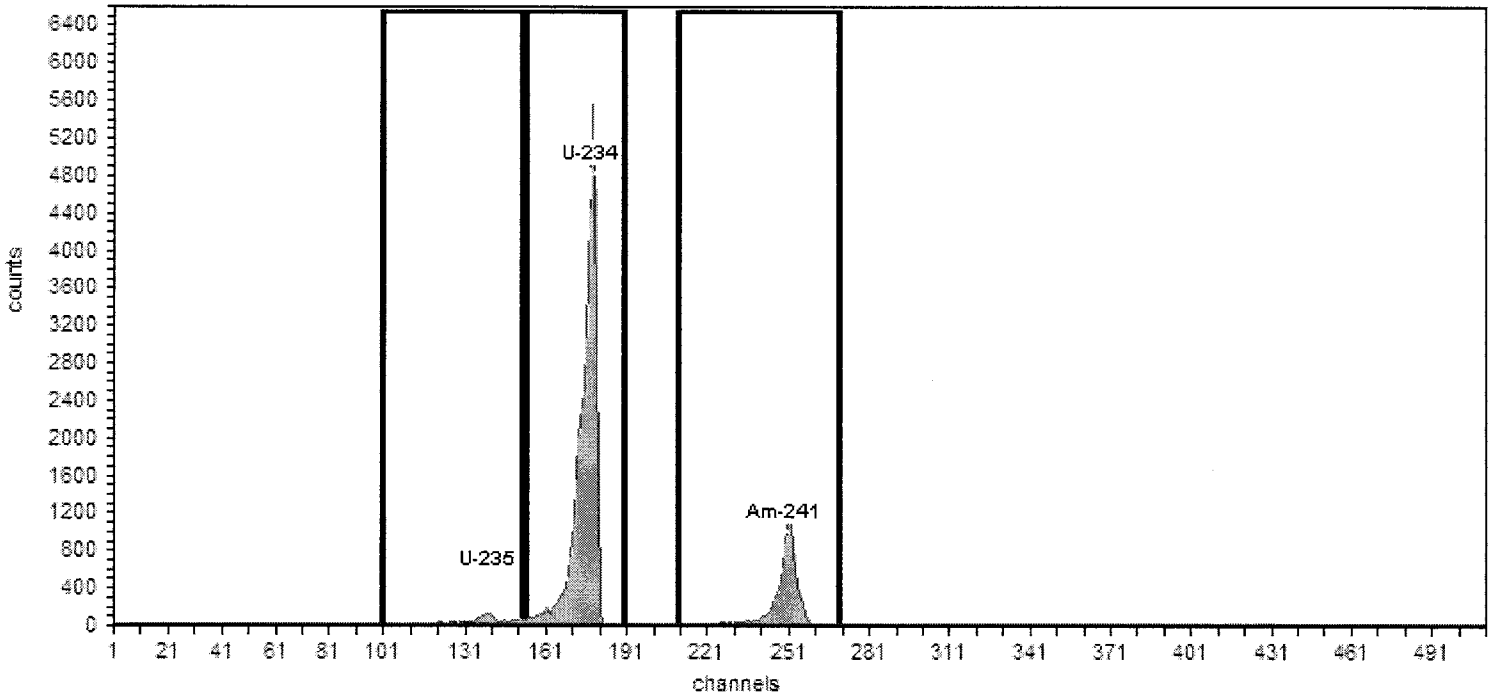
Detector: 129, SN:5505430, ID: 129
Acquisition Start Date: 10/5/2016 7:45:09AM

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

Efficiency Calibration Name: SOURCE190A_10.04.16 (#9)

Energy Calibration Equation:
Gain = 9.9003 keV / Ch
Offset = 3,021.28 keV
Quadratic = 0.0000 keV / Ch^2

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

10/4/16

Eckert & Ziegler
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#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.

Daniel James Van Dalsem
Quality Control

2-OCT-13
Date

IPL Ref. No.: 987-28

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

PAI 187
recalibrated 4-1503

TM 10/5/16

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CERTIFICATE OF CALIBRATION
MIXED ALPHA STANDARD SOURCE

Radionuclide A:	U-234	**Customer:**	PARAGON ANALYTICS, INC.
Radionuclide B:	U-235	**P.O. No.:**	EW040203/R2193
Radionuclide C:	Am-241	**Catalog No.:**	MISC-STD
Half Life (U-234):	(2.454 ± 0.006)E+05 years	**Reference Date:**	1-May-03 12:00 PST
Half Life (U-235):	(7.037 ± 0.011)E+08 years	**Source No.:**	92MIX2203026
Half Life (Am-241):	432.17 ± 0.66 years		

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:	± 0.7%
B. Type B (systematic) uncertainty:	± 3.0%
C. Uncertainty in aliquot weighing:	± 0.0%
D. Total uncertainty at the 99% confidence level:	± 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 2π on 11 Apr 03.

Daniel James Van Dalsem
Quality Control

15-Apr-03
Date Signed

IPL Ref. No.: 987-7

Re-Calibrated 10/4/16
New Exp Date 10/4/2017
PAI 183
Recalibrated 4-15-03

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CERTIFICATE OF CALIBRATION
MIXED ALPHA STANDARD SOURCE

Radionuclide A:	U-234	**Customer:**	PARAGON ANALYTICS, INC.
Radionuclide B:	U-235	**P.O. No.:**	EW040203/R2193
Radionuclide C:	Am-241	**Catalog No.:**	MISC-STD
Half Life (U-234):	(2.454 ± 0.006)E+05 years	**Reference Date:**	1-May-03 12:00 PST
Half Life (U-235):	(7.037 ± 0.011)E+08 years	**Source No.:**	92MIX2203028
Half Life (Am-241):	432.17 ± 0.66 years		

Contained Radioactivity:

U-234:	6.467	nCi	(239.3 Bq)	Am-241:	0.6366	nCi	(23.55 Bq)
U-235:	0.1135	nCi	(4.200 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

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:	± 0.7%
B. Type B (systematic) uncertainty:	± 3.0%
C. Uncertainty in aliquot weighing:	± 0.0%
D. Total uncertainty at the 99% confidence level:	± 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

Re-Calibrated 10/14/16
New Exp Date 10/4/2017
JM 10/5/16

PAT F.D 184
recalibrated 4-1503

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CERTIFICATE OF CALIBRATION
MIXED ALPHA STANDARD SOURCE

Radionuclide A:	U-234	**Customer:**	PARAGON ANALYTICS, INC.
Radionuclide B:	U-235	**P.O. No.:**	EW040203/R2193
Radionuclide C:	Am-241	**Catalog No.:**	MISC-STD
Half Life (U-234):	(2.454 ± 0.006)E+05 years	**Reference Date:**	1-May-03 12:00 PST
Half Life (U-235):	(7.037 ± 0.011)E+08 years	**Source No.:**	92MIX2203024
Half Life (Am-241):	432.17 ± 0.66 years		

Contained Radioactivity:

U-234:	3.227	nCi	(119.4 Bq)	Am-241:	2.866	nCi	(106.0 Bq)
U-235:	0.05205	nCi	(1.926 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:	± 0.6%
B. Type B (systematic) uncertainty:	± 3.0%
C. Uncertainty in aliquot weighing:	± 0.0%
D. Total uncertainty at the 99% confidence level:	± 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

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

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

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CERTIFICATE OF CALIBRATION
ALPHA STANDARD SOURCE

Radionuclide A:	U-234	**Customer:**	PARAGON ANALYTICS, INC.
Radionuclide B:	U-235	**P.O. No.:**	EW030603/R2155
Radionuclide C:	Am-241	**Catalog No.:**	MISC-STD
Half Life (U-234):	(2.454 ± 0.006)E+05 years	**Reference Date:**	1-Apr-03 12:00 PST
Half Life (U-235):	(7.037 ± 0.011)E+08 years	**Source No.:**	92MIX2203021
Half Life (Am-241):	432.17 ± 0.66 years		

Contained Radioactivity:

U-234:	2.731	nCi	(101.0 Bq)	Am-241:	0.9325	nCi	(34.50 Bq)
U-235:	0.03416	nCi	(1.264 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:	± 0.8%
B. Type B (systematic) uncertainty:	± 3.1%
C. Uncertainty in aliquot weighing:	± 0.0%
D. Total uncertainty at the 99% confidence level:	± 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 2π on 18 Mar 03.

Daniel James Van Dalsem
Quality Control

19-Mar-03
Date Signed

IPL Ref. No.: 987-2

Re Calibrated 10/4/16
New Exp Date 10/4/2017
JP 10/5/16

PAIP 188
recd for recalibration
3-28-03

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CERTIFICATE OF CALIBRATION
ALPHA STANDARD SOURCE

Radionuclide A:	U-234	**Customer:**	PARAGON ANALYTICS, INC.
Radionuclide B:	U-235	**P.O. No.:**	EW030603/R2155
Radionuclide C:	Am-241	**Catalog No.:**	MISC-STD
Half Life (U-234):	(2.454 ± 0.006)E+05 years	**Reference Date:**	1-Apr-03 12:00 PST
Half Life (U-235):	(7.037 ± 0.011)E+08 years	**Source No.:**	92MIX2203023
Half Life (Am-241):	432.17 ± 0.66 years		

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:	± 0.8%
B. Type B (systematic) uncertainty:	± 3.1%
C. Uncertainty in aliquot weighing:	± 0.0%
D. Total uncertainty at the 99% confidence level:	± 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

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

PAI, ID 189
recd 4-2-03
recalibrated 4-15-03

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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 ± 0.006)E+05 years
Half Life (U-235): (7.037 ± 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)	Am-241:	1.433	nCi	(53.02 Bq)
U-235:	0.1771	nCi	(6.553 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:	± 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 11950 α/min in 2π on 11 Apr 03.

Daniel James Van Dalsem
Quality Control

15-Apr-03
Date Signed

IPL Ref. No.: 987-7