



facility 755652  
facility 755653  
project 10243

# Lead-210

## Case Narrative

---

### COGCC

PW NORM 2017 – 10048

Work Order Number: 1706286

1. This report consists of analytical results and supporting documentation for two water samples received by ALS on 06/13/2017.
2. These samples were analyzed for the presence of  $^{210}\text{Pb}$  according to the current revision of SOP 704. The analyses were completed on 07/07/2017.
3. Sample volume was insufficient to allow preparation of a duplicate. A laboratory control sample duplicate (LCSD) was prepared in lieu of a client sample duplicate.
4. The analysis results for these samples are reported in units of pCi/L. The samples were filtered prior to analysis.
5. In the analysis of the raw data, "Window 2" is monitored for high-energy beta contamination. Samples 1706286-3 and PB170704-1MB had "Window 2" count rates slightly above the upper control limit of 0.837 cpm, established from calibration on 07/05/2017 through 07/07/2017, at 0.86 cpm and 0.85 cpm, respectively. The samples had observed activity at a level below the achieved MDC. Thus, the data quality is believed to be unaffected and the results are submitted without further qualification.
6. The requested detection limit was not met for samples 1706286-1 and -3. To prevent matrix interference, these samples were prepared at a reduced aliquot. The results for these samples are identified with an 'M' qualifier on the final reports. The results are submitted without further qualification.
7. No further anomalous situations were encountered during the preparation or analysis of these samples. All remaining quality control criteria were met.



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

Jean Anderson

Jean Anderson  
Radiochemistry Primary Data Reviewer

7/24/17  
Date

Shih-Li Lomax

Radiochemistry Final Data Reviewer

7/26/17  
Date

## Section 1

# CHAIN OF CUSTODY

# ALS -- Fort Collins

## Sample Number(s) Cross-Reference Table

---

**OrderNum:** 1706286

**Client Name:** COGCC

**Client Project Name:** PW NORM 2017

**Client Project Number:** 10048

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

---

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



## Chain-of-Custody

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

**ALSWORKORDER #**

982907

[illegible]



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

**ALS WORKORDER #**

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

[illegible]



ALS Environmental - Fort Collins  
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: COGCC

Workorder No: 1706286

Project Manager: SS

Initials: JNS

Date: 6/13/17

1. Does this project require any special handling in addition to standard ALS procedures?		YES	<u>NO</u>
2. Are custody seals on shipping containers intact?	<u>NONE</u>	YES	NO
3. Are Custody seals on sample containers intact?	<u>NONE</u>	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?		<u>YES</u>	NO
5. Are the COC and bottle labels complete and legible?		<u>YES</u>	NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)		<u>YES</u>	NO
7. Were airbills / shipping documents present and/or removable?	<u>DROP OFF</u>	YES	NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	N/A	<u>YES</u>	NO
9. Are all aqueous non-preserved samples pH 4-9?	N/A	<u>YES</u>	NO
10. Is there sufficient sample for the requested analyses?		<u>YES</u>	NO
11. Were all samples placed in the proper containers for the requested analyses?		<u>YES</u>	NO
12. Are all samples within holding times for the requested analyses?		<u>YES</u>	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)		<u>YES</u>	NO
14. Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: <u>    </u> < green pea <u>    </u> > green pea	N/A	<u>YES</u>	NO
15. Do any water samples contain sediment? Amount of sediment: <u>    </u> dusting <u>X</u> moderate <u>    </u> heavy	N/A	<u>YES</u>	NO
16. Were the samples shipped on ice?		<u>YES</u>	NO
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #2 <u>#4</u>	RAD ONLY	<u>YES</u>	NO
Cooler #:	<u>1</u>	<u>2</u>	<u>3</u>
Temperature (°C):	<u>amb</u>	<u>amb</u>	<u>4</u>
No. of custody seals on cooler:	<u>0</u>	<u>0</u>	<u>0</u>
External µR/hr reading:	<u>1.2</u>		
Background µR/hr reading:	<u>10</u>		
Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES / NO <u>NA</u> (If no, see Form 008.)			

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

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

Project Manager Signature / Date: Philab

## Section 2



# **SAMPLE RESULTS SUMMARY**



# Lead-210 by Liquid Scintillation Sample Results Summary

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

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

Lab Sample ID	Client Sample ID	Sample Type	Nuclide	Result +/- 2 s TPU	MDC	DL	Units	Matrix	Prep Batch	Date Analyze	Flags
1706286-1	755652 Coalview	Sample	Pb-210	2E-01 +/- 9E-01	1.51E+00	NA	pCi/l	WATER	Pb170704-1	7/5/2017	U,M
1706286-3	755653 Oscar Y	Sample	Pb-210	9.3E-01 +/- 9.2E-01	1.46E+00	NA	pCi/l	WATER	Pb170704-1	7/5/2017	U,M

Comments:

Data Package ID: PB1706286-1

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



# Lead-210 by Liquid Scintillation

PAI 704 Rev 11

## Method Blank Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: Pb170704-1MB

Sample Matrix: WATER

Prep SOP: PAI 726 Rev 9

Date Collected: 04-Jul-17

Date Prepared: 04-Jul-17

Date Analyzed: 07-Jul-17

Prep Batch: Pb170704-1

QCBatchID: Pb170704-1-1

Run ID: pb170704-1a

Count Time: 118.469 minutes

Final Aliquot: 833 ml

Result Units: pCi/l

File Name: Q181801N.001

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
14255-04-0	Pb-210	5E-02 +/- 3.6E-01	6.1E-01	1E+00	NA	U

## Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
LEAD	9.270E+02	8.170E+02	ug	88.1	40 - 110 %	

## 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: PB1706286-1

Date Printed: Monday, July 17, 2017

ALS -- Fort Collins

LIMS Version: 6.843

Page 1 of 1

# Lead-210 by Liquid Scintillation

PAI 704 Rev 11

## Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: Pb170704-1LCS

Sample Matrix: WATER

Prep SOP: PAI 726 Rev 9

Date Collected: 04-Jul-17

Date Prepared: 04-Jul-17

Date Analyzed: 07-Jul-17

Prep Batch: Pb170704-1

QCBatchID: Pb170704-1-1

Run ID: pb170704-1a

Count Time: 29.6302 minutes

Final Aliquot: 833 ml

Result Units: pCi/l

File Name: Q191901N.001

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
14255-04-0	Pb-210	4.4E+01 +/- 1.1E+01	1E+00	4.270E+01	102	75 - 125	P,M3

## Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
LEAD	9.510E+02	8.160E+02	ug	85.7	40 - 110 %	

## 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: PB1706286-1

# Lead-210 by Liquid Scintillation

PAI 704 Rev 11

## Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: Pb170704-1LCSD

Sample Matrix: WATER

Prep SOP: PAI 726 Rev 9

Date Collected: 04-Jul-17

Date Prepared: 04-Jul-17

Date Analyzed: 07-Jul-17

Prep Batch: Pb170704-1

QCBatchID: Pb170704-1-1

Run ID: pb170704-1a

Count Time: 29.6136 minutes

Final Aliquot: 833 ml

Result Units: pCi/l

File Name: Q202001N.001

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
14255-04-0	Pb-210	4.5E+01 +/- 1.1E+01	1E+00	4.270E+01	105	75 - 125	P,M3

## Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
LEAD	9.350E+02	7.850E+02	ug	83.9	40 - 110 %	

## 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: PB1706286-1

# Lead-210 by Liquid Scintillation

PAI 704 Rev 11

## Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID:	
Lab ID:	Pb170704-1LCSD

Sample Matrix: WATER

Prep SOP: PAI 726 Rev 9

Date Collected: 04-Jul-17

Date Prepared: 04-Jul-17

Date Analyzed: 07-Jul-17

Prep Batch: Pb170704-1

QCBatchID: Pb170704-1-1

Run ID: pb170704-1a

Count Time: 29.6136 minutes

Final Aliquot: 833 ml

Prep Basis: Unfiltered

Moisture(%): NA

Result Units: pCi/l

File Name: Q202001N.001

CASNO	Analyte	Sample				Duplicate				DER	DER Lim
		Result +/-	2 s TPU	MDC	Flags	Result +/-	2 s TPU	MDC	Flags		
14255-04-0	Pb-210	4.4E+01 +/- 1.1E+01		1E+00	P,M3	4.5E+01 +/- 1.1E+01		1E+00	P,M3	0.0632	2.13

### Comments:

#### Duplicate Qualifiers/Flags:

U - Result is less than the sample specific MDC.

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

Y2 - Chemical Yield outside default limits.

W - DER is greater than Warning Limit of 1.42

D - DER is greater than Control Limit of 2.13

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: PB1706286-1

Date Printed: Monday, July 17, 2017

ALS -- Fort Collins

LIMS Version: 6.843

Page 1 of 1

## Section 4

# INDIVIDUAL SAMPLE RESULTS



# Lead-210 by Liquid Scintillation

PAI 704 Rev 11

## Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 755652 Coalview

Lab ID: 1706286-1

Sample Matrix: WATER

Prep SOP: PAI 726 Rev 9

Date Collected: 13-Jun-17

Date Prepared: 04-Jul-17

Date Analyzed: 05-Jul-17

Prep Batch: Pb170704-1

QCBatchID: Pb170704-1-1

Run ID: pb170704-1a

Count Time: 118.469 minutes

Report Basis: Filtered

Final Aliquot: 416 ml

Prep Basis: Filtered

Moisture(%): NA

Result Units: pCi/l

File Name: Q040401N.001

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
14255-04-0	Pb-210	2E-01 +/- 9E-01	1.51E+00	1E+00	NA	U,M

## Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
LEAD	9.330E+02	6.650E+02	ug	71.3	40 - 110 %	

**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:** PB1706286-1



# Lead-210 by Liquid Scintillation

PAI 704 Rev 11

## Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1706286

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 755653 Oscar Y

Lab ID: 1706286-3

Sample Matrix: WATER

Prep SOP: PAI 726 Rev 9

Date Collected: 13-Jun-17

Date Prepared: 04-Jul-17

Date Analyzed: 05-Jul-17

Prep Batch: Pb170704-1

QCBatchID: Pb170704-1-1

Run ID: pb170704-1a

Count Time: 118.469 minutes

Report Basis: Filtered

Final Aliquot: 416 ml

Prep Basis: Filtered

Moisture(%): NA

Result Units: pCi/l

File Name: Q050501N.001

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
14255-04-0	Pb-210	9.3E-01 +/- 9.2E-01	1.46E+00	1E+00	NA	U,M

## Chemical Yield Summary

Carrier/Tracer	Amount Added	Result	Units	Yield	Control Limits	Flag
LEAD	9.220E+02	6.810E+02	ug	73.9	40 - 110 %	

**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:** PB1706286-1

## Section 5

# RAW DATA

5

# Lead-210 by Liquid Scintillation Raw Data Report

Laboratory Name: ALS -- Fort Collins

Prep SOP: PAI 726

Reported on: Friday, July 07, 2017

PAI Work Order: 1706286

Analytical SOP: PAI 704

12:31:43 PM

Sample ID QC Type	Nuclide Type	Sample Date/Time	Prep Batch QC Batch ID	Ingrowth Date /Time	Quench Factor %Lum	Matrix %Moist	Samp Aliq Analy Aliq	Inst ID Det ID	AnRunID File Name	Count Date/Time	GrossCPM BkgCPM	BaseEff ProgEff	CntDur(min) Yield	Activity +/- 2 s TPU	MDC DeclEv	ReportUnits ReportBasis	DER RPD	%Spk. Recov Flags
1706286-1	Pb-210 Trg. Analyte	6/13/2017 10:16:00 AM	Pb170704-1	7/05/2017 11:30:00 AM	778.99 0.324875	WATER NA	500 ml 416 ml	Q1220 1-4	Pb170704-1a Q040401N001	7/5/2017 9:15 PM	3.070 2.967	76.44% NA	118.469 71.3%	2E-01 9E-01	1.51E+00	pCi/l Filtered	NA NA	U,M
1706286-3	Pb-210 Trg. Analyte	6/13/2017 11:36:00 AM	Pb170704-1	7/05/2017 11:30:00 AM	781.32 0	WATER NA	500 ml 416 ml	Q1220 1-5	Pb170704-1a Q050501N001	7/5/2017 11:17 PM	3.450 2.967	76.44% NA	118.469 73.9%	9.3E-01 9.2E-01	1.48E+00	pCi/l Filtered	NA NA	U,M
Pb170704-1	Pb-210 Trg. Analyte	7/4/2017 7:30:42 AM	Pb170704-1	7/05/2017 11:30:00 AM	782.56 0	WATER NA	1000 ml 833 ml	Q1220 1-18	Pb170704-1a Q181801N001	7/7/2017 12:32 AM	3.030 2.967	76.44% NA	118.469 88.1%	5E-02 3.6E-01	6.1E-01	pCi/l Unfiltered	NA NA	U
Pb170704-1	Pb-210 Trg. Analyte	7/4/2017 7:30:42 AM	Pb170704-1	7/05/2017 11:30:00 AM	779.06 0	WATER NA	1000 ml 833 ml	Q1220 1-19	Pb170704-1a Q191901N001	7/7/2017 2:34 AM	55.850 2.967	76.44% NA	29.6302 85.7%	4.4E+01 1.1E+01	1E+00	pCi/l Unfiltered	NA NA	102 P,M3
Pb170704-1	Pb-210 Trg. Analyte	7/4/2017 7:30:42 AM	Pb170704-1	7/05/2017 11:30:00 AM	776.84 0.0536481	WATER NA	1000 ml 833 ml	Q1220 1-20	Pb170704-1a Q202001N001	7/7/2017 3:07 AM	55.890 2.967	76.44% NA	29.6136 83.9%	4.6E+01 1.1E+01	1E+00	pCi/l Unfiltered	0.06 NA	105 P,M3

Comments:

Data Package ID: PB1706286-1

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 2.13  
+ - Duplicate RPD not within limits.  
LT - Result is less than Request MDC, greater than sample specific MDC  
\* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'  
# - Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'

Notes:

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

Abbreviations:

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

Date Printed: Monday, July 17, 2017

ALS -- Fort Collins

LIMS Version: 6.843

Page 1 of 1

LabID:	WIN 1 (190 - 325)					WIN 2 (800 - 1024)					Upper Control Limit	Win 2 Check
	Count Rate Spectrum 11	Count Rate Spectrum 12	Lumex Corrected	Lumex (%)	Lumex Check	Count Rate Spectrum 11	Count Rate Spectrum 12	Lumex Corrected	Lumex (%)	Lower Control Limit		
PB170704-1CB1	.00	3.26	3.26	0.00	OK	.00	.86	0.86	0.00	NA	NA	NA
PB170704-1CB2	.00	2.58	2.58	0.00	OK	.00	.60	0.6	0.00	NA	NA	NA
PB170704-1CB3	.05	3.11	3.06	1.61	OK	.00	.40	0.4	0.00	NA	NA	NA
1706271-1	.00	35.43	35.43	0.00	OK	.00	1.49	1.49	0.00	0.402969	0.837031	HIGH
1706271-2	.03	3.63	3.6	0.83	OK	.00	1.00	1	0.00	0.402971	0.837029	HIGH
1706286-1	.01	3.08	3.07	0.32	OK	.00	.79	0.79	0.00	0.402972	0.837028	OK
1706286-3	.00	3.45	3.45	0.00	OK	.00	.86	0.86	0.00	0.402972	0.837028	HIGH
1706299-1	.01	2.93	2.92	0.34	OK	.00	.81	0.81	0.00	0.402972	0.837028	OK
1706299-2	.00	2.99	2.99	0.00	OK	.00	.91	0.91	0.00	0.402972	0.837028	HIGH
1706329-1	.00	3.27	3.27	0.00	OK	.00	.82	0.82	0.00	0.402970	0.837030	OK
1706329-2	.00	3.22	3.22	0.00	OK	.00	.66	0.66	0.00	0.402970	0.837030	OK
1706341-1	.00	2.92	2.92	0.00	OK	.00	.81	0.81	0.00	0.402969	0.837031	OK
1706341-3	.00	3.56	3.56	0.00	OK	.00	.72	0.72	0.00	0.402969	0.837031	OK
1706423-1	.00	2.97	2.97	0.00	OK	.00	.70	0.7	0.00	0.402969	0.837031	OK
1706426-1	.02	3.05	3.03	0.66	OK	.00	.63	0.63	0.00	0.402969	0.837031	OK
1706426-3	.00	3.12	3.12	0.00	OK	.00	.64	0.64	0.00	0.402971	0.837029	OK
1706600-1	.00	2.83	2.83	0.00	OK	.00	.69	0.69	0.00	0.402972	0.837028	OK
1706600-3	.00	2.83	2.83	0.00	OK	.00	.72	0.72	0.00	0.402972	0.837028	OK
PB170704-1MB	.00	3.03	3.03	0.00	OK	.00	.85	0.85	0.00	0.402972	0.837028	HIGH
PB170704-1LCS	.00	55.85	55.85	0.00	OK	.00	.77	0.77	0.00	0.186040	1.05396	OK
PB170704-1LCSD	.03	55.92	55.89	0.05	OK	.00	.94	0.94	0.00	0.185918	1.05408	OK

Lumex LCL = 0.00
Lumex UCL = 10.00

The gross count rates and count times used for the final activity calculations and the lumex correction sheet are different than the values shown on the raw data output. These values come from two software programs which round the sample counts differently. The difference between these two values is believed to be insignificant. Window 2 control limits are established using the average count rate from the three reagent blanks +/- 3X the estimated Poisson uncertainty.

# Spectrum report

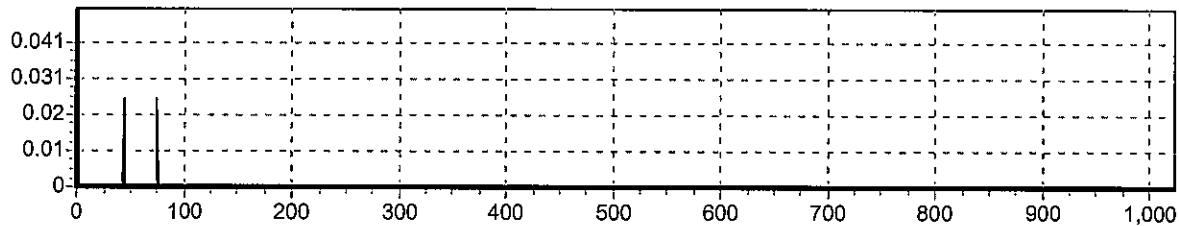
7/7/17 10:26:11 AM

Setup information  
C:\Program Files\wallac\easy view\PB-210.wss

Window 1 = 190..325 190..325, MCA 11 mode CPM  
volume 10 ml  
Window 2 = 800..1024 800..1024, MCA 11 mode CPM  
volume 10 ml  
Window 3 = 190..325 190..325, MCA 12 mode CPM  
volume 10 ml  
Window 4 = 800..1024 800..1024, MCA 12 mode CPM  
volume 10 ml

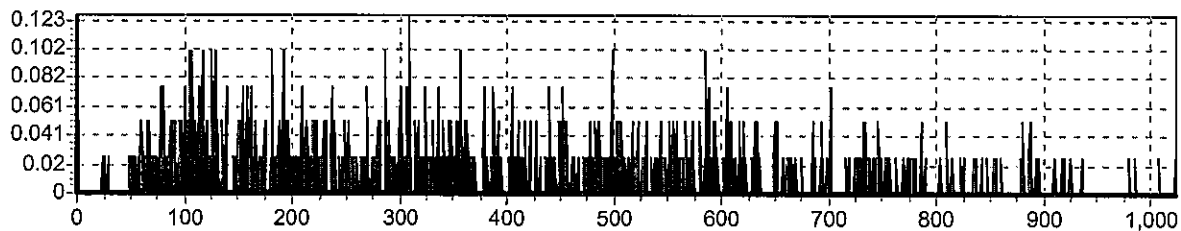
file :C:\Pb-210\ PB-0705\  
Q010101N.001  
spectrum :11  
counting time :2371.14 s  
SQP(E) :782.29 ✓  
counting :7/5/17 5:08:00 PM  
sampling :7/5/17 5:08:00 PM  
ID: PB170704-1CB1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0705\  
Q010101N.001  
spectrum :12  
counting time :2371.14 s  
SQP(E) :782.29 ✓  
counting :7/5/17 5:08:00 PM  
sampling :7/5/17 5:08:00 PM  
ID: PB170704-1CB1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.264	0.287				0.000		
800..1024	0.860	0.148				0.000		



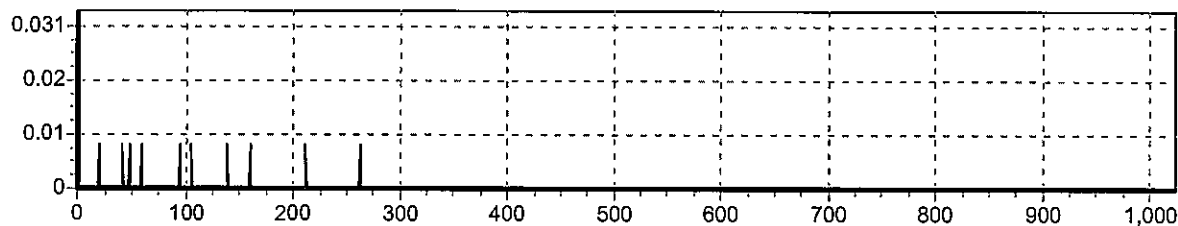
file :C:\Pb-210\ PB-0705\  
Q020201N.001  
spectrum :11  
counting time :7109.90 s  
SQP(E) :777.24 ✓  
counting :7/5/17 7:11:00 PM  
sampling :7/5/17 7:11:00 PM  
ID: 1706271-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.008	0.008				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

JP 7/11/17  
7/7/17  
21 of 95

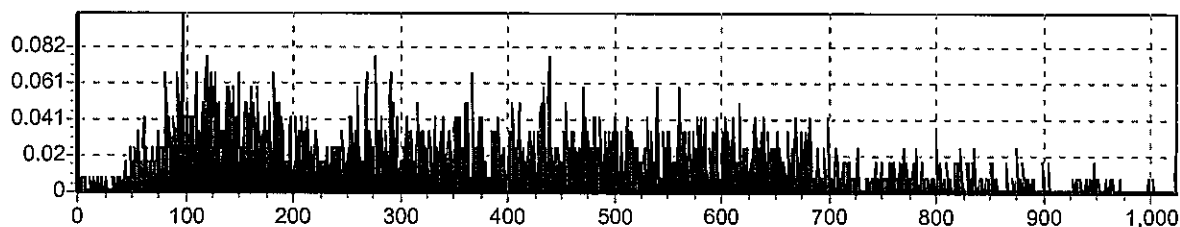
file :C:\Pb-210\ PB-0705\  
 Q040401N.001  
 spectrum :11  
 counting time :7110.11 s  
 SQP(E) :778.99✓  
 counting :7/5/17 11:16:00 PM  
 sampling :7/5/17 11:16:00 PM  
 ID: 1706286-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.017	0.012				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



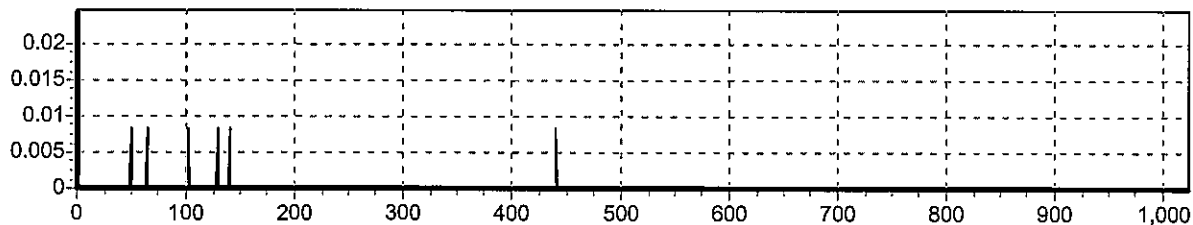
file :C:\Pb-210\ PB-0705\  
 Q040401N.001  
 spectrum :12  
 counting time :7110.11 s  
 SQP(E) :778.99✓  
 counting :7/5/17 11:16:00 PM  
 sampling :7/5/17 11:16:00 PM  
 ID: 1706286-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.080	0.161				0.000		
800..1024	0.793	0.082				0.000		



file :C:\Pb-210\ PB-0705\  
 Q050501N.001  
 spectrum :11  
 counting time :7110.13 s  
 SQP(E) :781.32✓  
 counting :7/6/17 1:18:00 AM  
 sampling :7/6/17 1:18:00 AM  
 ID: 1706286-3

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

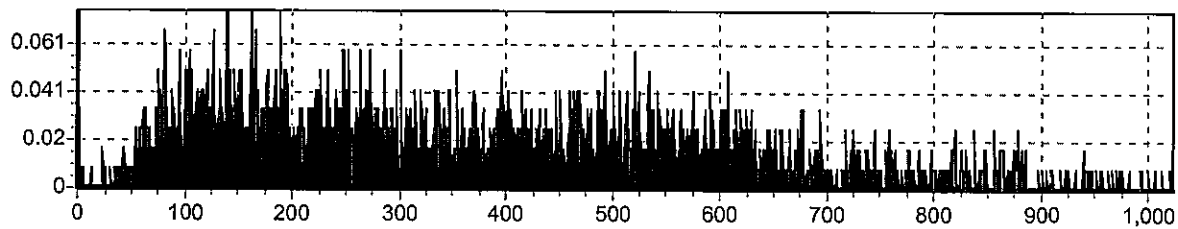


file :C:\Pb-210\ PB-0705\  
 Q050501N.001  
 spectrum :12  
 counting time :7110.13 s  
 SQP(E) :781.32✓  
 counting :7/6/17 1:18:00 AM  
 sampling :7/6/17 1:18:00 AM  
 ID: 1706286-3

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.451	0.171				0.000		
800..1024	0.861	0.085				0.000		

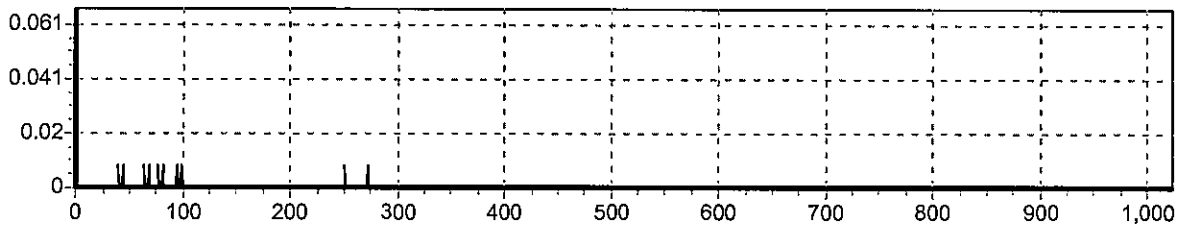
JP 7/11/17

7/11/17 22 of 95



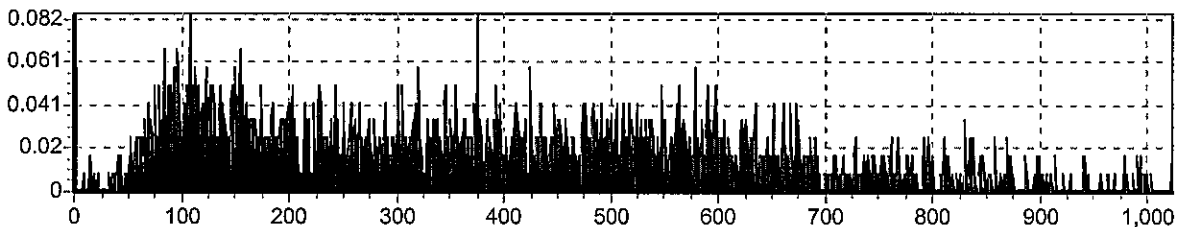
file :C:\Pb-210\ PB-0705\  
 Q060601N.001  
 spectrum :11  
 counting time :7110.12 s  
 SQP(E) :779.50✓  
 counting :7/6/17 3:21:00 AM  
 sampling :7/6/17 3:21:00 AM  
 ID: 1706299-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.017	0.012				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



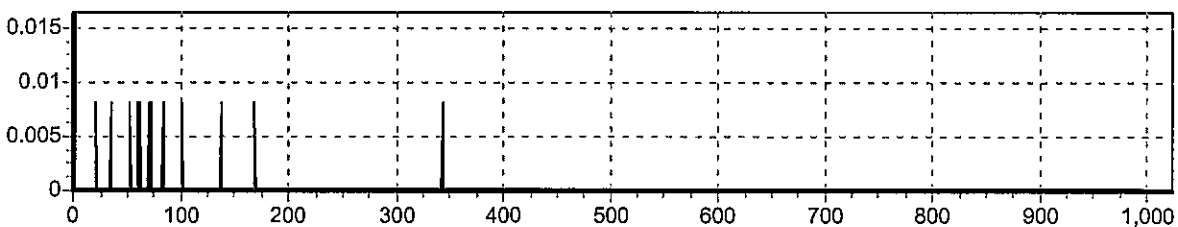
file :C:\Pb-210\ PB-0705\  
 Q060601N.001  
 spectrum :12  
 counting time :7110.12 s  
 SQP(E) :779.50✓  
 counting :7/6/17 3:21:00 AM  
 sampling :7/6/17 3:21:00 AM  
 ID: 1706299-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	2.937	0.157				0.000		
800..1024	0.810	0.083				0.000		



file :C:\Pb-210\ PB-0705\  
 Q070701N.001  
 spectrum :11  
 counting time :7110.09 s  
 SQP(E) :787.13✓  
 counting :7/6/17 5:24:00 AM  
 sampling :7/6/17 5:24:00 AM  
 ID: 1706299-2

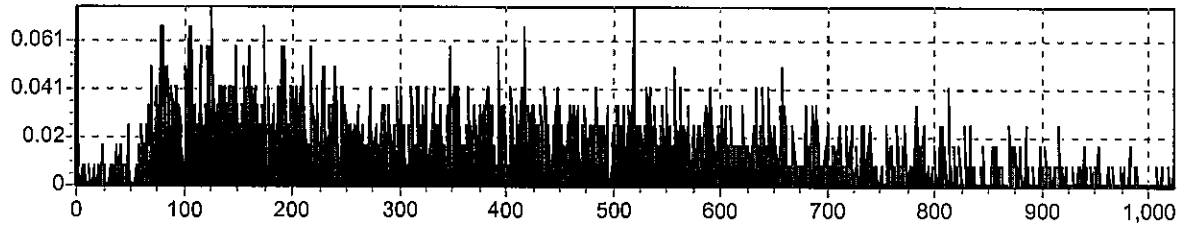
	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



JP 7/11/17  
 23 of 95  
 7/7/17

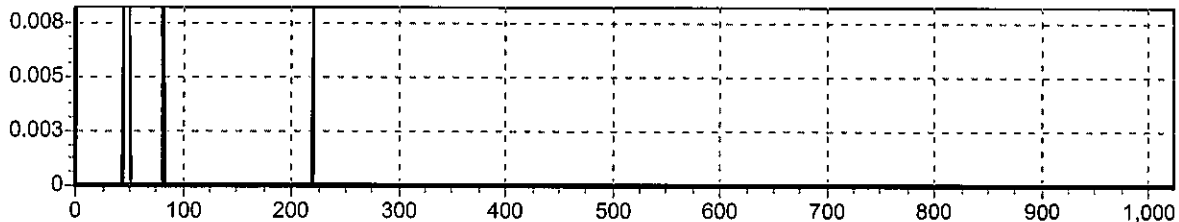
file :C:\Pb-210\ PB-0705\  
 Q070701N.001  
 spectrum :12  
 counting time :7110.09 s  
 SQP(E) :787.13✓  
 counting :7/6/17 5:24:00 AM  
 sampling :7/6/17 5:24:00 AM  
 ID: 1706299-2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	2.996	0.159				0.000		
800..1024	0.911	0.088				0.000		



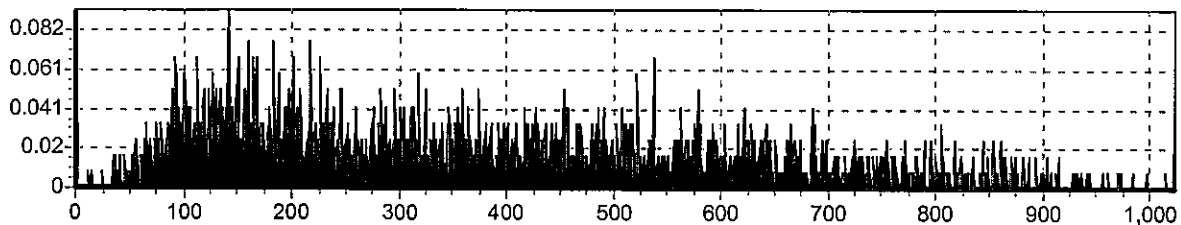
file :C:\Pb-210\ PB-0705\  
 Q080801N.001  
 spectrum :11  
 counting time :7109.99 s  
 SQP(E) :781.23✓  
 counting :7/6/17 7:26:00 AM  
 sampling :7/6/17 7:26:00 AM  
 ID: 1706329-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.008	0.008				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0705\  
 Q080801N.001  
 spectrum :12  
 counting time :7109.99 s  
 SQP(E) :781.23✓  
 counting :7/6/17 7:26:00 AM  
 sampling :7/6/17 7:26:00 AM  
 ID: 1706329-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.274	0.166				0.000		
800..1024	0.827	0.084				0.000		



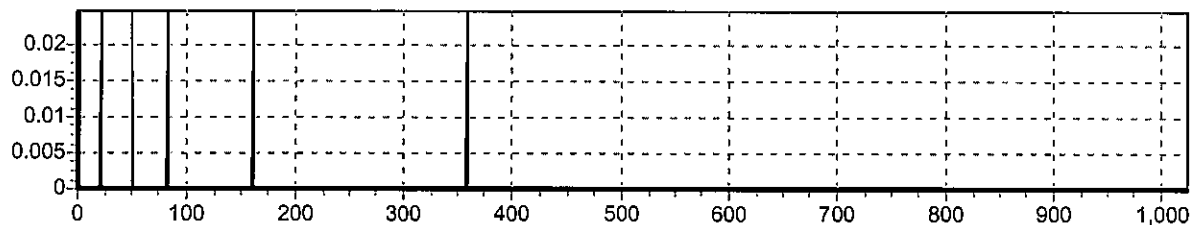
file :C:\Pb-210\ PB-0705\  
 Q090901N.001  
 spectrum :11  
 counting time :2371.15 s  
 SQP(E) :777.92✓  
 counting :7/6/17 8:09:00 AM  
 sampling :7/6/17 8:09:00 AM  
 ID: PB170704-1CB2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

JP 7/11/17

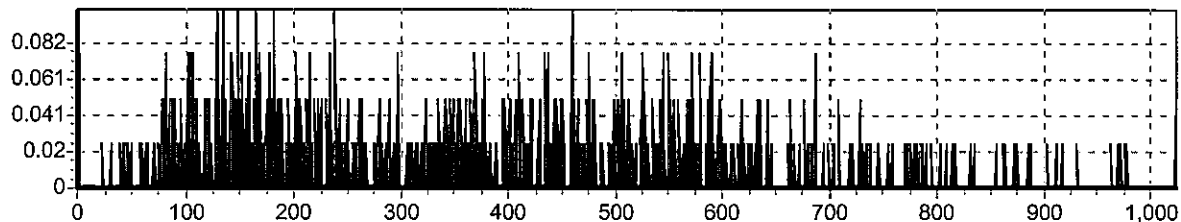
7/11/17





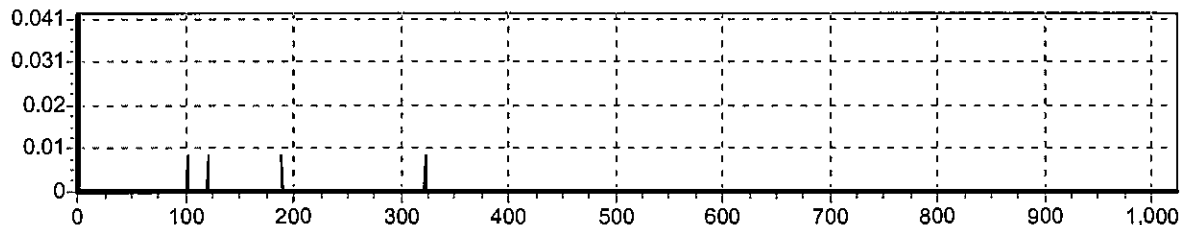
file :C:\Pb-210\ PB-0705\  
 Q090901N.001  
 spectrum :12  
 counting time :2371.15 s  
 SQP(E) :777.92✓  
 counting :7/6/17 8:09:00 AM  
 sampling :7/6/17 8:09:00 AM  
 ID: PB170704-1CB2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	2.581	0.256				0.000		
800..1024	0.607	0.124				0.000		



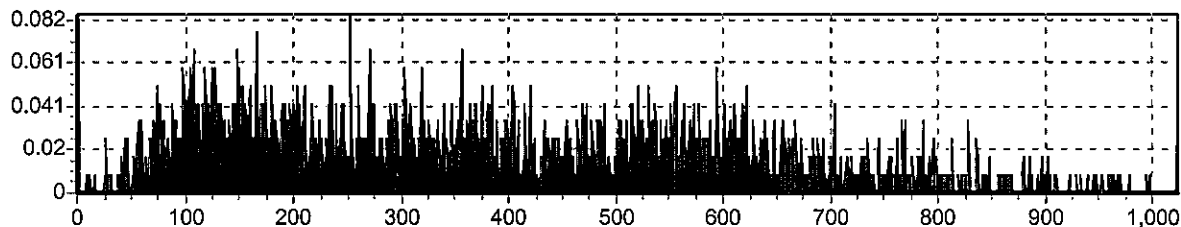
file :C:\Pb-210\ PB-0705\  
 Q101001N.001  
 spectrum :11  
 counting time :7109.95 s  
 SQP(E) :778.32✓  
 counting :7/6/17 10:12:00 AM  
 sampling :7/6/17 10:12:00 AM  
 ID: 1706329-2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.008	0.008				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0705\  
 Q101001N.001  
 spectrum :12  
 counting time :7109.95 s  
 SQP(E) :778.32✓  
 counting :7/6/17 10:12:00 AM  
 sampling :7/6/17 10:12:00 AM  
 ID: 1706329-2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.224	0.165				0.000		
800..1024	0.667	0.075				0.000		

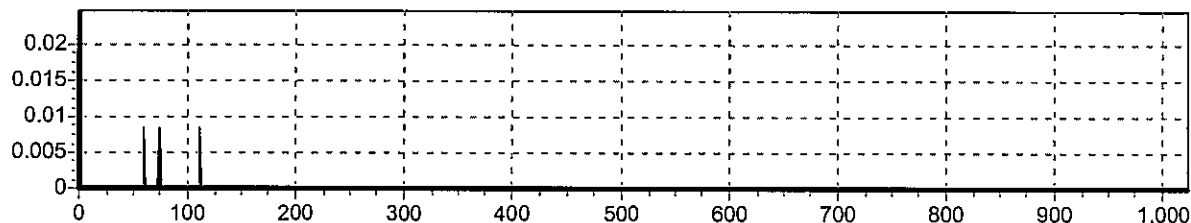


*JP*  
 7/11/17

*Av*  
 7/15/17

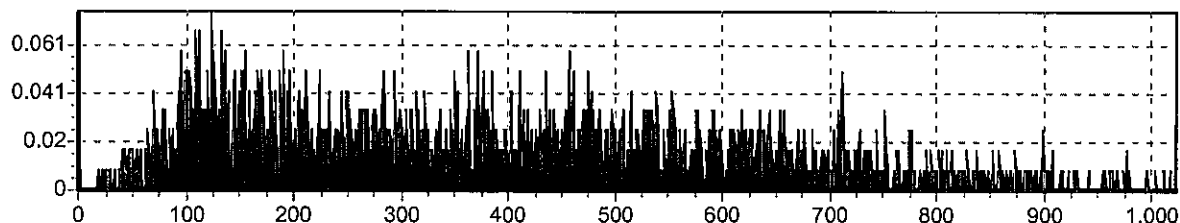
file :C:\Pb-210\ PB-0705\  
 Q181801N.001  
 spectrum :11  
 counting time :7110.12 s  
 SQP(E) :782.56✓  
 counting :7/7/17 2:33:00 AM  
 sampling :7/7/17 2:33:00 AM  
 ID: PB170704-1MB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



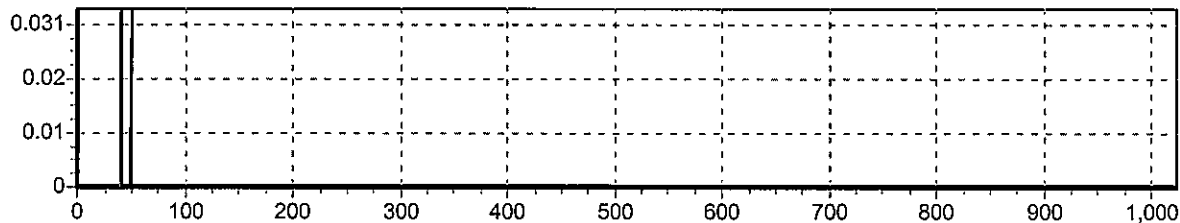
file :C:\Pb-210\ PB-0705\  
 Q181801N.001  
 spectrum :12  
 counting time :7110.12 s  
 SQP(E) :782.56✓  
 counting :7/7/17 2:33:00 AM  
 sampling :7/7/17 2:33:00 AM  
 ID: PB170704-1MB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.038	0.160				0.000		
800..1024	0.852	0.085				0.000		



file :C:\Pb-210\ PB-0705\  
 Q191901N.001  
 spectrum :11  
 counting time :1778.81 s  
 SQP(E) :779.06✓  
 counting :7/7/17 3:05:00 AM  
 sampling :7/7/17 3:05:00 AM  
 ID: PB170704-1LCS

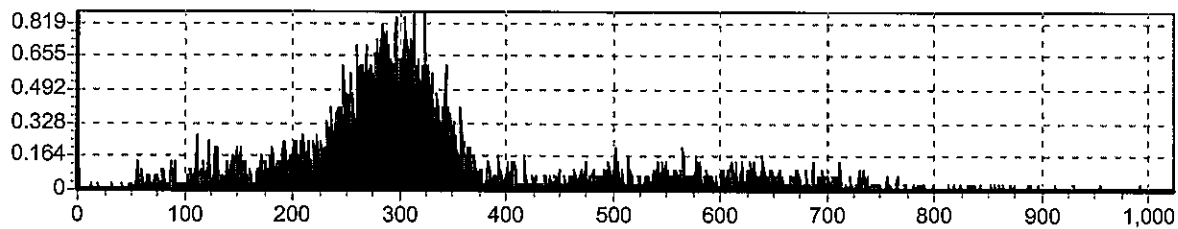
	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0705\  
 Q191901N.001  
 spectrum :12  
 counting time :1778.81 s  
 SQP(E) :779.06✓  
 counting :7/7/17 3:05:00 AM  
 sampling :7/7/17 3:05:00 AM  
 ID: PB170704-1LCS

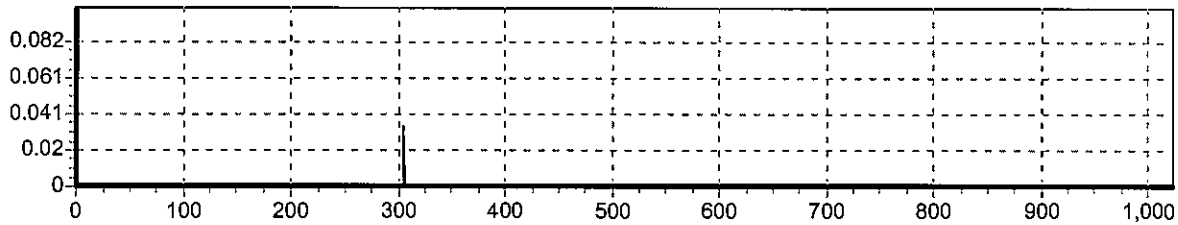
	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	55.858	1.373				0.000		
800..1024	0.776	0.162				0.000		

JP 7/11/17  
 ah  
 7/7/17  
 26 of 95



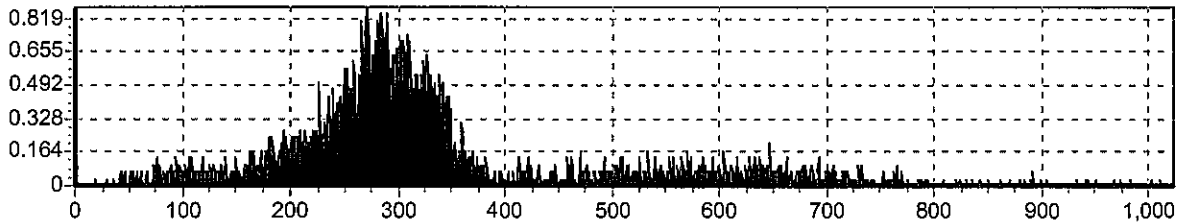
file :C:\Pb-210\ PB-0705\  
 Q202001N.001  
 spectrum :11  
 counting time :1778.82 s  
 SQP(E) :776.84 ✓  
 counting :7/7/17 3:38:00 AM  
 sampling :7/7/17 3:38:00 AM  
 ID: PB170704-1LCSD

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.034	0.034				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



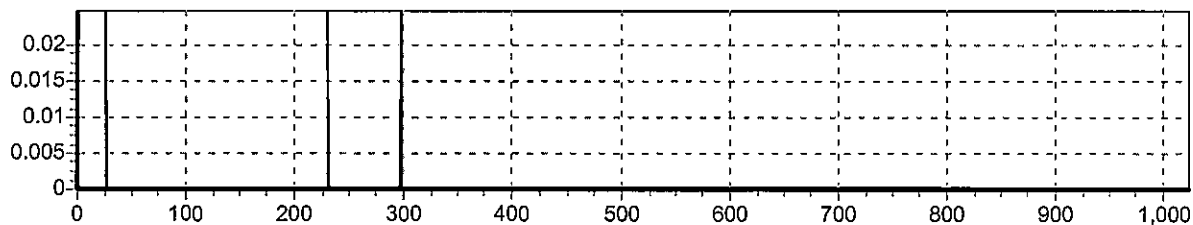
file :C:\Pb-210\ PB-0705\  
 Q202001N.001  
 spectrum :12  
 counting time :1778.82 s  
 SQP(E) :776.84 ✓  
 counting :7/7/17 3:38:00 AM  
 sampling :7/7/17 3:38:00 AM  
 ID: PB170704-1LCSD

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	55.925	1.373				0.000		
800..1024	0.944	0.178				0.000		



file :C:\Pb-210\ PB-0705\  
 Q212101N.001  
 spectrum :11  
 counting time :2371.20 s  
 SQP(E) :775.42 ✓  
 counting :7/7/17 4:21:00 AM  
 sampling :7/7/17 4:21:00 AM  
 ID: PB170704-1CB3

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.051	0.036				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

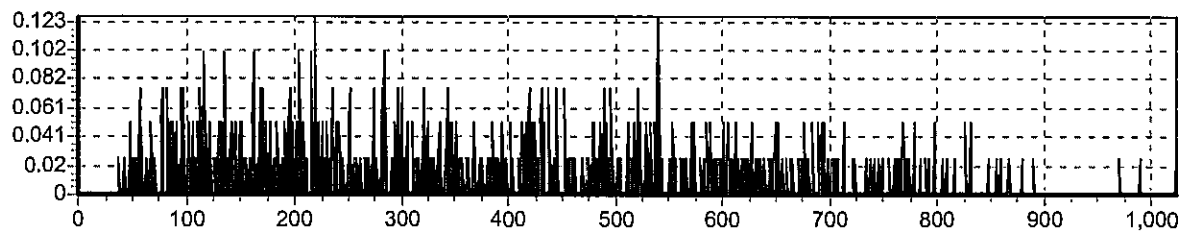


JP/11/17

7676f35

file :C:\Pb-210\ PB-0705\  
 Q212101N.001  
 spectrum :12  
 counting time :2371.20 s  
 SQP(E) :775.42✓  
 counting :7/7/17 4:21:00 AM  
 sampling :7/7/17 4:21:00 AM  
 ID: PB170704-1CB3

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.112	0.281				0.000		
800..1024	0.405	0.101				0.000		



JP 7/11/17

7/7/17



ALS Global

LSC Run Log

\* Temp. 13 C Therm. ID 80241569

Instrument ID: Quantulus 1220

Load Date *	Sample ID	CountTime (min.)	Position	Protocol	File Name	Batch ID	Position Check	Initials	Comments
7/14/17	1706354-2	69.14	25	C-14	C-0630	C170628-1	JP	JP	na
	1706383-11		26						
	-11D		27						
	1706469-5		28						
	C170628-10B2		29						
	1706479-1		30						
	-1D		31						
	-2		32						
	-2MS		33						
	C170628-1MB		34						
	103		35						
	OC3	59.26	36						
7/11/17	Daily QC	10	51-54	H <sub>2</sub> 10mL	QC-0702		JP	JP	
7/11/17	1706407-3MS	29.65	5		H-0702	3H170619-2	JP	JP	
	3H170619-20B2	39.76	6						
	1706407-4	98.28	7						
	-4D		8						
	3H170615-2MB		9						
	103	29.65	10						
	OC3	330.76	11						
7/14/17	Daily QC	10	51-54		QC-0704		JP	JP	
7/15/17	Daily QC	10	51-54		QC-0705		Ar	Ar	
7/15/17	PB170704-10B1	39.5	1	PB-210	PB-0705	PB170704-1	Ar	Ar	
	1706271-1	119.5	2						
	-2		3						
	286-1		4						
	-3		5						
	2M-1		6						
	-2		7						
	329-1		8						

Reviewed by / Date

Ar 7/17/17

FORM 700\_Quantulus3.xls (9/22/09)

# ALS Global

# LSC Run Log

**Instrument ID: Quantulus 1220**

\*Temp. 13 C Therm. ID 80241569

ル 74117

Load Date *	Sample ID	Count Time (min.)	Position	Protocol	File Name	Batch ID	Position Check	Initials	Comments
7/5/17	PB170704-1CB2	39.5	1	PB-20	PB-0705	PB170704-1	OK	AK	NA
	1706324-2	118.5	10						
	241-1		11						
	↓ -3		12						
	423-1		13						
	426-1		14						
	↓ -3		15						
	600-1		16						
	↓ -3		17						
	PB170704-1MAB		18						
	↓ -1L65	29.7	19						
	↓ -1L650	↓	20						
	↓ -1CB3	24.5	21						
7/7/17	Daily QC	60	51-54		QC-0707		OK	AK	

Reviewed by / Date

28 7/7/17

FORM 700\_Quantulusr3.xls (9/22/09)

471025

# Radiochemistry ICP Worksheet

ALS -- Fort Collins

Prep Batch: Pb170704-1

Prep Procedure: Pb210\_LiqS

Reviewed By: ars

Review Date: 7/5/2017

## LEAD Recovery Results

### Reference Carrier

LabID	QC Type	Car Vol	Ref Carr Dil Vol	Ref Carr ICP Alq	Ref Carr ICP Dil Vol	Ref Carr ICP Run	Ref Carr ICP Conc
Pb170704-1	CAR	1	50	1	5	ir170705-2a1	4.074488

### Samples

Prep Num	LabID	QC Type	Init Samp Alq (ml)	Car Vol (ml)	Samp Dil Vol (ml)	Init ICP Alq (ml)	Pre-Con Vol (ml)	Post-Con Vol (ml)	Pre-Sep Vol (ml)	Post-Sep Vol (ml)	Fin ICP Alq (ml)	Fin ICP Dil Vol (ml)	Initial ICP Run	Final ICP Run	Init ICP Conc (ug/ml)	Fin ICP Conc (ug/ml)	Init Samp Mass (ug)	Ref Mass (ug)	Flag	Fin Samp Mass (ug)	% Yield	Final Sample Alq	
1	1706271-1	SMP	100	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.20788	1.576846	883.5034	864.9638		804.1916	91.02%	83.25
1	1706271-2	SMP	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.21744	1.304337	924.1309	864.9638		665.2119	71.98%	832.5
1	1706286-1	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.21943	1.30412	932.577	864.9638		665.1013	71.32%	416.3
1	1706286-3	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.21690	1.335058	921.8341	864.9638		680.8796	73.86%	416.3
1	1706299-1	SMP	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.23062	1.599311	980.1532	864.9638		815.6489	83.22%	832.5
1	1706299-2	SMP	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.22547	1.591854	958.2618	864.9638		811.8454	84.72%	832.5
1	1706329-1	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.21021	1.306255	893.3947	864.9638		666.1898	74.57%	416.3
1	1706329-2	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.2151	1.317309	914.165	864.9638		671.8273	73.49%	416.3
1	1706341-1	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.19695	1.494135	837.0426	864.9638	LB	762.0087	88.10%	416.3
1	1706341-3	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.20933	1.605949	889.6732	864.9638		819.0341	92.06%	416.3
1	1706423-1	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.22867	1.377787	971.8359	864.9638		702.6715	72.30%	416.3
1	1706426-1	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.22253	1.457805	945.7593	864.9638		743.4807	78.61%	416.3
1	1706426-3	SMP	500	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.22138	1.540775	940.848	864.9638		785.7955	83.52%	416.3
1	1706600-1	SMP	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.21402	1.498951	909.6024	864.9638		764.4648	84.04%	832.5
1	1706600-3	SMP	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.22409	1.470743	952.3932	864.9638		750.0788	78.76%	832.5
1	Pb170704-1	MB	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.21816	1.60252	927.1744	864.9638		817.2853	88.15%	832.5
1	Pb170704-1	LCS	1000	1	1002	1	5	1001	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.22360	1.599155	951.2507	864.9646		815.569	85.74%	832.5
1	Pb170704-1	LCSD	1000	1	1002	1	5	1001	6	5.1	5.1	0.1	10	ir170705-2a1	ir170705-2a1	0.21979	1.538838	935.023	864.9646		784.8074	83.93%	832.5

12070705-2A1

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	49.2244	19.7348	47.2341	50.2665	49.2965	0.4864	0.9860	5.1292	50.1907	0.9744	0.9855	0.9522
CCB	0.0061	0.0035	-0.0440	0.0066	0.0089	0.0000	0.0000	0.0000	-0.0216	-0.0001	0.0024	-0.0006
Z	12.8653	0.2855	106.3474	21.1931	271.3263	0.4390	0.0666	21.5307	0.0222	0.0205	0.2590	0.0066
I 1706271-2	22.8098	3.0340	10.7818	2.7030	254.6302	2.3759	0.0522	7.5444	0.0269	0.2351	0.2174	-0.0001
I 1706286-1	26.4188	5.1843	4.0973	3.1155	213.9388	4.1193	0.0673	0.2184	0.0024	1.7345	0.2194	0.0016
I 1706286-3	32.6047	14.1666	8.6440	3.9562	247.3125	4.4207	0.2630	19.2044	0.0369	0.1040	0.2169	0.0206
I 1706299-1	0.7202	0.4707	1.1662	0.1286	140.3327	0.0710	0.0073	2.5525	0.0578	0.0868	0.2306	0.0052
I 1706299-2	0.5859	0.3741	1.0791	0.1210	113.4258	0.0438	0.0106	0.1979	0.0199	0.2167	0.2255	0.0006
I 1706329-1	87.5138	0.1222	137.1289	9.8773	247.0532	2.3824	0.0049	48.7157	0.0263	0.0187	0.2102	0.0012
I 1706329-2	67.0842	0.4898	143.0562	8.1503	243.0077	1.5447	0.0108	68.6147	0.0309	0.1033	0.2151	0.0040
I 1706341-1	64.1224	0.2611	141.5856	8.0396	240.7827	1.5081	0.0071	67.1648	0.0286	0.0116	0.1970	0.0020
I 1706341-3	89.8637	0.7687	139.8483	10.0692	243.3441	2.4410	0.0068	49.4184	0.2749	0.0163	0.2093	0.0013
I 1706423-1	29.7922	1.9621	9.1878	2.7433	245.9149	6.2014	0.0260	0.6624	0.0753	3.7171	0.2287	0.0010
I 1706426-1	14.6423	9.9031	3.6675	1.1154	182.7421	1.5215	0.1313	0.5816	0.0275	3.9676	0.2225	0.0006
I 1706426-3	14.7652	9.3508	3.6992	1.1128	186.8119	1.5383	0.1330	0.6624	0.3456	3.9369	0.2214	0.0022
I 1706600-1	1.1826	0.1847	1.5858	0.2358	127.6943	0.0667	0.0083	2.0759	0.0607	0.0692	0.2140	0.0032
I 1706600-3	0.3904	0.2967	1.1507	0.1082	101.5207	0.0253	0.0044	0.2019	0.2953	0.0874	0.2241	0.0006
I PB170704-1MB	0.0390	0.0542	-0.0130	0.0066	0.1804	0.0002	0.0003	0.0283	0.0123	0.0012	0.2182	-0.0007
I PB170704-1LCS	0.1976	0.7347	-0.0147	0.0531	2.1066	0.0011	0.0478	0.2948	3.2912	0.0050	0.2236	0.0962
Z	0.0427	0.0194	-0.0448	-0.0010	0.6141	0.0003	-0.0001	0.0525	0.0251	0.0190	0.3412	0.0003
CCV	49.3857	19.6919	47.4690	50.3170	48.8978	0.4905	0.9800	5.1373	50.3202	0.9805	0.9787	0.9706
CCB	0.0064	0.0043	-0.0289	0.0036	0.0424	0.0001	0.0000	0.0202	0.0018	-0.0001	0.0025	-0.0004
F 1706271-1	45.6486	0.0215	-0.0354	0.0424	1.3919	0.0327	0.0160	0.0242	0.0269	0.0032	1.5768	-0.0001
F 1706271-2	45.2734	0.0354	-0.0431	0.0301	1.3858	0.1326	0.0099	0.0242	0.0204	0.0091	1.3043	0.0004
F 1706286-1	44.8666	0.0307	-0.0224	0.0240	0.8338	0.2459	0.0064	0.0242	0.0222	0.0270	1.3041	-0.0002
F 1706286-3	46.2284	0.0536	-0.0301	0.0847	0.9731	0.6240	0.2922	0.0242	0.0222	0.0274	1.3351	-0.0008
F 1706299-1	45.3296	0.0730	-0.0313	0.0322	0.8009	0.0780	0.0194	0.1171	0.0251	0.0175	1.5993	0.0022
F 1706299-2	44.2099	0.0003	-0.0391	-0.2113	0.7977	0.0423	0.0109	0.0242	-0.1408	0.0209	1.5919	-0.0283
F 1706329-1	45.4746	0.0358	-0.0566	0.0505	0.7173	0.0491	0.0364	0.0404	0.0257	0.0021	1.3063	-0.0002
F 1706329-2	45.4879	0.0209	-0.0407	0.0317	0.6981	0.0425	0.0132	0.0202	0.0198	0.0021	1.3173	-0.0009
F 1706341-1	44.2432	0.0260	-0.0285	0.0322	0.7210	0.1290	0.0056	0.0202	0.0280	0.0018	1.4941	0.0009
F 1706341-3	45.7004	0.0419	-0.0358	0.0286	0.6772	0.0882	0.0050	0.0929	0.0216	0.0615	1.6059	-0.0005
F 1706423-1	45.7424	0.0429	-0.0411	0.0301	1.0176	0.0713	0.0056	0.0363	0.0280	0.0398	1.3778	0.0012
F 1706426-1	45.6050	0.0694	-0.0338	0.0378	0.9125	0.1028	0.0084	0.0323	0.0567	0.0640	1.4578	0.0301
F 1706426-3	45.5575	0.0219	-0.0362	0.0291	0.7555	0.0577	0.0045	0.0242	0.0280	0.0437	1.5408	-0.0001
F 1706600-1	45.3157	0.0232	-0.0346	0.0281	0.6654	0.0300	0.0125	0.0565	0.0310	0.0036	1.4990	-0.0003
F 1706600-3	45.9240	0.0936	-0.0484	0.0230	0.7156	0.0233	0.0060	0.0202	0.0280	0.0046	1.4707	-0.0009
F PB170704-1MB	45.0025	0.0396	-0.0444	0.0296	0.7131	0.0181	0.0034	0.0929	0.0239	0.0017	1.6025	0.0006
F PB170704-1LCS	45.2313	0.0519	-0.0448	0.0255	0.7784	0.0242	0.0052	0.0323	0.0304	0.0351	1.5992	-0.0003
F PB170704-1LCS	44.9039	0.0250	-0.0423	0.0317	0.6966	0.0179	0.0051	0.0202	0.0292	0.0033	1.5388	-0.0014
PB170704-1RC	0.0617	0.2934	-0.0085	0.0107	0.0175	0.0002	0.0020	0.0404	0.0263	0.0007	4.0745	0.0011
I 1706271-1	22.3008	2.9623	10.7928	2.6642	264.9925	2.3629	0.0508	7.4313	0.0794	0.2359	0.2079	0.0015
I PB170704-1LCS	0.2012	0.7259	-0.0199	0.0480	2.2015	0.0013	0.0470	0.2989	3.3163	0.0049	0.2198	0.0980
CCV	49.4541	19.5405	47.0905	50.0638	48.7361	0.4863	0.9710	5.0323	49.8137	0.9743	0.9589	0.9805
CCB	0.0073	0.0041	-0.0366	0.0077	0.0389	0.0002	0.0001	0.0040	0.0193	0.0006	0.0048	0.0000

2



## Section 6

# QUALITY ASSURANCE SUMMARY REPORTS

**6**

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

## Section 7

# LABORATORY BENCH SHEETS



# Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: Pb170704-1

Prep Procedure: Pb210\_LiqS

Analytical QASS / NCR? Y N

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Report Units	Cnt 1 File/Inst	Cnt 1 Rack-Pos	Cnt 1 Pos Chk By	Cnt 2 File/Inst	Cnt 2 Rack-Pos	Cnt 2 Pos Chk By	Cnt 3 File/Inst	Cnt 3 Rack-Pos	Cnt 3 Pos Chk By	Notes
1	1706271-1	SMP	100	1000	ml	pCi/l	2	NA							
1	1706271-2	SMP	1000	1000	ml	pCi/l	3								
1	1706286-1	SMP	500	1000	ml	pCi/l	4								
1	1706286-3	SMP	500	1000	ml	pCi/l	5								
1	1706299-1	SMP	1000	1000	ml	pCi/l	6								
1	1706299-2	SMP	1000	1000	ml	pCi/l	7								
1	1706329-1	SMP	500	1000	ml	pCi/l	8								
1	1706329-2	SMP	500	1000	ml	pCi/l	10								
1	1706341-1	SMP	500	1000	ml	pCi/l	11								
1	1706341-3	SMP	500	1000	ml	pCi/l	12								
1	1706423-1	SMP	500	1000	ml	pCi/l	13								
1	1706426-1	SMP	500	1000	ml	pCi/l	14								
1	1706426-3	SMP	500	1000	ml	pCi/l	15								
1	1706600-1	SMP	1000	1000	ml	pCi/l	16								
1	1706600-3	SMP	1000	1000	ml	pCi/l	17								
1	17070704-1CB1	MB	1000	1000	ml	pCi/l	1								
1	17070704-1CB2	MB	1000	1000	ml	pCi/l	9								
1	17070704-1CB3	MB	1000	1000	ml	pCi/l	21								
1	17070704-1	MB	1000	1000	ml	pCi/l	18								
1	17070704-1	LCS	1000	1000	ml	pCi/l	19								
1	17070704-1	LCS	1000	1000	ml	pCi/l	20								

## Tracer/Carrier Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
T1	LEAD	418231		1,001.811	pCi/ml	NA	1	ml	RS-037

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Pb-210	899.4095.66		94.735	DPW/ml	07/04/17	1	ml	RS-037
S1	Pb-210	899.4095.66		94.735	DPW/ml	07/04/17	1	ml	RS-037

## Sample Barcodes

1706271-1  
Pb170704-1PS1

1706271-2  
Pb170704-1PS2

1706286-1  
Pb170704-1PS3

# Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: Pb170704-1

Prep Procedure: Pb210\_LiqS

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

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	Units	Report Units	Cnt 1 FileInst	Cnt 1 Rack-Pos	Cnt 1 Pos Chk By	Cnt 2 FileInst	Cnt 2 Rack-Pos	Cnt 2 Pos Chk By	Cnt 3 FileInst	Cnt 3 Rack-Pos	Cnt 3 Pos Chk By	Notes
1706286-3 Pb170704-1PS4								1706289-1 Pb170704-1PS5						1706289-2 Pb170704-1PS6		
1706329-1 Pb170704-1PS7								1706329-2 Pb170704-1PS8						1706341-1 Pb170704-1PS9		
1706341-3 Pb170704-1PS10								1706423-1 Pb170704-1PS11						1706426-1 Pb170704-1PS12		
1706426-3 Pb170704-1PS13								1706600-1 Pb170704-1PS14						1706600-3 Pb170704-1PS15		
Pb170704-1CB1MB Pb170704-1PS16								Pb170704-1CB2MB Pb170704-1PS17						Pb170704-1CB3MB Pb170704-1PS18		
Pb170704-1MB Pb170704-1PS19								Pb170704-1LCS Pb170704-1PS20						Pb170704-1LCS Pb170704-1PS21		
Pb170704-1CAR Pb170704-1PS22																

## Reporting Units

LabID	1stGrpName	RptUnits
1706600-1	Pb210L	pCi/l
1706426-1	Pb210L	pCi/l
1706423-1	Pb210L	pCi/l
1706341-1	Pb210L	pCi/l
1706329-1	Pb210L	pCi/l
1706299-1	Pb210L	pCi/l
1706286-1	Pb210L	pCi/l
1706271-1	Pb210L	pCi/l
1706329-2	Pb210L	pCi/l
1706299-2	Pb210L	pCi/l
1706271-2	Pb210L	pCi/l
1706600-3	Pb210L	pCi/l
1706426-3	Pb210L	pCi/l
1706341-3	Pb210L	pCi/l
1706286-3	Pb210L	pCi/l

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: Pb170704-1

Prep Procedure: Pb210\_LiqS

Reviewed By: ars *og* Review Date: 7/5/2017

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

Prep SOP: PAI 726 Rev: 9  
Prep SOP: NONE  
Matrix Class: liquid

Prep Analyst: Andrew R. Steger *for ALS*  
Prep Date: 7/4/2017  
Prep Dept: RS

Balance: NA  
Cocktail: UGLLT  
Cocktail Pipet: T004  
Aliquot Pipet: AW029

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Ingrowth Date/Time	Standards	Prep Notes
1	1	1706271-1	SMP	<i>NA</i>	100	832.5009	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
2	1	1706271-2	SMP		1000	832.5009	Filtered	07/05/17 11:30	T1	<i>at 7/5/17</i>
3	1	1706286-1	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
4	1	1706286-3	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
5	1	1706299-1	SMP		1000	832.5009	Unfiltered	07/05/17 11:30	T1	
6	1	1706299-2	SMP		1000	832.5009	Unfiltered	07/05/17 11:30	T1	<i>at 7/5/17</i>
7	1	1706329-1	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
8	1	1706329-2	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
9	1	1706341-1	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
10	1	1706341-3	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
11	1	1706423-1	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
12	1	1706426-1	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
13	1	1706426-3	SMP		500	416.2504	Filtered	07/05/17 11:30	T1	A reduced aliquot was taken in order to prevent matrix interference.
14	1	1706600-1	SMP		1000	832.5009	Filtered	07/05/17 11:30	T1	
15	1	1706600-3	SMP		1000	832.5009	Filtered	07/05/17 11:30	T1	
16	1	Pb170704-1CB1 MB			1000	1000	Unfiltered	07/05/17 11:30	<i>NA</i>	
17	1	Pb170704-1CB2 MB			1000	1000	Unfiltered	07/05/17 11:30		
18	1	Pb170704-1CB3 MB			1000	1000	Unfiltered	07/05/17 11:30		
19	1	Pb170704-1 MB			1000	832.5009	Unfiltered	07/05/17 11:30	T1	
20	1	Pb170704-1 LCS			1000	832.5017	Unfiltered	07/05/17 11:30	T1,S1	
21	1	Pb170704-1 LCSD			1000	832.5017	Unfiltered	07/05/17 11:30	T1,S1	

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: Pb170704-1

Prep Procedure: Pb210\_LiqS

Reviewed By: ars Review Date: 7/5/2017

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

Prep SOP: PAI 726 Rev: 9  
Prep SOP: NONE  
Matrix Class: liquid

Prep Analyst: Andrew R. Steger  
Prep Date: 7/4/2017  
Prep Dept: RS

Cocktail: UGLLT  
Cocktail Pipet: T004  
Aliquot Pipet: AW029

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Ingrowth Date/Time	Standards	Prep Notes

## Comments

An LCSD was created in order to conserve sample volume.

Spiked By: Andrew R. Steger Date: 7/4/2017  
Witnessed By: Rebecca M. Olivares Date: 7/4/2017

## Tracer/Carrier Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
T1	LEAD	418231		1,001.811	pCi/ml	NA	1	ml	RS-037

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Pb-210	899.4095.66		94.735	DPM/ml	07/04/17	1	ml	RS-037
S1	Po-210	899.4095.66		94.735	DPM/ml	07/04/17	1	ml	RS-037

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: Pb170704-1

Prep Procedure: Pb210\_LiqS

**Prep Batch Not Validated!!!**

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

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

Prep QASS / NCR? Y / N

Prep SOP: PAI 726 Rev: 9

Prep Analyst: Andrew R. Steger *AS*

Balance: NA

Prep Date: 7/4/2017

Cocktail Pipet:

Matrix Class: liquid

Prep Dept: RS

Balance: NA

Aliquot Pipet:

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Ingrowth Date/Time	Standards	Prep Notes
1	1	1706271-1	SMP		1000	1000		7/5/17 11:30	T1	
2	1	1706271-2	SMP		1000	1000			T1	
3	1	1706286-1	SMP		1000	1000			T1	
4	1	1706286-3	SMP		1000	1000			T1	
5	1	1706299-1	SMP		1000	1000			T1	
6	1	1706299-2	SMP		1000	1000			T1	
7	1	1706329-1	SMP		1000	1000			T1	
8	1	1706329-2	SMP		1000	1000			T1	
9	1	1706341-1	SMP		1000	1000			T1	
10	1	1706341-3	SMP		1000	1000			T1	
11	1	1706423-1	SMP		1000	1000			T1	
12	1	1706426-1	SMP		1000	1000			T1	
13	1	1706426-3	SMP		1000	1000			T1	
14	1	1706600-1	SMP		1000	1000			T1	
15	1	1706600-3	SMP		1000	1000			T1	
16	1	Pb170704-1CB1	MB		1000	1000				
17	1	Pb170704-1CB2	MB		1000	1000				
18	1	Pb170704-1CB3	MB		1000	1000				
19	1	Pb170704-1	MB		1000	1000			T1	
20	1	Pb170704-1	LCS		1000	1000			T1,S1	
21	1	Pb170704-1	LCSD		1000	1000			T1,S1	



# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: Pb170704-1

Prep Procedure: Pb210\_LiqS

**Prep Batch Not Validated!!!**

Reviewed By:

Review Date:

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

Prep QASS / NCR? Y / N

Prep SOP: PAI 726 Rev: 9

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Andrew R. Steger *al*

Prep Date: 7/4/2017

Prep Dept: RS

Balance: NA

Balance: NA

Cocktail: UGLLT

Cocktail Pipet:

Aliquot Pipet:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Ingrowth Date/Time	Standards	Prep Notes
----------	----------	-------	---------	----------	--------------	-------------	------------	--------------------	-----------	------------

Comments

Spiked By: *Andrew R. Steger* Date: 7/4/17

Witnessed By: *QMO* Date: 7/4/17

## Tracer/Carrier Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
T1	LEAD	418231	8/23/17	1,001.811	pCi/ml	NA	1	ml	RS-037

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Pb-210	899.4095.66	10/21/17	94.735	DPM/ml	07/04/17	1	ml	RS-037
S1	Pb-210	899.4095.66	↓	94.735	DPM/ml	07/04/17	1	ml	RS-037

Sample Condition Form (Liquid)				
Analyst: <u>Andrew Steger</u>				
Analysis Date: <u>7/4/17</u>			Method: <u>Prep</u>	
		Sample Condition (Visual Appearance of Analysis Aliquot at Time of Prep)		
Work Order	Sample ID	pH	Color	Remarks
1706271	1	<2	light tan	100ml aliquot taken to prevent matrix interference. Oily. Filtered
↓	2		tan	Oily. Filtered.
1706286	1		↓	500ml aliquot to prevent matrix interference. Oily. Filtered.
↓	3		↓	
1706299	1		clear	None
↓	2		↓	↓
1706329	1		light tan	500ml aliquot to prevent matrix interference. Oily. Filtered.
↓	2		↓	
1706341	1		↓	
↓	3		↓	
1706423	1		clear	500ml aliquot to prevent matrix interference slightly oily. Filtered.
1706426	1		↓	↓
↓	3			
1706600	1			Slightly oily. Filtered.
↓	3	↓	↓	↓
at 7/4/17				

## Section 8

# **STANDARDS TRACEABILITY DOCUMENTS**



# Radiochemistry Solution Report

Solution Id: 418231	Name: Pb carrier	Lot:	Vendor Name:	Type: IS
---------------------	------------------	------	--------------	----------

Final Vol: 4000	Dept: RD	Prep By	CAS	on	8/27/2015	Reviewed By	td	on	8/27/2015
Units: mL	Location: SR/RA	Opened By		on		Verified By	TDE	on	8/27/2015
Matrix: LIQUID	ExpireDate: 8/26/2017	Received By		on		Deactivated By		on	

Comment:

Component Name	Component ID	Volume Added	Units
Lead nitrate<4>	J45597	6.4054	g

## Calibrated Primary Calibration Reference

CompName	Act/Conc	Date	1/2 Life (Yrs)	Final Act/Conc	Summed Conc	Units
LEAD	625604	10/2/2016		1001.811		pCi/ml

## Associated Parent IDs

J45597

Abbreviations: NC = Not Calculated for reagents when the volume added is not entered. (Pmt) = Secular equilibrium; parent half life used to calculate concentration.  
NE = Not Entered

Date Printed: Sunday, October 02, 2016

ALS Environmental -- FC

Standards DB Version: 1.111

Page 1 of 1

Pb-210 899.4095.66 working standard

Prepare a working dilution of 899.3610.42

1. Density of 1M HNO<sub>3</sub>, lot # 0000084176  
 Mass of 100mL vol. flask: 56.4468g Balance # 12  
 Mass of flask & 100mL acid: 159.4521g Balance # 12  
 Net Mass: 103.0053g  
 Density: 1.0301 g/mL

2. Mass of 899.3610.42 transferred:  
 Mass of open empty nalgene: 74.5139g Balance # 12  
 Mass of nalgene & standard: 77.1985g Balance # 12  
 Net mass of standard transferred: 2.6846g Balance # NA

3. Dilute to final volume:  
 Mass of nalgene, standard, & diluent: 1147.7g Balance # 26  
 Mass of empty nalgene (from above): 74.5139g Balance # 12  
 Net mass of new dilution: 1073.1861g Balance # NA

4. Final activity calculation:

$$46,996.4 \text{ dpm/g} (1.0301 \text{ g/mL}) (2.6846 \text{ g}) = 121.10 \text{ dpm/mL}$$

$$(1073.1861 \text{ g})$$

Std ID: 899.4095.66

Description: Pb-210

Expiration: 10/26/2016

Activity: 121.10 dpm/mL

2s Uncertainty: 3.39 dpm/mL

Ref. Date: 8/10/2009

Ref Time: N/A

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

Matrix/Comp. 1 M HNO<sub>3</sub>

Half Life (y): 2.22E+01

Reverification Log		
Analysis Date	Initials	Expiration Date
10/21/2016	JP	10/21/2017

Continued on Page

Signed

Date

Read and Understood By

Signed

Date 45 of 95



Eckert & Ziegler

Analytics

R508  
899  
rec  
8-14-09

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

# CERTIFICATE OF CALIBRATION

## Standard Radionuclide Source

80328-307

Pb-210 5 mL Liquid in Flame Sealed Vial

Customer: ALS Laboratory Group / Fort Collins  
P.O. No.: 73625 07-24-09, Item 1

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting. Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below. 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*, %			Reference Date (12:00 PM EST)
			$u_A$	$u_B$	U	
Pb-210	8145.1	4.078E+04	0.1	1.4	2.8	08/10/2009

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

### Comments:

Impurities: gamma-impurities <0.1%, alpha-impurities (other than decay products) <0.01%. 52.06357 grams 1M HNO<sub>3</sub> solution, carrier free.

Source Prepared by:

N. E. Kasate  
N. E. Kasate, Radiochemist

QA Approved:

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

Date: 8-13-09



Corporate Office

24937 Avenue Tibbitts Valencia, California 91355

Laboratory

1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30314 46 of 95

## Section 9

# **ADDITIONAL SUPPORTING DOCUMENTATION**

## **Liquid Scintillation Counter**

### **Instrumentation Calibration**

### **Initial Efficiency Calibration Standards Traceability**



# Q1220 Pb-210 Background Determination

Interim control limits are established from the initial calibration for the analysis and geometry of interest QR from the initial batch calibration blank data set acquired after the instrument re-calibration. Limits are +/- 3 standard deviations (counting unc.) from the initial calibration blank data. Once enough historical data is acquired, new historical limits are set as follows: Control limits for reagent blanks are established from 30 individual historical data points (10 batches). Limits are +/- 3 standard deviations from 30 individual historical data points. Individual reagent blanks and the average of reagent blanks from each batch are in control if the Count Rate (CPM) is within the established control limits.

## CURRENTLY UNDER HISTORICAL LIMITS

Updated on 05/30/13 NES									
COUNT DATE	#	Sample ID	Count Duration (m)	Count Rate (CPM)	Total Cts.	Mean	Individual Reagent Blanks		
							LCL	UCL	Pass ?
7/5/2017	661	PB170704-1CB1	39.5	3.26	128.77		2.0410	4.2714	PASS
7/6/2017	662	PB170704-1CB2	39.5	2.58	101.91		2.0410	4.2714	PASS
7/7/2017	663	PB170704-1CB3	39.5	3.06	120.87	2.967	2.0410	4.2714	PASS
							Average of Reagent Blanks		
							LCL	UCL	Pass ?
							2.0410	4.2714	PASS

# PB-210 Efficiency Calibration Q1220

5 mL sample (8N HNO<sub>3</sub>) + 15 mL Ultima Gold LLT

2/23/2017

Q1220

Standard used: 901.3610.50

2633.37 dpm/ml as of 6/15/2006  
1/2 life = 2.23E+01 yrs.  
current activity = 1888.65 dpm/ml  
volume = 1.0000 ml  
Spike Activity = 1888.65 dpm  
(190-325) (800-1024)

## Window 1 CPM adjusted for chemical yield and volume

Sample ID	WIN1 CORR	Yield	Vol Adj.	Adj WIN1 CPM
1714005-1	1030.579	0.8827	0.8274	1411.08
1714005-2	1041.611	0.9266	0.8274	1358.62
1714005-3	1073.692	0.8257	0.8274	1571.60

Sample ID	WIND1 cpm*	WIND2 cpm	%LUMEX	SQP(E) #
1714005-1	1411.083	0.877	0.000	784.13
1714005-2	1358.619	0.843	0.000	779.19
1714005-3	1571.600	0.742	4.380	777.66
PB170221-1AMB	3.499	0.883	0.000	776.17
PB170221-1BMB	3.483	0.765	0.000	780.79
PB170221-1CMB	3.500	0.855	0.000	778.67

average LCS= 1447.10 0.834 0.730 779.44 averages

average bkg= 3.494

net cpm= 1443.61

/known dpm= 1888.65

efficiency= 0.7644

WIND2 cpm	%LUMEX	SQP(E) #	
1.04	10.00	794.44	UCL
0.63	0.00	764.44	LCL
See Tech. Mgr.	See Tech. Mgr.	Std. Addition	Corrective Action

\*WIND1 cpm were corrected for chemical yield and volume (Pb-210 spiked into 1000 mL)

Instrument Technician:

Signature & Date

Supervisory Review:

Signature & Date

# **PB 210 Efficiency Calibration Verification / Method Blank Verification 3/1/2017**

## **Calibration Source Check**

Q1220

Analysis Date: 3/1/2017  
Nuclide: PB210  
Half Life: 2.23E+01

## **Calibration Check Source:**

Spike Standard: 899.4095.66  
Reference Date: 8/10/2009  
Spiked DPM/mL: 121.10 dpm/mL  
Spike Volume: 1.0 mL  
Spiked into: 1000.0 mL  
Current Spk. Act: 43.14 dpm/L

Control Limits: 70%-130%

## **Calibration Check Source Count**

Sample ID	Position	Prep Date	Cnt. Dur.	Anal. Vol. (L)	GrsCPM	BkgCPM	Efficiency	Activity	Units	Chem. Yield	LCS Recovery:	Pass/Fail
1714006-1	2	2/27/2017	29.6	0.8325	59.330	3.050	0.7644	42.41	pCi/L	93.95%	98.3%	PASS
1714006-2	3	2/27/2017	29.6	0.8325	58.650	3.050	0.7644	41.16	pCi/L	95.63%	95.4%	PASS
1714006-3	4	2/27/2017	29.6	0.8325	62.160	3.050	0.7644	44.57	pCi/L	93.89%	103.3%	PASS

## **Method Blank Check Count**

Sample ID	Position	Prep Date	Cnt. Dur.	Anal. Vol.	GrsCPM	BkgCPM	Efficiency	Chem. Yield	k (denom.)	activity	MDC	Pass/Fail	Units	2s CU	1 $\sigma$ IU	1 $\sigma$ PU	2 $\sigma$ PU	2 $\sigma$ TPU
PB170227-1AMB	6	2/27/2017	177.72	0.8325	3.050	3.050	0.7644	95.59%	1.350	0.0000	0.46	PASS	pCi/L	0.274	0.00000	0.00000	0.00000	0.274
PB170227-1BMB	7	2/27/2017	177.72	0.8325	3.350	3.050	0.7644	94.75%	1.338	0.2242	0.49	PASS	pCi/L	0.284	0.02511	0.02287	0.02287	0.286
PB170227-1CMB	8	2/27/2017	177.72	0.8325	3.110	3.050	0.7644	96.48%	1.363	0.0440	0.46	PASS	pCi/L	0.273	0.00493	0.00449	0.00449	0.273

OK JP  
3/2/17

Luminescence Correction Quantulus 1220  
**PB170221-1**  
 2/23/2017

sample ID	WIN 1 (190-325)					WIN 2 (800-1024)					Wind 2 check
	count rate spectrum 11	count rate spectrum 12	lumex corrected	% lumex	% lumex check	count rate spectrum 11	count rate spectrum 12	lumex corrected	% lumex		
1714005-1	0.000	1030.579	1030.579	0.00	OK	0.000	0.877	0.877	0.00		
1714005-2	0.034	1041.645	1041.611	0.00	OK	0.000	0.843	0.843	0.00		
1714005-3	0.000	1073.692	1073.692	0.00	OK	0.034	0.776	0.742	4.38		
PB170221-1AMB	0.006	3.505	3.499	0.17	OK	0.000	0.883	0.883	0.00		
PB170221-1BMB	0.006	3.489	3.483	0.17	OK	0.000	0.765	0.765	0.00		
PB170221-1CMB	0.011	3.511	3.500	0.31	OK	0.000	0.855	0.855	0.00		

0.00  
 10.00

5/2/17

LabID:	WIN 1 (190 - 325)					WIN 2 (800 - 1024)					Win 2 Check	
	Count Rate Spectrum 11	Count Rate Spectrum 12	Lumex Corrected	Lumex (%)	Lumex Check	Count Rate Spectrum 11	Count Rate Spectrum 12	Lumex Corrected	Lumex (%)	Lower Control Limit	Upper Control Limit	Win 2 Check
PB170227-1CB1	.08	2.88	2.8	2.78	OK	.00	.57	0.57	0.00	NA	NA	NA
PB170227-1CB2	.00	3.00	3	0.00	OK	.00	.65	0.65	0.00	NA	NA	NA
PB170227-1CB3	.00	3.35	3.35	0.00	OK	.00	.72	0.72	0.00	NA	NA	NA
1714006-1	.00	59.33	59.33	0.00	OK	.00	.87	0.87	0.00	0.203343	1.08999	OK
1714006-2	.00	58.65	58.65	0.00	OK	.00	.91	0.91	0.00	0.203343	1.08999	OK
1714006-3	.00	62.16	62.16	0.00	OK	.00	.33	0.33	0.00	0.203343	1.08999	OK
PB170227-1AMB	.00	3.05	3.05	0.00	OK	.00	.93	0.93	0.00	0.465693	0.827641	HIGH
PB170227-1BMB	.01	3.36	3.35	0.30	OK	.00	.73	0.73	0.00	0.465693	0.827640	OK
PB170227-1CMB	.01	3.12	3.11	0.32	OK	.00	.76	0.76	0.00	0.465693	0.827641	OK

Lumex LCL = 0.00
Lumex UCL = 10.00

gross count rates and count times used for the final activity calculations and the lumex correction sheet are different than the values shown on the raw data output. These values come from two software programs which round the sample counts differently. The difference between these two values is believed to be insignificant. Window 2 control limits are established using the average count rate from the three reagent blanks +/- 3X the estimated Poisson uncertainty.

# Spectrum report

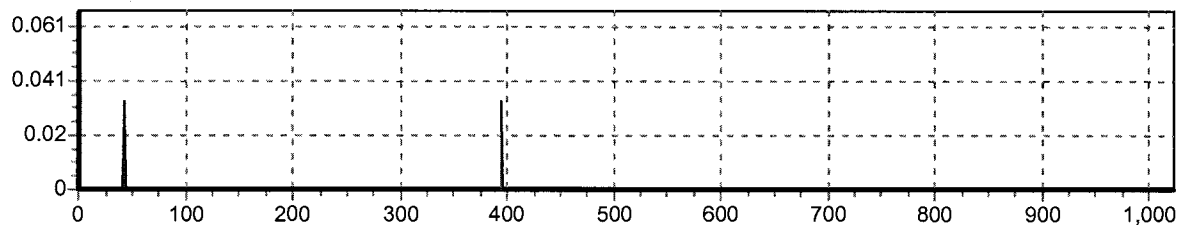
2/24/17 8:54:34 AM

Setup information  
C:\Program Files\wallac\easy view\PB-210.wss

Window 1 = 190..325 190..325, MCA 11 mode CPM  
volume 10 ml  
Window 2 = 800..1024 800..1024, MCA 11 mode CPM  
volume 10 ml  
Window 3 = 190..325 190..325, MCA 12 mode CPM  
volume 10 ml  
Window 4 = 800..1024 800..1024, MCA 12 mode CPM  
volume 10 ml

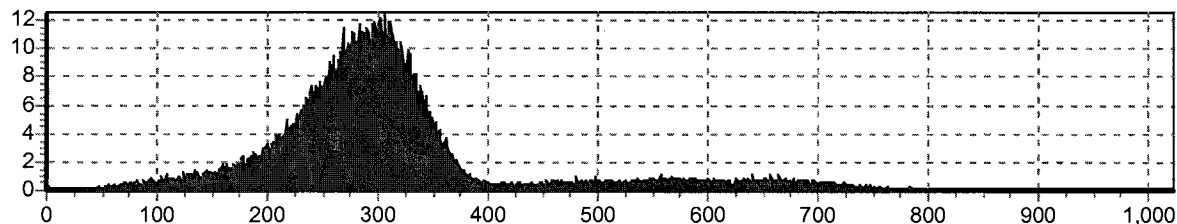
file :C:\Pb-210\ PB-0223\  
Q010801N.001  
spectrum :11  
counting time :1778.38 s  
SQP(E) :784.13  
counting :2/23/17 2:21:00 PM  
sampling :2/23/17 2:21:00 PM  
ID: 1714005-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0223\  
Q010801N.001  
spectrum :12  
counting time :1778.38 s  
SQP(E) :784.13  
counting :2/23/17 2:21:00 PM  
sampling :2/23/17 2:21:00 PM  
ID: 1714005-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	1030.579	5.897				0.000		
800..1024	0.877	0.172				0.000		

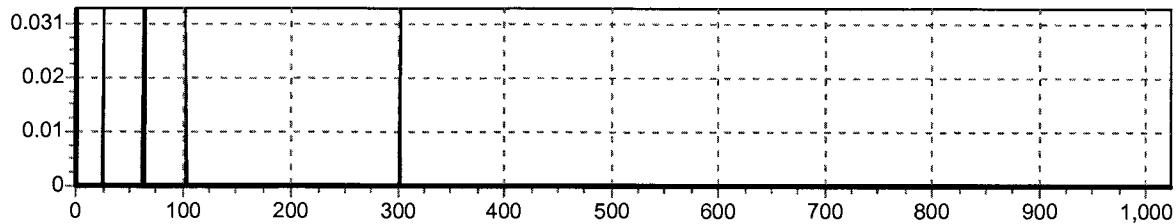


file :C:\Pb-210\ PB-0223\  
Q020901N.001  
spectrum :11  
counting time :1778.38 s  
SQP(E) :779.19  
counting :2/23/17 2:53:00 PM  
sampling :2/23/17 2:53:00 PM  
ID: 1714005-2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.034	0.034				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

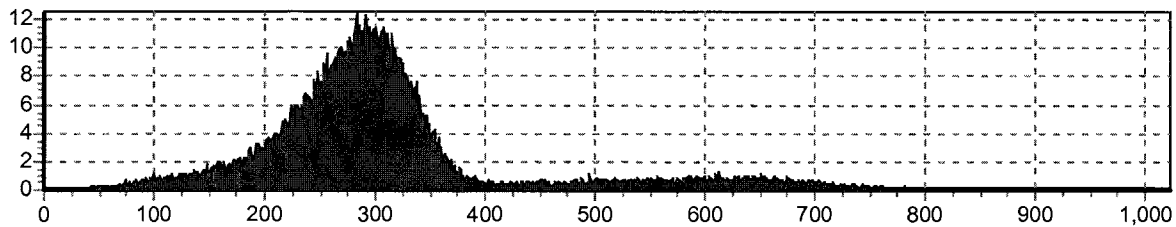
JP 3/2/17

2/28/17



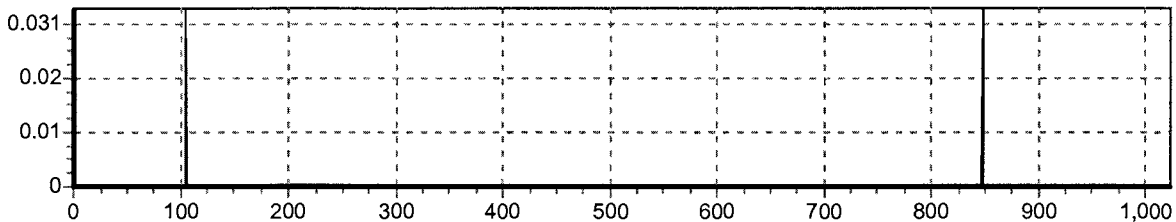
file :C:\Pb-210\ PB-0223\  
 Q020901N.001  
 spectrum :12  
 counting time :1778.38 s  
 SQP(E) :779.19  
 counting :2/23/17 2:53:00 PM  
 sampling :2/23/17 2:53:00 PM  
 ID: 1714005-2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	1041.645	5.928				0.000		
800..1024	0.843	0.169				0.000		



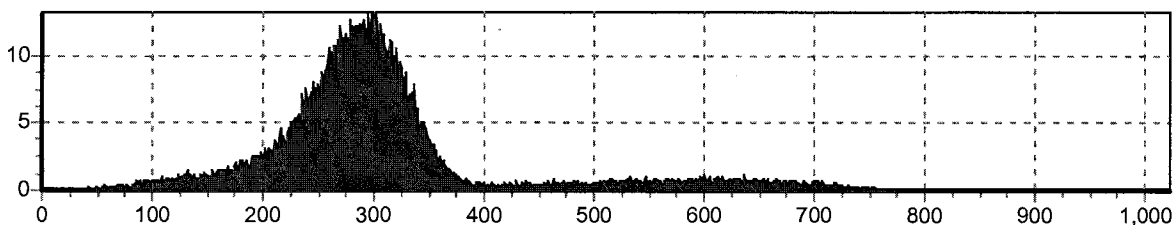
file :C:\Pb-210\ PB-0223\  
 Q031001N.001  
 spectrum :11  
 counting time :1778.39 s  
 SQP(E) :777.66  
 counting :2/23/17 3:26:00 PM  
 sampling :2/23/17 3:26:00 PM  
 ID: 1714005-3

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.034	0.034				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0223\  
 Q031001N.001  
 spectrum :12  
 counting time :1778.39 s  
 SQP(E) :777.66  
 counting :2/23/17 3:26:00 PM  
 sampling :2/23/17 3:26:00 PM  
 ID: 1714005-3

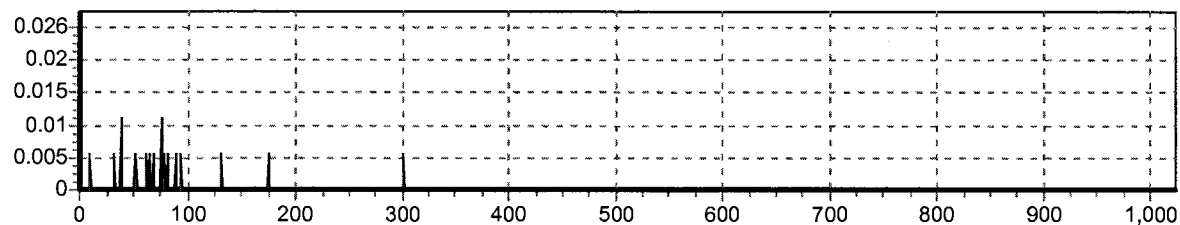
	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	1073.692	6.019				0.000		
800..1024	0.776	0.162				0.000		



JP 3/2/17

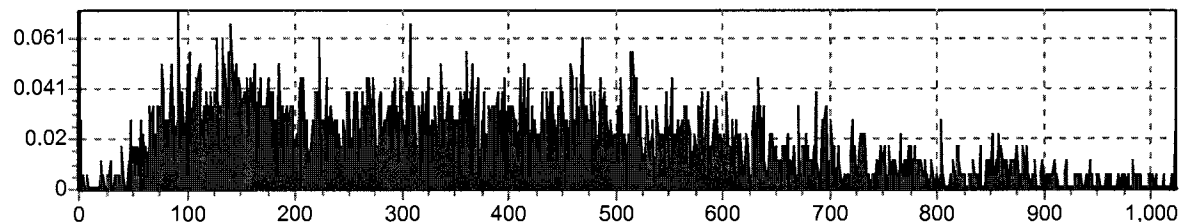
file :C:\ Pb-210\ PB-0223\  
 Q041101N.001  
 spectrum :11  
 counting time :10663.99 s  
 SQP(E) :776.17  
 counting :2/23/17 6:29:00 PM  
 sampling :2/23/17 6:29:00 PM  
 ID: PB170221-1AMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.006	0.006				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



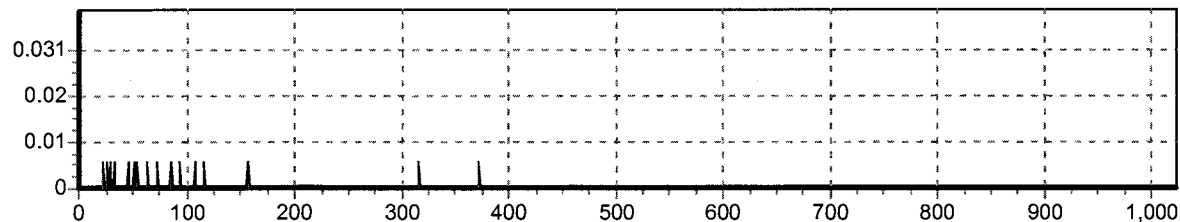
file :C:\ Pb-210\ PB-0223\  
 Q041101N.001  
 spectrum :12  
 counting time :10663.99 s  
 SQP(E) :776.17  
 counting :2/23/17 6:29:00 PM  
 sampling :2/23/17 6:29:00 PM  
 ID: PB170221-1AMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.505	0.140				0.000		
800..1024	0.883	0.070				0.000		



file :C:\ Pb-210\ PB-0223\  
 Q051201N.001  
 spectrum :11  
 counting time :10663.03 s  
 SQP(E) :780.79  
 counting :2/23/17 9:31:00 PM  
 sampling :2/23/17 9:31:00 PM  
 ID: PB170221-1BMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.006	0.006				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



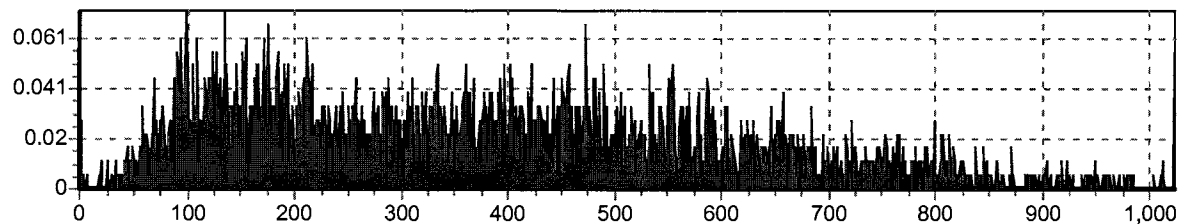
file :C:\ Pb-210\ PB-0223\  
 Q051201N.001  
 spectrum :12  
 counting time :10663.03 s  
 SQP(E) :780.79  
 counting :2/23/17 9:31:00 PM  
 sampling :2/23/17 9:31:00 PM  
 ID: PB170221-1BMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.489	0.140				0.000		
800..1024	0.765	0.066				0.000		

JP 3/2/17

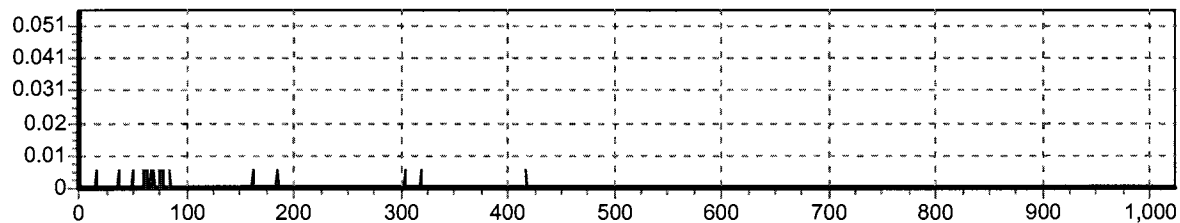
2/28/15





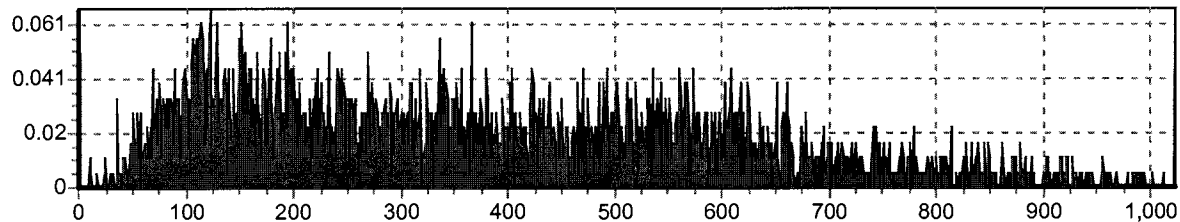
file :C:\Pb-210\ PB-0223\  
 Q061301N.001  
 spectrum :11  
 counting time :10664.02 s  
 SQP(E) :778.67  
 counting :2/24/17 12:34:00 AM  
 sampling :2/24/17 12:34:00 AM  
 ID: PB170221-1CMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.011	0.008				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0223\  
 Q061301N.001  
 spectrum :12  
 counting time :10664.02 s  
 SQP(E) :778.67  
 counting :2/24/17 12:34:00 AM  
 sampling :2/24/17 12:34:00 AM  
 ID: PB170221-1CMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.511	0.141				0.000		
800..1024	0.855	0.069				0.000		



JD 3/2/17

# Spectrum report

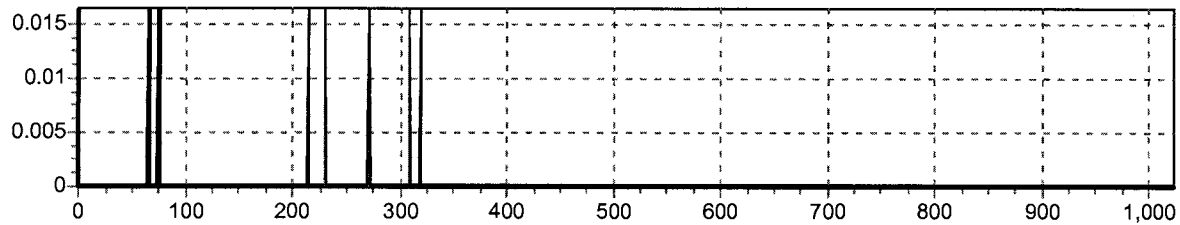
3/2/17 7:57:58 AM

Setup information  
C:\Program Files\wallac\easy view\PB-210.wss

Window 1 = 190..325 190..325, MCA 11 mode CPM  
volume 10 ml  
Window 2 = 800..1024 800..1024, MCA 11 mode CPM  
volume 10 ml  
Window 3 = 190..325 190..325, MCA 12 mode CPM  
volume 10 ml  
Window 4 = 800..1024 800..1024, MCA 12 mode CPM  
volume 10 ml

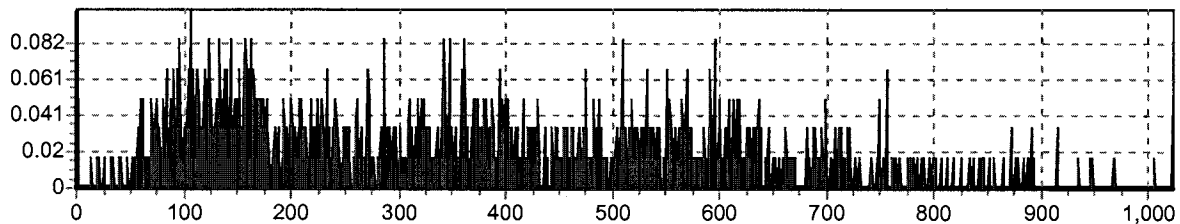
file :C:\Pb-210\ PB-0301\  
Q010101N.001  
spectrum :11  
counting time :3555.84 s  
SQP(E) :783.73  
counting :3/1/17 1:05:00 PM  
sampling :3/1/17 1:05:00 PM  
ID: PB170227-1CB1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.084	0.038				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0301\  
Q010101N.001  
spectrum :12  
counting time :3555.84 s  
SQP(E) :783.73  
counting :3/1/17 1:05:00 PM  
sampling :3/1/17 1:05:00 PM  
ID: PB170227-1CB1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	2.885	0.221				0.000		
800..1024	0.574	0.098				0.000		

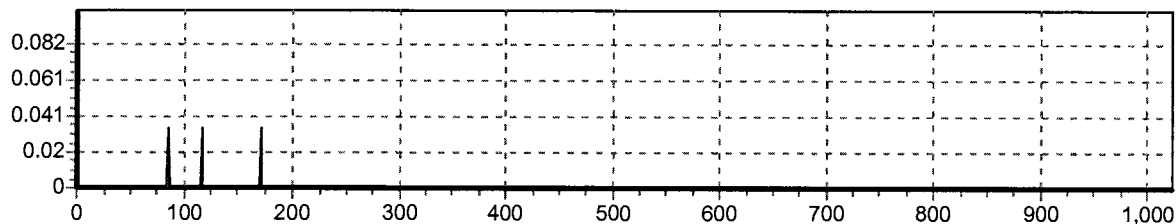


file :C:\Pb-210\ PB-0301\  
Q020201N.001  
spectrum :11  
counting time :1778.78 s  
SQP(E) :782.99  
counting :3/1/17 1:37:00 PM  
sampling :3/1/17 1:37:00 PM  
ID: 1714006-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

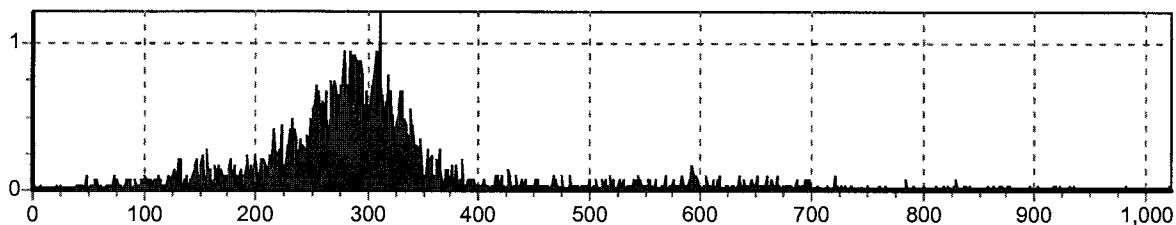
*JP 3/2/17*

*AK*  
*3/2/17*  
58 of 95



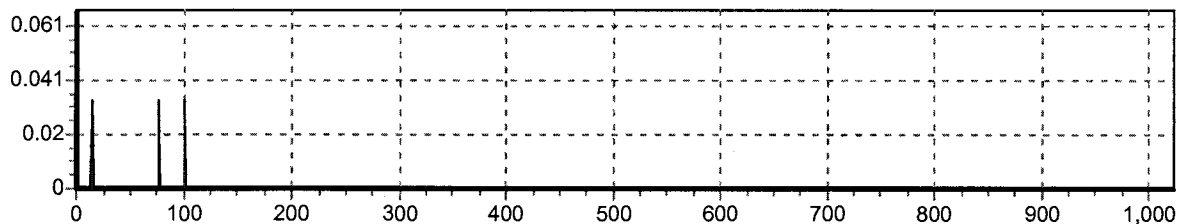
file :C:\Pb-210\ PB-0301\  
 Q020201N.001  
 spectrum :12  
 counting time :1778.78 s  
 SQP(E) :782.99  
 counting :3/1/17 1:37:00 PM  
 sampling :3/1/17 1:37:00 PM  
 ID: 1714006-1

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	59.333	1.415				0.000		
800..1024	0.877	0.172				0.000		



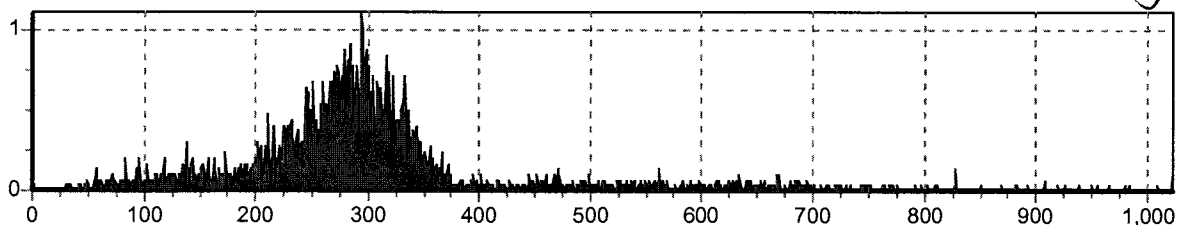
file :C:\Pb-210\ PB-0301\  
 Q030301N.001  
 spectrum :11  
 counting time :1778.77 s  
 SQP(E) :780.69  
 counting :3/1/17 2:10:00 PM  
 sampling :3/1/17 2:10:00 PM  
 ID: 1714006-2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\Pb-210\ PB-0301\  
 Q030301N.001  
 spectrum :12  
 counting time :1778.77 s  
 SQP(E) :780.69  
 counting :3/1/17 2:10:00 PM  
 sampling :3/1/17 2:10:00 PM  
 ID: 1714006-2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	58.658	1.407				0.000		
800..1024	0.911	0.175				0.000		

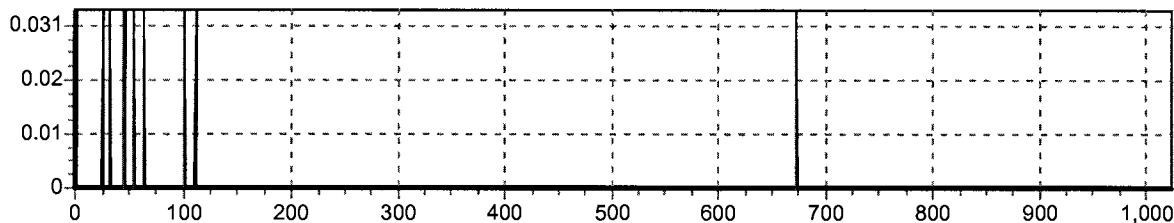


*JP 3/2/17*

*OK 3/2/17 of 95*

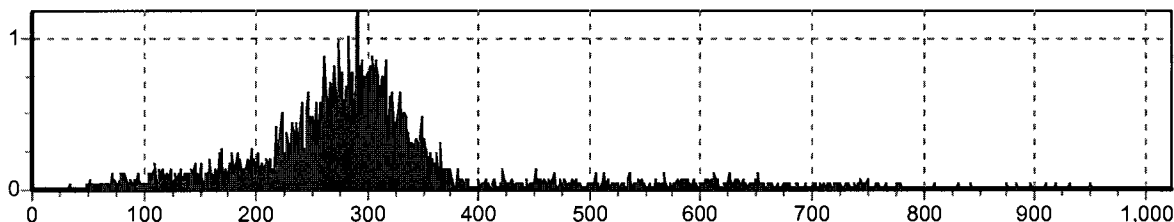
file :C:\Pb-210\ PB-0301\  
 Q040401N.001  
 spectrum :11  
 counting time :1778.78 s  
 SQP(E) :781.85  
 counting :3/1/17 2:43:00 PM  
 sampling :3/1/17 2:43:00 PM  
 ID: 1714006-3

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



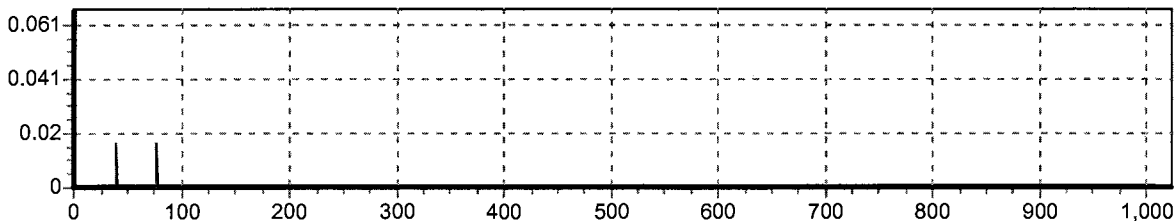
file :C:\Pb-210\ PB-0301\  
 Q040401N.001  
 spectrum :12  
 counting time :1778.78 s  
 SQP(E) :781.85  
 counting :3/1/17 2:43:00 PM  
 sampling :3/1/17 2:43:00 PM  
 ID: 1714006-3

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	62.166	1.448				0.000		
800..1024	0.337	0.107				0.000		



file :C:\Pb-210\ PB-0301\  
 Q050501N.001  
 spectrum :11  
 counting time :3555.84 s  
 SQP(E) :780.24  
 counting :3/1/17 3:45:00 PM  
 sampling :3/1/17 3:45:00 PM  
 ID: PB170227-1CB2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

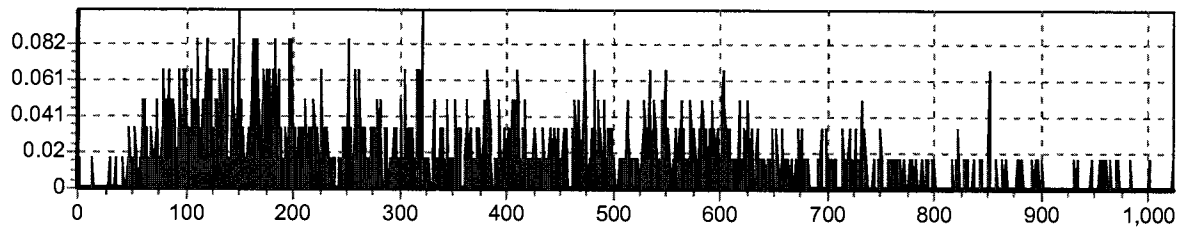


file :C:\Pb-210\ PB-0301\  
 Q050501N.001  
 spectrum :12  
 counting time :3555.84 s  
 SQP(E) :780.24  
 counting :3/1/17 3:45:00 PM  
 sampling :3/1/17 3:45:00 PM  
 ID: PB170227-1CB2

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.004	0.225				0.000		
800..1024	0.658	0.105				0.000		

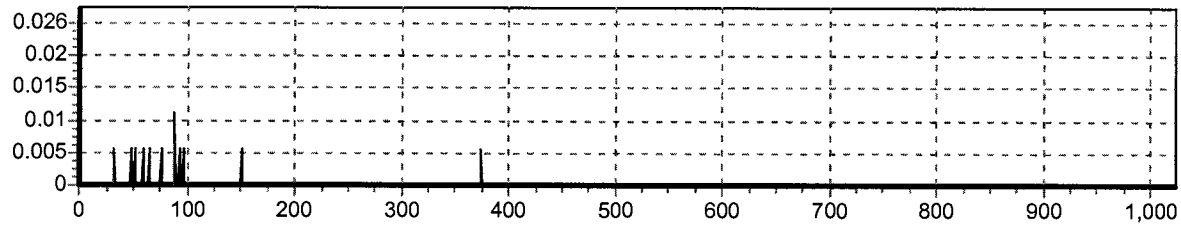
*JP 3/2/17*

*3/2/17*  
*366 of 95*



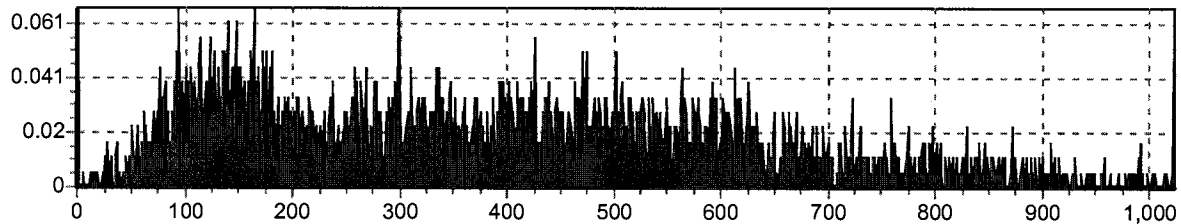
file :C:\Pb-210\ PB-0301\  
 Q060601N.001  
 spectrum :11  
 counting time :10664.06 s  
 SQP(E) :783.62  
 counting :3/1/17 6:48:00 PM  
 sampling :3/1/17 6:48:00 PM  
 ID: PB170227-1AMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



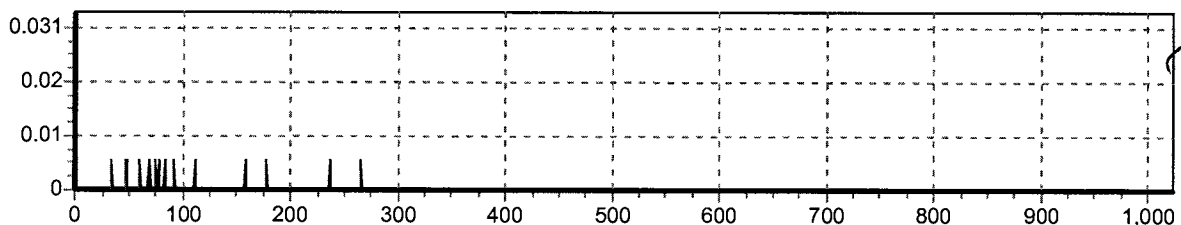
file :C:\Pb-210\ PB-0301\  
 Q060601N.001  
 spectrum :12  
 counting time :10664.06 s  
 SQP(E) :783.62  
 counting :3/1/17 6:48:00 PM  
 sampling :3/1/17 6:48:00 PM  
 ID: PB170227-1AMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.055	0.131				0.000		
800..1024	0.940	0.073				0.000		



file :C:\Pb-210\ PB-0301\  
 Q070701N.001  
 spectrum :11  
 counting time :10664.14 s  
 SQP(E) :780.20  
 counting :3/1/17 9:50:00 PM  
 sampling :3/1/17 9:50:00 PM  
 ID: PB170227-1BMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.011	0.008				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

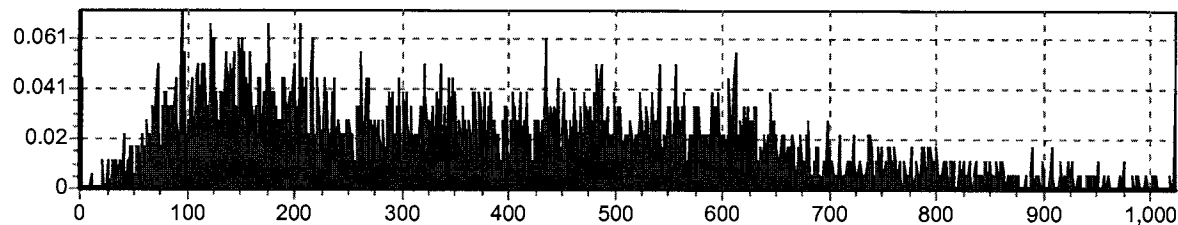


JP  
 3/2/17

AL  
 3/1/17

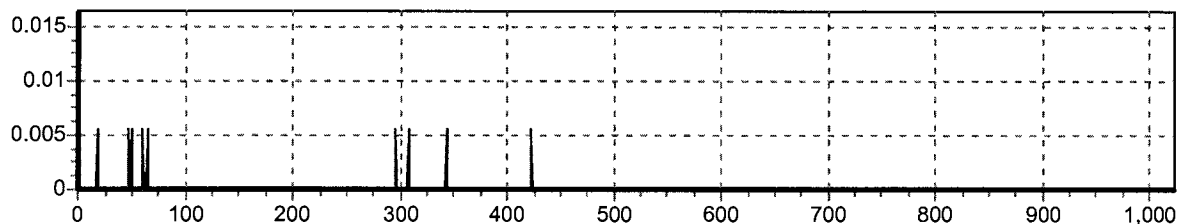
file :C:\ Pb-210\ PB-0301\  
 Q070701N.001  
 spectrum :12  
 counting time :10664.14 s  
 SQP(E) :780.20  
 counting :3/1/17 9:50:00 PM  
 sampling :3/1/17 9:50:00 PM  
 ID: PB170227-1BMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.365	0.138				0.000		
800..1024	0.737	0.064				0.000		



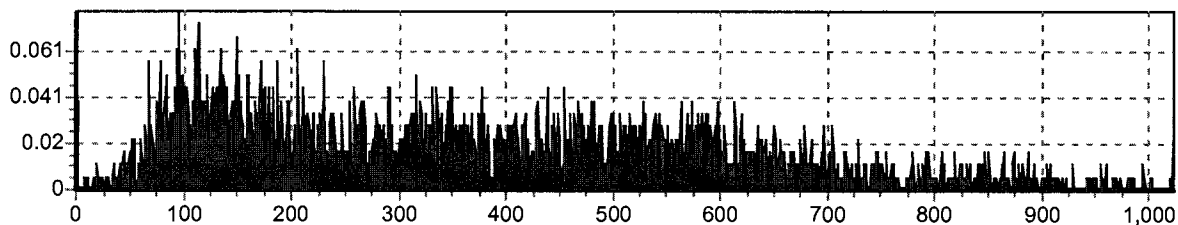
file :C:\ Pb-210\ PB-0301\  
 Q080801N.001  
 spectrum :11  
 counting time :10664.09 s  
 SQP(E) :779.28  
 counting :3/2/17 12:53:00 AM  
 sampling :3/2/17 12:53:00 AM  
 ID: PB170227-1CMB

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.011	0.008				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								



file :C:\ Pb-210\ PB-0301\  
 Q080801N.001  
 spectrum :12  
 counting time :10664.09 s  
 SQP(E) :779.28  
 counting :3/2/17 12:53:00 AM  
 sampling :3/2/17 12:53:00 AM  
 ID: PB170227-1CMB

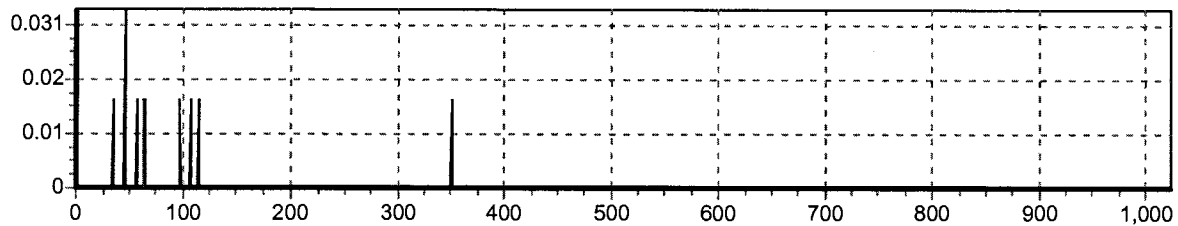
	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.128	0.133				0.000		
800..1024	0.765	0.066				0.000		



file :C:\ Pb-210\ PB-0301\  
 Q090901N.001  
 spectrum :11  
 counting time :3555.84 s  
 SQP(E) :780.56  
 counting :3/2/17 1:56:00 AM  
 sampling :3/2/17 1:56:00 AM  
 ID: PB170227-1CB3

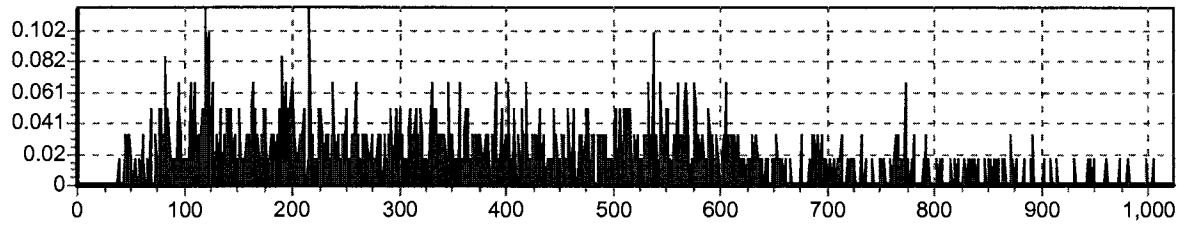
	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325	0.000	0.000				0.000		
800..1024	0.000	0.000				0.000		
190..325								
800..1024								

JP  
 3/2/17  
 ac  
 623/13/17  
 95

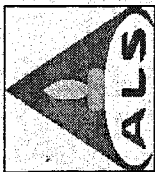


file :C:\Pb-210\ PB-0301\  
 Q090901N.001  
 spectrum :12  
 counting time :3555.84 s  
 SQP(E) :780.56  
 counting :3/2/17 1:56:00 AM  
 sampling :3/2/17 1:56:00 AM  
 ID: PB170227-1CB3

	C rate	Error	D rate	D error	Eff	BG	FM	MDA
190..325								
800..1024								
190..325	3.358	0.238				0.000		
800..1024	0.726	0.111				0.000		



JP  
 3/2/17  
 63 df 95



ALS Global

LSC Run Log

\* Temp.      °C Therm. ID 80241569

Instrument ID: Quantulus 1220

Load Date *	Sample ID	Count Time (min.)	Position	Protocol	File Name	Batch ID	Position Check	Initials	Comments
2/25/17	C170216-16B2	51.3	5	C14	C-0221E0	C170216-1	OK	AL	C14 KCal
	C170216-14MB	177.7	6						
	16MB		7						
	16MB		8						
	16B3	51.3	9						
2/22/17	Daily QC	10	51-54		QC-0222		OK	AL	NA
2/22/17	PB170207-16B1	51.26	1	PB210	PB-0222	PB170207-1	OK	AL	
	1701323-1	177.7	2						
	PB170207-1MB		3						
	16B2	51.26	4						
	16B3	21.6	5						
	16B4		6						
	16B5	51.26	7						
2/23/17	Daily QC	10.08	51-54		QC-0223		OK	AL	NA
2/23/17	1714005-1	8.246	8	PB-210	PB-0223	PB170221-1	OK	AL	PB cal 364
	1714005-1	8.246	9						
	1714005-1	8.246	10						
	1714005-1	8.246	11						
	1714005-1	8.246	12						
	1714005-1	8.246	13						
	1714005-1	8.246	14						
	1714005-1	8.246	15						
	1714005-1	8.246	16						
	1714005-1	8.246	17						
	1714005-1	8.246	18						
	1714005-1	8.246	19						
	1714005-1	8.246	20						
2/24/17	Daily QC	10	51-54		QC-0224		OK	AL	NA
2/24/17	C170217-16B1	61.1	21	C14	C-0224	C170217-1	OK	AL	
	1702007-21		22						
	1702007-21		23						
	1702007-21		24						
	1702007-21		25						
	1702007-21		26						
	1702007-21		27						
	1702007-21		28						
	1702007-21		29						
	1702007-21		30						

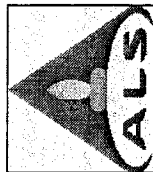
Reviewed by / Date

AL 2/25/17

FORM 700\_Quantulus3.xls (9/22/09)

459192





ALS Global

LSC Run Log

\* Temp.      C Therm. ID 80241569

Instrument ID: Quantulus 1220

Load Date *	Sample ID	CountTime (min.)	Position	Protocol	File Name	Batch ID	Position Check	Initials	Comments
2/24/17	1702058-5	69.1	30	C14	C-0224	C170217-1	AC	AC	NA
	C170217-1C82		31						
	1702058-5DUP		32						
	-11		33						
	-23		34						
	-29		35						
	-42		36						
	-48		37						
	-54		38						
	C170217-1MB		39						
	-165		40						
	-163		41						
2/25/17	Daily QC	10	51-54		QC-0225		AC	AC	NA
2/25/17	C170217-2C81	69.1	1	C14	C-0225	C170217-2	AC	AC	NA
	1702089-5		2						
	-18		3						
	-27		4						
	-42		5						
	1702109-5		6						
	-30		7						
	-36		8						
	-42		9						
	1702133-5		10						
	-11		11						
	C170217-2C82		12						
	1702160-5-17		13						
	5-KDOP-5		14						
	5-N -5DUP		15						
	5-N-17-11		16						
	5-89-17		17						

Reviewed by / Date

AC 2/27/17

FORM 700\_Quantulus3.xls (9/22/09)

459193



**Instrument ID: Quantulus 1220**

# LSC Run Log

[illegible]

Reviewed by / Date

AL 3/2/17

FORM 700 Quantulus3.xls (9/22/09)

459194

# Radiochemistry ICP Worksheet

ALS -- Fort Collins

Prep Batch: PB170221-1

Prep Procedure: Pb210\_Liqs

Reviewed By: rlm *rlm* Review Date: 2/23/2017

## LEAD Recovery Results

### Reference Carrier

LabID	QC Type	Carr Vol	Ref Carr Dil Vol	Ref Carr ICP Alq	Ref Carr ICP Run	Ref Carr ICP Conc
PB170221-1	CAR	1	201	0.5	10	IR170222-2A1 0.2538763

### Samples

Prep Num	LabID	QC Type	Init Samp Alq (ml)	Car Vol (ml)	Samp Dil Vol (ml)	Init ICP Alq (ml)	Init ICP Dil Vol (ml)	Pre-Con Vol (ml)	Post-Con Vol (ml)	Pre-Sep Vol (ml)	Post-Sep Vol (ml)	Fin ICP Alq (ml)	Fin ICP Dil Vol (ml)	Initial ICP Run	Final ICP Run	Init ICP Conc (ug/ml)	Fin ICP Conc (ug/ml)	Init Samp Mass (ug)	Ref Mass (ug)	Flag	Fin Samp Mass (ug)	% Yield	Final Sample Alq
1	1714005-1	SMP	1000	1	7	0.05	10.05	6.95	6	5.05	5.05	0.05	10.05	IR170222-2A1	IR170222-2A1	0.75593	0.772889	888.8019	852.8549		784.5212	88.27%	827.4
1	1714005-2	SMP	1000	1	7	0.05	10.05	6.95	6	5.05	5.05	0.05	10.05	IR170222-2A1	IR170222-2A1	0.76134	0.817126	895.1542	852.8549		829.4234	92.66%	827.4
1	1714005-3	SMP	1000	1	7	0.05	10.05	6.95	6	5.05	5.05	0.05	10.05	IR170222-2A1	IR170222-2A1	0.77781	0.743962	914.518	852.8549		755.1581	82.57%	827.4
1	PB170221-1A	MB	1000	1	6	0.05	10.05	5.95	6	5.05	5.05	0.05	10.05	IR170222-2A1	IR170222-2A1	0.89859	0.781105	904.5103	851.8323		792.861	87.66%	826.4
1	PB170221-1B	MB	1000	1	6	0.05	10.05	5.95	6	5.05	5.05	0.05	10.05	IR170222-2A1	IR170222-2A1	0.99861	0.794982	1005.189	851.8323		806.9464	80.28%	826.4
1	PB170221-1C	MB	1000	1	6	0.05	10.05	5.95	6	5.05	5.05	0.05	10.05	IR170222-2A1	IR170222-2A1	0.89364	0.814381	899.5306	851.8323		826.6373	91.90%	826.4

12170222-2A1

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	50.1201	20.0155	50.2305	50.1242	50.1866	0.5029	0.9995	5.0330	50.1499	1.0077	0.9824	1.0133
CCB	0.0262	0.0111	0.0312	0.0366	0.0183	0.0003	0.0007	0.0124	0.0350	0.0007	0.0067	0.0016
I 1714005-1	0.0007	0.0082	-0.0009	-0.0120	-0.0185	-0.0005	-0.0002	0.0000	0.0337	-0.0002	0.7559	0.0044
I 1714005-2	-0.0131	-0.0054	0.0264	-0.0143	-0.0209	-0.0005	-0.0001	0.0124	-0.0039	-0.0001	0.7613	0.0054
I 1714005-3	-0.0138	-0.0056	0.0269	-0.0223	-0.0213	-0.0005	-0.0003	0.0124	-0.0065	-0.0002	0.7778	0.0041
I PBI7221-1AMB	-0.0124	-0.0049	0.0238	-0.0137	-0.0214	-0.0005	-0.0002	0.0083	-0.0097	-0.0001	0.8986	0.0064
I PBI7221-1BMB	-0.0094	-0.0052	0.0199	-0.0183	-0.0199	-0.0005	-0.0003	0.0083	-0.0104	-0.0002	0.9986	0.0055
I PBI7221-1CMB	-0.0148	-0.0055	0.0191	-0.0137	-0.0220	-0.0005	-0.0001	0.0083	-0.0123	0.0000	0.8936	0.0065
PBI7221-1RC	-0.0077	0.0032	0.0594	-0.0080	-0.0214	-0.0004	0.0003	0.0165	-0.0175	0.0001	0.2539	0.0016
F 1714005-1	22.8858	-0.0043	0.0290	0.0023	0.3928	0.0085	-0.0001	0.0165	-0.0156	0.0010	0.7729	0.0005
F 1714005-2	24.3155	-0.0051	0.0256	-0.0046	0.3462	0.0092	-0.0001	0.0000	-0.0136	0.0011	0.8171	0.0019
F 1714005-3	22.9022	-0.0041	0.0195	0.0000	0.3454	0.0088	0.0001	0.0083	-0.0032	0.0012	0.7440	0.0009
F PBI7221-1AMB	23.9385	0.0132	0.0117	0.0006	0.3706	0.0094	0.0003	0.0041	-0.0182	0.0014	0.7811	0.0011
F PBI7221-1BMB	23.6115	-0.0063	0.0338	-0.0023	0.3488	0.0084	-0.0001	0.0206	-0.0110	0.0009	0.7950	0.0012
F PBI7221-1CMB	24.8347	-0.0040	0.0403	0.0086	0.4573	0.0093	0.0002	0.0206	-0.0175	0.0014	0.8144	0.0032
CCV	50.0054	19.9418	50.0576	49.9788	50.1478	0.5014	1.0000	5.0454	50.0955	1.0034	0.9808	1.0029
CCB	0.0312	0.0125	0.0381	0.0361	0.0196	0.0003	0.0006	0.0083	0.0266	0.0007	0.0077	0.0012

22

# Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: PB170221-1

Prep Procedure: Pb210\_LiqS

Analytical QASS / NCR? Y N

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	Cnt 1 File/Inst	Cnt 1 Rack-Pos	Cnt 1 Pos Chk By	Cnt 2 File/Inst	Cnt 2 Rack-Pos	Cnt 2 Pos Chk By	Cnt 3 File/Inst	Cnt 3 Rack-Pos	Cnt 3 Pos Chk By	Notes
1	1714005-1	SMP	1000	827.38	ml	pCi/l	1714005-1	8	1714005-1	1714005-1	8	1714005-1	1714005-1	8	1714005-1	1714005-1
1	1714005-2	SMP	1000	827.38	ml	pCi/l	1714005-2	9	1714005-2	1714005-2	9	1714005-2	1714005-2	9	1714005-2	1714005-2
1	1714005-3	SMP	1000	827.38	ml	pCi/l	1714005-3	10	1714005-3	1714005-3	10	1714005-3	1714005-3	10	1714005-3	1714005-3
1	PB170221-1A	MB	1000	826.39	ml	pCi/l	PB170221-1A	11	PB170221-1A	PB170221-1A	11	PB170221-1A	PB170221-1A	11	PB170221-1A	PB170221-1A
1	PB170221-1B	MB	1000	826.39	ml	pCi/l	PB170221-1B	12	PB170221-1B	PB170221-1B	12	PB170221-1B	PB170221-1B	12	PB170221-1B	PB170221-1B
1	PB170221-1C	MB	1000	826.39	ml	pCi/l	PB170221-1C	13	PB170221-1C	PB170221-1C	13	PB170221-1C	PB170221-1C	13	PB170221-1C	PB170221-1C

## Tracer/Carrier Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
T1	LEAD	418231		1,001.811	pCi/ml	NA	1	ml	RS-033

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Pb-210	901.3610.50		1,888.885	DPM/ml	02/21/17	1	ml	RS-033
S1	Pb-210	901.3610.50		1,888.885	DPM/ml	02/21/17	1	ml	RS-033

## Sample Barcodes

1714005-1 PB170221-1PS1	1714005-2 PB170221-1PS2	1714005-3 PB170221-1PS3
PB170221-1AMB PB170221-1PS4	PB170221-1BMB PB170221-1PS5	PB170221-1CMB PB170221-1PS6
PB170221-1CAR PB170221-1PS7		

## Reporting Units

LabID	InstGrpName	RptUnits
1714005-1	Pb210L	pCi/l
1714005-2	Pb210L	pCi/l
1714005-3	Pb210L	pCi/l

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: PB170221-1

Prep Procedure: Pb210\_LiqS

Reviewed By: rlm Review Date: 2/23/2017

Non-Routine Pre-Treatment? Y ☒ Batch: MA Re-Prep? Y ☒ Prep QASS / NCR? Y ☒ 1/14

Prep SOP: PAI 726 Rev: 9

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 2/21/2017

Prep Dept: RS

Balance: na

Balance: na

Cocktail: UGLLT

Cocktail Pipet: T-004

Aliquot Pipet: RS-033

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Ingrowth Date/Time	Standards	Prep Notes
1	1	1714005-1	SMP	MA	1000	827.3809	Unfiltered	02/22/17 09:20	T1, S1	
2	1	1714005-2	SMP		1000	827.3809	Unfiltered	02/22/17 09:20	T1, S1	
3	1	1714005-3	SMP		1000	827.3809	Unfiltered	02/22/17 09:20	T1, S1	
4	1	PB170221-1A	MB		1000	826.3889	Unfiltered	02/22/17 09:20	T1	
5	1	PB170221-1B	MB		1000	826.3889	Unfiltered	02/22/17 09:20	T1	
6	1	PB170221-1C	MB		1000	826.3889	Unfiltered	02/22/17 09:20	T1	

## Comments

Pb21- single point calibration. Samples spiked (calibration spike) into 5ml 8N HNO3. A 0.05mL initial ICP was taken and samples loaded onto Sr spec column to remove Bi-210.

Spiked By: Rebecca L. Merola Date: 2/22/2017

Witnessed By: Hunter C. Jordan Date: 2/22/2017

Tracer/Carrier Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
T1	LEAD	418231		1,001.811	pCi/ml	RS-033

Spike Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
S1	Pb-210	901.3610.50		1,888.885	DPM/ml	RS-033
S1	Pb-210	901.3610.50		1,888.885	DPM/ml	RS-033

## Reagent Solution IDs\*

47171749 97-15251 H04156 J26A03 K37027

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

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: PB170221-1

Prep Procedure: Pb210\_LiqS

**Prep Batch Not Validated!!!**

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

Non-Routine Pre-Treatment? Y / N Batch: see comments Re-Prep? Y / N Batch: \_\_\_\_\_ Prep QASS / NCR? Y / N \_\_\_\_\_

Prep SOP: PAI 726 Rev: 9

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 2/21/2017

Prep Dept: RS

Balance:

Balance:

Cocktail:

Cocktail Pipet:

Aliquot Pipet:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Ingrowth Date/Time	Standards	Prep Notes
1	1	1714005-1	SMP		1000	827.3809	Unfiltered	2/22/17	T1,S1	
2	1	1714005-2	SMP		1000	827.3809	Unfiltered	0920	T1,S1	
3	1	1714005-3	SMP		1000	827.3809	Unfiltered		T1,S1	
4	1	PB170221-1A	MB		1000	826.3889	Unfiltered		T1	
5	1	PB170221-1B	MB		1000	826.3889	Unfiltered		T1	
6	1	PB170221-1C	MB		1000	826.3889	Unfiltered		T1	

Comments

Pb21- single point calibration. Samples spiked (calibration spike) into 5ml 8N HNO3. A 0.05mL initial ICP was taken and samples loaded onto Sr spec column to remove Bi-210.

Spiked By: Rebecca L. Merola Date: 2/22/17

Witnessed By: RLC Date: 2/22/17

## Tracer/Carrier Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
T1	LEAD	418231	8/22/17	1,001.811	pCi/ml	NA	1	ml	RS-033

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Pb-210	901.3610.50	10/21/17	1,888.885	DPM/ml	02/21/17	1	ml	RS-033
S1	Pb-210	901.3610.50	8/22/17	1,888.885	DPM/ml	02/21/17	1	ml	RS-033

## Reagent Solution IDs\*

47171749	97-15251	H04156	J26A03	K37027
----------	----------	--------	--------	--------

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

## Sample Condition Form (Liquid)

Analyst: [Signature]

Analysis Date: 2/21/17

Method: Prep

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

[illegible]



# Radiochemistry ICP Worksheet

ALS -- Fort Collins

Prep Batch: PB170227-1

Prep Procedure: Pb210\_LiqS

Reviewed By: rim

Review Date: 3/1/2017

## LEAD Recovery Results

### Reference Carrier

LabID	QC Type	Car Vol	Ref Carr Dil Vol	Ref Carr ICP Alq	Ref Carr ICP Run	Ref Carr ICP Conc
PB170227-1	CAR	1	50	1	5	IR170301-2A1 3.906219

### Samples

Prep Num	LabID	QC Type	Init Samp Alq (ml)	Car Vol (ml)	Samp Dil Vol (ml)	Init ICP Alq (ml)	Init ICP Dil Vol (ml)	Pre-Con Vol (ml)	Post-Con Vol (ml)	Pre-Sep Vol (ml)	Post-Sep Vol (ml)	Fin ICP Alq (ml)	Fin ICP Dil Vol (ml)	Initial ICP Run	Final ICP Run	Init ICP Conc (ug/ml)	Fin ICP Conc (ug/ml)	Init Samp Mass (ug)	Ref Mass (ug)	Flag	Fin Samp Mass (ug)	% Yield	Final Sample Alq
1	1714006-1	SMP	1000	1	1002	1	5	1001	6	5.1	5.1	0.1	10	IR170301-2A1	IR170301-2A1	0.19743	1.547313	839.9287	829.243		789.1296	93.95%	832.5
1	1714006-2	SMP	1000	1	1002	1	5	1001	6	5.1	5.1	0.1	10	IR170301-2A1	IR170301-2A1	0.19417	1.554877	826.058	829.243	LB	792.9871	95.63%	832.5
1	1714006-3	SMP	1000	1	1002	1	5	1001	6	5.1	5.1	0.1	10	IR170301-2A1	IR170301-2A1	0.19969	1.563869	849.5192	829.243		797.5732	93.89%	832.5
1	PB170227-1A	MB	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	IR170301-2A1	IR170301-2A1	0.18835	1.554279	800.5052	829.2422	LB	792.6823	95.59%	832.5
1	PB170227-1B	MB	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	IR170301-2A1	IR170301-2A1	0.19338	1.540615	821.8544	829.2422	LB	785.7136	94.75%	832.5
1	PB170227-1C	MB	1000	1	1001	1	5	1000	6	5.1	5.1	0.1	10	IR170301-2A1	IR170301-2A1	0.17417	1.568767	740.2247	829.2422	LB	800.0712	96.48%	832.5

12170301-2A1

Sample Id1	Ca	Fe	K	Mg	Na	Sr	Mn	S	Al	Ba	Pb	Ni
CCV	49.8731	19.9369	50.8715	50.2686	50.8990	0.5035	0.9963	4.9701	50.8612	1.0079	0.9901	1.0033
CCB	0.0219	0.0093	0.0606	0.0201	0.0256	0.0005	0.0002	0.0075	0.0244	0.0005	0.0011	0.0006
I 1714006-1	-0.0172	-0.0072	0.0441	-0.0288	-0.0083	-0.0001	-0.0006	0.0000	-0.0144	-0.0002	0.1974	0.0001
I 1714006-2	0.0125	0.0775	0.0504	-0.0359	-0.0046	-0.0001	0.0002	0.0112	-0.0106	-0.0002	0.1942	-0.0008
I 1714006-3	-0.0231	0.0157	0.0259	-0.0375	-0.0102	-0.0002	-0.0004	0.0075	-0.0069	-0.0003	0.1997	-0.0013
I PB170227-1AMB	-0.0209	-0.0119	0.0246	-0.0391	-0.0100	-0.0002	-0.0006	0.0075	-0.0119	-0.0002	0.1884	-0.0006
I PB170227-1BMB	-0.0203	-0.0077	0.0305	-0.0381	-0.0099	-0.0002	-0.0004	0.0224	0.0025	-0.0002	0.1934	-0.0008
I PB170227-1DMB	0.8775	0.0035	0.0407	-0.0272	0.0070	0.0002	0.0002	0.0187	0.0125	0.0003	0.1742	0.0011
PB170227-1RC	-0.0109	0.0658	0.0356	-0.0381	-0.0019	-0.0001	0.0003	0.0149	-0.0069	0.0000	3.9062	0.0007
F 1714006-1	46.5057	-0.0034	0.0059	-0.0125	0.9647	0.0186	0.4110	0.0112	0.0031	0.0025	1.5473	0.0014
F 1714006-2	46.5735	-0.0028	0.0034	-0.0152	0.9764	0.0178	0.1371	0.0187	0.0063	0.0024	1.5549	0.0007
F 1714006-3	46.5851	0.0025	0.0030	-0.0163	0.6196	0.0177	0.2764	0.0000	0.0006	0.0022	1.5639	0.0019
F PB170227-1AMB	46.4473	-0.0038	0.0229	-0.0158	0.6170	0.0180	0.1108	0.0075	-0.0006	0.0024	1.5543	0.0004
F PB170227-1BMB	46.5745	-0.0055	0.0466	-0.0098	0.9798	0.0179	0.0303	-0.0037	-0.0138	0.0022	1.5406	0.0007
F PB170227-1DMB	47.0991	-0.0046	0.0365	-0.0163	2.4618	0.0170	0.0224	0.0037	-0.0019	0.0019	1.5688	0.0017
CCV	49.5181	19.7109	49.9780	49.5711	50.1230	0.4953	0.9843	4.9701	49.7590	0.9916	0.9830	0.9961
CCB	0.0312	0.0125	0.0644	0.0261	0.0336	0.0006	0.0004	0.0187	0.0319	0.0005	0.0032	0.0006

AL

# Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: PB170227-1

Prep Procedure: Pb210\_LiqS ILV-ICD c.m.

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

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Report Units	Cnt 1 File/Inst	Cnt 1 Rack-Pos	Cnt 1 Pos Chk By	Cnt 2 File/Inst	Cnt 2 Rack-Pos	Cnt 2 Pos Chk By	Cnt 3 File/Inst	Cnt 3 Rack-Pos	Cnt 3 Pos Chk By	Notes
1	1714006-1	SMP	1000	832.50	ml	pCi/l	PB-0301	2	<i>NA</i>							
1	1714006-2	SMP	1000	832.50	ml	pCi/l		3								
1	1714006-3	SMP	1000	832.50	ml	pCi/l		4								
1	PB170227-1A	MB	1000	832.50	ml	pCi/l		6								
1	PB170227-1B	MB	1000	832.50	ml	pCi/l		7								
1	PB170227-1CB	MB	1000	1000	ml	pCi/l		1								
1	PB170227-1CB	MB	1000	1000	ml	pCi/l		5								
1	PB170227-1CB	MB	1000	1000	ml	pCi/l		9								
1	PB170227-1D	MB	1000	832.50	ml	pCi/l		8								

*NA 3/2/17*

## Tracer/Carrier Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
T1	LEAD	418231		1,001.811	pCi/ml	NA	1	ml	RS-033

## Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Pb-210	899.4095.66		95.764	DPM/ml	02/27/17	1	ml	RS-033
S1	Po-210	899.4095.66		95.764	DPM/ml	02/27/17	1	ml	RS-033

## Sample Barcodes

1714006-1 PB170227-1PS1		1714006-2 PB170227-1PS2		1714006-3 PB170227-1PS3	
PB170227-1AMB PB170227-1PS4		PB170227-1BMB PB170227-1PS5		PB170227-1CB1MB PB170227-1PS6	
PB170227-1CB2MB PB170227-1PS7		PB170227-1CB3MB PB170227-1PS8		PB170227-1DMB PB170227-1PS9	
PB170227-1ICAR PB170227-1PS10					

## Reporting Units

LabID	TstGrpName	RptUnits
1714006-1	Pb210L	pCi/l
1714006-2	Pb210L	pCi/l
1714006-3	Pb210L	pCi/l

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: PB170227-1

Prep Procedure: Pb210\_LiqS

Reviewed By: rlm Review Date: 3/1/2017

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

Prep QASS / NCR? Y / NA

Prep SOP: PAI 726 Rev: 9

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola RLM

Balance: NA

Cocktail: UGLLT

Cocktail Pipet: T-004

Aliquot Pipet:

Prep Date: 2/27/2017

Prep Dept: RS

Sample Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Ingrowth Date/Time	Standards	Prep Notes
1	1	1714006-1	SMP	<u>NA</u>	1000	832.5017	Unfiltered	03/01/17 08:40	T1, S1	
2	1	1714006-2	SMP		1000	832.5017	Unfiltered	03/01/17 08:40	T1, S1	
3	1	1714006-3	SMP		1000	832.5017	Unfiltered	03/01/17 08:40	T1, S1	
4	1	PB170227-1A	MB		1000	832.5009	Unfiltered	03/01/17 08:40	T1	
5	1	PB170227-1B	MB		1000	832.5009	Unfiltered	03/01/17 08:40	T1	
6	1	PB170227-1CB1	MB		1000	1000	Unfiltered	03/01/17 08:40		
7	1	PB170227-1CB2	MB		1000	1000	Unfiltered	03/01/17 08:40		
8	1	PB170227-1CB3	MB		1000	1000	Unfiltered	03/01/17 08:40		
9	1	PB170227-1C	MB		1000	832.5009	Unfiltered	03/01/17 08:40	T1	

## Comments

Pb210 ICVs and ICBs, MBD was changed to MBC due to importing issues.

Spiked By: Rebecca L. Merola Date: 2/27/2017

Witnessed By: Macey S. Hall Date: 2/27/2017

Tracer/Carrier Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
T1	LEAD	418231		1,001.811	pCi/ml	NA
						1 ml RS-033

Spike Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
S1	Pb-210	899.4095.66		95.764	DPM/ml	02/27/17 1 ml RS-033
S1	Pb-210	899.4095.66		95.764	DPM/ml	02/27/17 1 ml RS-033

## Reagent Solution IDs\*

47171749 97-15251 H04156 J26A03 K37027

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

# Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: PB170227-1

Prep Procedure: Pb210\_LiqS

**Prep Batch Not Validated!!!**

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

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

Prep SOP: PAI 726 Rev: 9

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 2/27/2017

Prep Dept: RS

Balance: NA

Balance: NA

Cocktail: UGLLT

Cocktail Pipet: T-004

Aliquot Pipet:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Aliq ml	Fin Aliq ml	Prep Basis	Ingrowth Date/Time	Standards	Prep Notes
1	1	1714006-1	SMP		1000	832.5017	Unfiltered	8/27/17 0840	T1, S1	
2	1	1714006-2	SMP		1000	832.5017	Unfiltered		T1, S1	
3	1	1714006-3	SMP		1000	832.5017	Unfiltered		T1, S1	
4	1	PB170227-1A	MB		1000	832.5009	Unfiltered		T1	
5	1	PB170227-1B	MB		1000	832.5009	Unfiltered		T1	
6	1	PB170227-1CB1	MB		1000	1000	Unfiltered			
7	1	PB170227-1CB2	MB		1000	1000	Unfiltered			
8	1	PB170227-1CB3	MB		1000	1000	Unfiltered			
9	1	PB170227-1D	MB		1000	832.5009	Unfiltered		T1	

Comments

Pb210 ICVs and ICBs

Spiked By: Rebecca L. Merola Date: 2/27/17

Witnessed By: MSH Date: 2/27/17

Tracer/Carrier Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
T1	LEAD	418231	8/27/17	1,001.811	pCi/ml	NA
						RS-033

Spike Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
S1	Pb-210	899.4095.66	10/21/17	95.764	DPM/ml	RS-033
S1	Pb-210	899.4095.66		95.764	DPM/ml	RS-033

Reagent Solution IDs\*

47171749 97-15251 H04156 J26A03 K37027

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

Sample Condition Form (Liquid)				
Analyst: <i>DN</i>				
Analysis Date: <i>2/27/17</i>			Method: <i>Pcep</i>	
		Sample Condition (Visual Appearance of Analysis Aliquot at Time of Prep)		
Work Order	Sample ID	pH	Color	Remarks
<i>1714006</i>	<i>1</i>	<i>6.0</i>	<i>clear</i>	<i>DI water</i>
<i>↓</i>	<i>2</i>	<i>↓</i>	<i>↓</i>	<i>↓</i>
<i>↓</i>	<i>3</i>	<i>↓</i>	<i>↓</i>	<i>↓</i>
<i>DN</i>				
<i>3/1/17</i>				
<i>2/2</i>				
<i>3/1/17</i>				

# Q1220 Pb-210 Background Determination

Interim control limits are established from the initial calibration for the analysis and geometry of interest **OR** from the initial batch calibration blank data set acquired after the instrument re-calibration. Limits are  $\pm 3$  standard deviations (counting unc.) from the initial calibration blank data. Once enough historical data is acquired, new historical limits are set as follows: Control limits for reagent blanks are established from 30 individual historical data points (10 batches). Limits are  $\pm 3$  standard deviations from 30 individual historical data points. Individual reagent blanks and the average of reagent blanks from each batch are in control if the Count Rate (CPM) is within the established control limits.

## CURRENTLY UNDER HISTORICAL LIMITS

Updated on 05/30/13 NES							Individual Reagent Blanks						Average of Reagent Blanks		
COUNT DATE	#	Sample ID	Count Duration (m)	Count Rate (CPM)	Total Cts.	Mean	LCL	UCL	Pass ?	LCL	UCL	Pass ?			
3/1/2017	613	PB170227-1CB1	59.3	2.8	166.04		2.0410	4.2714	PASS						
3/1/2017	614	PB170227-1CB2	59.3	3	177.9		2.0410	4.2714	PASS						
3/2/2017	615	PB170227-1CB3	59.3	3.35	198.655	3.050	2.0410	4.2714	PASS	2.0410	4.2714	PASS	2.0410	4.2714	PASS

3/2/17

## Pb-210 "Window 2" Control Limits (Q1220)

The background count rate is determined from the average of the reagent blanks for the batch.  
Window 2 control limits are established using the average count rate from the three reagent blanks associated with each prep batch +/- 3X the estimated poisson uncertainty.

Updated on 01/11/2010. MH

COUNT DATE	OBS #	Sample ID	Count Duration (min.)	Average count Duration (min.)	Count Rate (CPM)	Batch Average Reagent Blank	Lower Control Limit	Upper Control Limit
3/1/2017	613	PB170227-1CB1	59.3	59.3	0.57	0.646666667	0.333	0.960
3/1/2017	614	PB170227-1CB2	59.3		0.65			
3/2/2017	615	PB170227-1CB3	59.3		0.72			
		177.7 MIN CTS	177.7				0.466	0.828
		29.6 MIN CTS	29.6				0.203	1.090

*M*  
3/2/17



Daily IPCs consist of the following standards;

NEW STANDARDS REC'D 05/20/16 LC

AL 3/2/17

Prepare a Calibration Source dilution of  
RSO # 901.

Density of 1M HNO<sub>3</sub> lot # H24026 + 085045  
Mass of 100 ml Volumetric flask 66.4330g  
Mass of flask + Acid 169.3090g  
Net Mass 102.874g  
 $\rho = 1.02874 \text{ g/ml}$

Mass of RSO 901 Transferred

Mass of Open, full Ampule + Beaker 37.7424g  
Mass of Empty Ampule + Beaker 32.7255g  
Net Mass transferred 5.0169g

Dilute to Final Mass

Mass of Std. Diluent + 1000 ml Xylene 1137.5g  
Mass of Xylene (empty) 74.8127g  
Net Mass of New dilution 1062.6873g

Final Activity

$$9.037 \text{ KBq} \left( \frac{10^3 \text{ Bq}}{1 \text{ KBq}} \right) \left( \frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left( \frac{5.0169 \text{ g}}{1062.6873 \text{ g}} \right) \left( \frac{1.02874 \text{ g/ml}}{1 \text{ g}} \right) = 2633.37 \text{ dpm/ml}$$

12/23/09

Std ID: 901.3610.50

Description: Pb-210

Expiration: 10/13/2011

Activity: 2633.37 dpm/mL

2s Uncertainty: 63.20 dpm/mL

Ref. Date: 6/15/2008

Ref Time: N/A

Prep Date: 12/23/2009 Prep by: JD

Matrix/Comp. 1M HNO<sub>3</sub>

Half Life (y): 2.22E+01

Reverification Log		
Analysis Date	Initials	Expiration Date
10/11/2011	RG	10/11/2012
10/17/2012	MC	10/17/2013
10/23/2013	JP	10/23/2014
10/27/2014	JP	10/27/2015
10/26/2015	JP	10/26/2016
10/21/2016	JP	10/21/2017

Continued on Page

Read and Understood By



Signed

12/23/09

Date



Signed

11/1/10

Date



# National Institute of Standards & Technology Certificate

RSO#  
901

REC  
11-2-2009

## Standard Reference Material 4337 Lead-210 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive lead-210 in a suitably stable and homogeneous matrix. It is intended primarily for the calibration of instruments that are used to measure radioactivity and for the monitoring of radiochemical procedures. The solution, whose composition is specified in Table 1, is contained in a flame-sealed, 5 mL, NIST, borosilicate-glass ampoule (see Note 1)\*.

The certified lead-210 massic activity value, at a Reference Time of 1200 EST, 15 June 2006, is:

$$(9.037 \pm 0.22) \text{ kBq} \cdot \text{g}^{-1}$$

Additional physical, chemical, and radiological properties for the SRM, as well as details on the standardization method, are given in Table 1. Uncertainty intervals for certified quantities are expanded ( $k=2$ ) uncertainties calculated according to the ISO and NIST Guidelines (see Note 2). Table 2 contains a specification of the components that comprise the uncertainty analyses.

The certification of this SRM, within the measurement uncertainties specified, is valid for at least five (5) years after receipt. The solution matrix, in an unopened ampoule, is believed to be indefinitely homogeneous and stable, within its half-life-dependent, useful lifetime. NIST will monitor this material and will report any substantive changes in certification to the purchaser. Should any of the certified values change, purchasers of this SRM will be notified of the change by NIST.

This SRM may represent a radiological hazard and a chemical hazard. Consult the Material Safety Data Sheet (MSDS), enclosed with the SRM shipment, for details (see Note 1).

This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, Dr. M.P. Unterwiesing, Acting Group Leader. The overall technical direction and physical measurements leading to certification were provided by Drs. R. Collé, and L. Laureano-Pérez of the Radioactivity Group with production assistance by D.B. Golas and O. Palabrica, Research Associates of the Nuclear Energy Institute and with measurement assistance by Drs. L. Outola, L. Pibida and R. Fitzgerald of the Radioactivity Group. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program.

Lisa R. Karam, Deputy Chief  
Ionizing Radiation Division

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

Gaithersburg, Maryland 20899  
November 2006

SRM 4337 page 1 of 4

\*Notes and references are in page 4.

Table 2. Uncertainty evaluation for the massic activity for SRM 4337

	Uncertainty component	Assessment Type <sup>†</sup>	Relative standard uncertainty contribution on massic activity of <sup>210</sup> Pb (%)
1	LS within measurement precision; typical standard deviation of the mean for 7 to 11 repeated measurements; values ranged from 0.008 % to 0.056 %	A	0.03
2	LS measurement precision; reproducibility in massic activity for 7 to 11 samples in two measurement series with three counters on two to three measurement occasions; standard deviation of the mean for $\nu = 443$ degrees freedom	A	0.067
3	Background LS measurement variability; wholly embodied in components 1 & 2	A	—
4	Scintillator dependencies; wholly embodied in components 1 & 2	A	—
5	LS cocktail stability and composition mismatch effect	B	0.35
6	Gravimetric (mass) measurements for LS sources and for <sup>3</sup> H standard dilution	B	0.07
7	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.06
8	Decay corrections for <sup>210</sup> Pb	B	0.002
9	Decay corrections for <sup>3</sup> H	B	0.0005
10	Limit for photon-emitting impurities	B	0.02
11	Beta endpoint energy, $E_{\beta(\max)}$ for <sup>210</sup> Pb for an uncertainty of 0.5 keV	B	0.033
12	Beta decay branching ratios for <sup>210</sup> Pb for an uncertainty of 0.03	B	0.39
13	$E_{\beta(\max)}$ for <sup>210</sup> Bi for an uncertainty of 1.5 keV	B	0.001
14	Computed $\beta$ detection efficiency for <sup>210</sup> Pb	B	1.1
15	Computed $\beta$ detection efficiency for <sup>210</sup> Bi	B	0.04
16	Assumed $\alpha$ detection efficiency for <sup>210</sup> Po, including extrapolation to zero energy	B	0.05
<b>Relative combined standard uncertainty</b>			<b>1.2</b>
<b>Relative expanded uncertainty (<math>k = 2</math>)</b>			<b>2.4</b>

<sup>†</sup> = (A) denotes evaluation by statistical methods; (B) denotes evaluation by other methods.

Table 1. Properties of SRM 4337

## Certified values

Radionuclide	Lead-210
Reference time	1200 EST, 15 June 2006
Massic activity of the solution	9.037 kBq·g <sup>-1</sup>
Relative expanded uncertainty ( <i>k</i> = 2)	2.4 % (see Note 2)*

## Uncertified information

Source description	Liquid in flame-sealed, 5 mL NIST borosilicate ampoule (see Note 1)
Solution composition	1.0 mol·L <sup>-1</sup> HNO <sub>3</sub> with 21 µg Bi <sup>+3</sup> and 11 µg Pb <sup>+2</sup> per gram of solution
Solution density	(1.028 ± 0.002) g·mL <sup>-1</sup> at 20.0 °C <sup>†</sup> (see Note 3)
Solution mass	(5.133 ± 0.002) g (see Note 3)
Photon-emitting impurities	None detected (see Note 4)
Half-lives used	<sup>210</sup> Pb : (22.20 ± 0.22) a <sup>†</sup> <sup>3</sup> H : (12.32 ± 0.02) a <sup>†</sup>
Nuclear data used in CN2003 computations (beta-particle maximum energies; branching ratios; transitions) [1]	<sup>3</sup> H : (18.394 ± 0.008) keV <sup>†</sup> ; 1, allowed <sup>210</sup> Pb : (63.5 ± 0.5) keV <sup>†</sup> ; (0.16 ± 0.03); non-unique first forbidden (17.0 ± 0.5) keV <sup>†</sup> ; (0.84 ± 0.03); non-unique first forbidden <sup>210</sup> Bi : (1162.1 ± 1.5) keV <sup>†</sup> ; 1; non-unique first forbidden
Calibration method (and instruments)	The certified massic activity for <sup>210</sup> Pb in radioactive equilibrium with <sup>210</sup> Bi and <sup>210</sup> Po was obtained by 4π $\alpha\beta$ liquid scintillation (LS) spectrometry with three commercial LS counters. The LS detection efficiency was calculated using the CN2003 code [2] for the CIEMAT/NIST method with composition matched LS cocktails of a <sup>3</sup> H standard as the efficiency detection monitor. Confirmatory measurements were also performed by high-resolution HPGe gamma-ray spectrometry, by 2π $\alpha$ spectrometry of separated <sup>210</sup> Po with a Si surface barrier detector, and by 4π $\beta$ (LS) - $\gamma$ (NaI) anticoincidence counting.

<sup>†</sup> See Note 5

## NOTES

Note 1. Refer to <http://physics.nist.gov/Divisions/Div846/srm.html> for the standardized ampoule dimensions and for assistance and instructions on how to properly open an ampoule. Information on additional storage and handling requirements is also included in the website.

Note 2. The uncertainties on certified values are expanded uncertainties,  $U = k u_c$ . The quantity  $u_c$  is the combined standard uncertainty calculated according to the ISO and NIST Guides (see references [3] and [4]). The combined standard uncertainty is multiplied by a coverage factor of  $k = 2$  and was chosen to obtain an approximate 95 % level of confidence.

Note 3. The stated uncertainty is two times the standard uncertainty. See reference [4].

Note 4. The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rates, on 27 December 2005, were:

1.7 s<sup>-1</sup> g<sup>-1</sup> for 20 keV < E < 60 keV

0.3 s<sup>-1</sup> g<sup>-1</sup> for 60 keV < E < 1800 keV

Note 5. The stated uncertainty is the standard uncertainty. See reference [4].

## REFERENCES

- [1] Evaluated Nuclear Structure Data File (ENSDF), online database, National Nuclear Data Center, Brookhaven Laboratory (Upton, NY), October 2006. Refer to <http://www.nndc.bnl.gov/ensdf/>
- [2] E. Gunther, Physikalisch-Technische Bundesanstalt (Braunschweig, Germany), private communication, 2003.
- [3] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993 (corrected and reprinted, 1995). Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
- [4] B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407, U.S.A.

Pb-210 899.4095.66 working standard

Prepare a working dilution of 899.3610.42

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

Mass of 100mL vol. flask:

56.4468g

Balance # 12

Mass of flask &amp; 100mL acid:

159.4521g

Balance# 12

Net Mass:

103.0053g

Density:

1.0301 g/mL

2. Mass of 899.3610.42 transferred:

Mass of open empty nalgene:

74.5139g

Balance# 12

Mass of nalgene &amp; standard:

77.1985g

Balance# 12

Net mass of standard transferred:

2.6846g

Balance# NA

3. Dilute to final volume:

Mass of nalgene, standard, &amp; diluent:

1147.7g

Balance# 26

Mass of empty nalgene (from above):

74.5139g

Balance# 12

Net mass of new dilution:

1073.1861g

Balance# NA

4. Final activity calculation:

$$46,996.4 \text{ dpm/g} (1.0301 \text{ g/mL}) (2.6846 \text{ g}) = 121.10 \text{ dpm/mL}$$

$$(1073.1861 \text{ g})$$

Std ID: 899.4095.66

Description: Pb-210

Expiration: 10/26/2016

Activity: 121.10 dpm/mL

2s Uncertainty: 3.39 dpm/mL

Ref. Date: 8/10/2009

Ref Time: N/A

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

Matrix/Comp. 1 M HNO<sub>3</sub>

Half Life (y): 2.22E+01

## Reverification Log

Analysis Date	Initials	Expiration Date
10/21/2016	JP	10/21/2017

Continued on Page

Signed

Date

Read and Understood By

Signed

Date



Eckert & Ziegler  
Analytics

R50#  
899

rec  
8-14-09

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

# CERTIFICATE OF CALIBRATION

## Standard Radionuclide Source

80328-307

Pb-210 8 mL Liquid in Flame Sealed Vial

Customer: ALS Laboratory Group / Fort Collins  
P.O. No.: 73625 07-24-09, Item 1

This standard radionuclide source was prepared gravimetrically from a calibrated master solution. The master solution was calibrated by liquid scintillation counting. Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below. 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*, %			Reference Date (12:00 PM EST)
			u <sub>A</sub>	u <sub>B</sub>	U	
Pb-210	8145.1	4.078E+04	0.1	1.4	2.8	08/10/2009

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

### Comments:

Impurities: gamma-impurities <0.1%, alpha-impurities (other than decay products) <0.01%. 52.06357 grams 1M HNO<sub>3</sub> solution, carrier free.

Source Prepared by: N. Kasate  
N. E. Kasate, Radiochemist

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

Date: 8-13-09



Corporate Office

24937 Avenue Tibbitts Valencia, California 91355

Laboratory

1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318



30  
PROJECT 708

500 12/23/09

901.3610.50

Pb-210

Notebook No. 3610

Continued From Page 4/4

Prepare a Calibration Source dilution of  
RSD # 901.

Density of 1 M HNO<sub>3</sub> 1.02874 g/mL  
Mass of 100 ml Volumetric flask 66.4330 g  
Mass of flask + HNO<sub>3</sub> 169.3090 g  
Net Mass 102.874 g  
 $\rho = 1.02874 \text{ g/mL}$

Mass of RSD 901 Transferred

Mass of Open, full Ampule + Beaker 37.7424 g  
Mass of Empty Ampule + Beaker 32.7255 g  
Net Mass transferred 5.0169 g

Dilute to Final Mass

Mass of Std, Diluent + 1000 ml Hexane 1137.5 g  
Mass of Hexane (Empty) 74.8123 g  
Net Mass of the dilution 1062.6873 g

Final Activity

$9.037 \text{ kBq} (10^3 \text{ Bq}) (60 \text{ dpm}) (5.0169 \text{ g}) (1.02874 \text{ g/mL}) = 2633.37 \text{ dpm/mL}$   
 $9.037 \text{ kBq} (10^3 \text{ Bq}) (1 \text{ Bq}) (5.133 \text{ g}) (1062.6873 \text{ g}) = 2633.37 \text{ dpm/mL}$

Std ID: 901.3610.50

Description: Pb-210

Expiration: 10/13/2011

Activity: 2633.37 dpm/mL

2s Uncertainty: 63.20 dpm/mL

Ref. Date: 6/15/2008

Ref Time: N/A

Prep Date: 12/23/2009 Prep by: JD

Matrix/Comp. 1M HNO<sub>3</sub>

Half Life (y): 2.22E+01

Reverification Log

Analysis Date	Initials	Expiration Date
10/11/2011	RG	10/11/2012
10/17/2012	MC	10/17/2013
10/23/2013	JP	10/23/2014
10/27/2014	JP	10/27/2015
10/26/2015	JP	10/26/2016
10/21/2016	JP	10/21/2017

Continued on Page

Read and Understood By



Signed

12/23/09

Date



Signed

1/16/10

Date



# National Institute of Standards & Technology

## Certificate

RSO#  
901

REC  
11-2-2009

### Standard Reference Material 4337 Lead-210 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive lead-210 in a suitably stable and homogeneous matrix. It is intended primarily for the calibration of instruments that are used to measure radioactivity and for the monitoring of radiochemical procedures. The solution, whose composition is specified in Table 1, is contained in a flame-sealed, 5 mL, NIST, borosilicate-glass ampoule (see Note 1)\*.

The certified lead-210 massic activity value, at a Reference Time of 1200 EST, 15 June 2006, is:

$$(9.037 \pm 0.22) \text{ kBq} \cdot \text{g}^{-1}$$

Additional physical, chemical, and radiological properties for the SRM, as well as details on the standardization method, are given in Table 1. Uncertainty intervals for certified quantities are expanded ( $k=2$ ) uncertainties calculated according to the ISO and NIST Guidelines (see Note 2). Table 2 contains a specification of the components that comprise the uncertainty analyses.

The certification of this SRM, within the measurement uncertainties specified, is valid for at least five (5) years after receipt. The solution matrix, in an unopened ampoule, is believed to be indefinitely homogeneous and stable, within its half-life-dependent, useful lifetime. NIST will monitor this material and will report any substantive changes in certification to the purchaser. Should any of the certified values change, purchasers of this SRM will be notified of the change by NIST.

This SRM may represent a radiological hazard and a chemical hazard. Consult the Material Safety Data Sheet (MSDS), enclosed with the SRM shipment, for details (see Note 1).

This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, Dr. M.P. Unterwieser, Acting Group Leader. The overall technical direction and physical measurements leading to certification were provided by Drs. R. Collé, and L. Laureano-Pérez of the Radioactivity Group with production assistance by D.B. Golas and O. Palabrica, Research Associates of the Nuclear Energy Institute and with measurement assistance by Drs. I. Outola, L. Pibida and R. Fitzgerald of the Radioactivity Group. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program.

Lisa R. Karam, Deputy Chief  
Ionizing Radiation Division

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

Gaithersburg, Maryland 20899  
November 2006

SRM 4337 page 1 of 4

\*Notes and references are in page 4

Table 2. Uncertainty evaluation for the massic activity for SRM 4337

Uncertainty component		Assessment Type <sup>†</sup>	Relative standard uncertainty contribution on massic activity of <sup>210</sup> Pb (%)
1	LS within measurement precision; typical standard deviation of the mean for 7 to 11 repeated measurements; values ranged from 0.008 % to 0.056 %	A	0.03
2	LS measurement precision; reproducibility in massic activity for 7 to 11 samples in two measurement series with three counters on two to three measurement occasions; standard deviation of the mean for $\nu = 443$ degrees freedom	A	0.067
3	Background LS measurement variability; wholly embodied in components 1 & 2	A	—
4	Scintillator dependencies; wholly embodied in components 1 & 2	A	—
5	LS cocktail stability and composition mismatch effect	B	0.35
6	Gravimetric (mass) measurements for LS sources and for <sup>3</sup> H standard dilution	B	0.07
7	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.06
8	Decay corrections for <sup>210</sup> Pb	B	0.002
9	Decay corrections for <sup>3</sup> H	B	0.0005
10	Limit for photon-emitting impurities	B	0.02
11	Beta endpoint energy, $E_{\beta(\max)}$ for <sup>210</sup> Pb for an uncertainty of 0.5 keV	B	0.033
12	Beta decay branching ratios for <sup>210</sup> Pb for an uncertainty of 0.03	B	0.39
13	$E_{\beta(\max)}$ for <sup>210</sup> Bi for an uncertainty of 1.5 keV	B	0.001
14	Computed $\beta$ detection efficiency for <sup>210</sup> Pb	B	1.1
15	Computed $\beta$ detection efficiency for <sup>210</sup> Bi	B	0.04
16	Assumed $\alpha$ detection efficiency for <sup>210</sup> Po, including extrapolation to zero energy	B	0.05
Relative combined standard uncertainty			1.2
Relative expanded uncertainty ( $k = 2$ )			2.4

<sup>†</sup> = (A) denotes evaluation by statistical methods; (B) denotes evaluation by other methods.

Table 1. Properties of SRM 4337

Certified values	
Radionuclide	Lead-210
Reference time	1200 EST, 15 June 2006
Massic activity of the solution	9.037 kBq·g <sup>-1</sup>
Relative expanded uncertainty ( $k = 2$ )	2.4 % (see Note 2)*

Uncertified information	
Source description	Liquid in flame-sealed, 5 mL NIST borosilicate ampoule (see Note 1)
Solution composition	1.0 mol·L <sup>-1</sup> HNO <sub>3</sub> with 21 µg Bi <sup>+3</sup> and 11 µg Pb <sup>+2</sup> per gram of solution
Solution density	(1.028 ± 0.002) g·mL <sup>-1</sup> at 20.0 °C <sup>†</sup> (see Note 3)
Solution mass	(5.133 ± 0.002) g (see Note 3)
Photon-emitting impurities	None detected (see Note 4)
Half-lives used	<sup>210</sup> Pb : (22.20 ± 0.22) a <sup>†</sup> <sup>3</sup> H : (12.32 ± 0.02) a <sup>†</sup>
Nuclear data used in CN2003 computations (beta-particle maximum energies; branching ratios; transitions) [1]	<sup>3</sup> H : (18.594 ± 0.008) keV <sup>†</sup> ; 1, allowed <sup>210</sup> Pb : (63.5 ± 0.5) keV <sup>†</sup> ; (0.16 ± 0.03); non-unique first forbidden (17.0 ± 0.5) keV <sup>†</sup> ; (0.84 ± 0.03); non-unique first forbidden <sup>210</sup> Bi : (1162.1 ± 1.5) keV <sup>†</sup> ; 1; non-unique first forbidden
Calibration method (and instruments)	The certified massic activity for <sup>210</sup> Pb in radioactive equilibrium with <sup>210</sup> Bi and <sup>210</sup> Po was obtained by 4πβ liquid scintillation (LS) spectrometry with three commercial LS counters. The LS detection efficiency was calculated using the CN2003 code [2] for the CIEMAT/NIST method with composition matched LS cocktails of a <sup>3</sup> H standard as the efficiency detection monitor. Confirmatory measurements were also performed by high-resolution HPGe gamma-ray spectrometry, by 2π $\alpha$ spectrometry of separated <sup>210</sup> Po with a Si surface barrier detector, and by 4πβ(LS) - γ(NaI) anticoincidence counting.

<sup>†</sup> See Note 5

## NOTES

Note 1. Refer to <http://physics.nist.gov/Divisions/Div846/srm.html> for the standardized ampoule dimensions and for assistance and instructions on how to properly open an ampoule. Information on additional storage and handling requirements is also included in the website.

Note 2. The uncertainties on certified values are expanded uncertainties,  $U = k u_c$ . The quantity  $u_c$  is the combined standard uncertainty calculated according to the ISO and NIST Guides (see references [3] and [4]). The combined standard uncertainty is multiplied by a coverage factor of  $k = 2$  and was chosen to obtain an approximate 95 % level of confidence.

Note 3. The stated uncertainty is two times the standard uncertainty. See reference [4].

Note 4. The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rates, on 27 December 2005, were:

$1.7 \text{ s}^{-1} \text{ g}^{-1}$  for  $20 \text{ keV} < E < 60 \text{ keV}$

$0.3 \text{ s}^{-1} \text{ g}^{-1}$  for  $60 \text{ keV} < E < 1800 \text{ keV}$ .

Note 5. The stated uncertainty is the standard uncertainty. See reference [4].

## REFERENCES

- [1] Evaluated Nuclear Structure Data File (ENSDF), online database, National Nuclear Data Center, Brookhaven Laboratory (Upton, NY), October 2006. Refer to <http://www.nndc.bnl.gov/ensdf/>
- [2] E. Gunther, Physikalisch-Technische Bundesanstalt (Braunschweig, Germany), private communication, 2003.
- [3] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993 (corrected and reprinted, 1995). Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.
- [4] B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407, U.S.A.

**Liquid Scintillation Counter**

**Quality Control Data**

**Daily Instrument Performance Checks**

DAILY INSTRUMENT PERFORMANCE CHECKS - QUANTULUS			
Daily IPCs consist of the following standards:			
Efficiency Checks		Background checks	
PerkinElmer Tritium Standard Lot: Dec. 14, 2015 211100.00 dpm 12/14/15 REF 12/14/20 EXP	PerkinElmer C-14 Standard Lot: Dec. 14, 2015 95600.00 dpm 12/14/15 REF 12/14/20 EXP	ALS-Laboratory Group-Ft Collins Blank EXP 9/25/17	
Historical limits		NEW REAGENT BLANK AS OF 9/25/2016	
UCL	Decay Corrected Tritium 115276.62	H3 window cpm	Quench Factor
Mean Value	114665.81	20.71	743.24
LCL	114055.00	16.22	735.31
		11.73	727.39
			C14 window cpm 13.69 10.13 6.58

NEW STANDARDS REC'D 05/2016 LC

Obs	Filename	Date	H-3 CPM	Decay Corrected H-CPM	C-14 CPM	ALS Reagent blank H3 WINDOW CPM	ALS RB Quench SOP(E)	ALS Reagent blank C14 WINDOW CPM
260	QC-0705	7/5/2017	105338.7	115020.84	91461.37	OK	742.46	OK
261	QC-0707	7/7/2017	105197.42	114902.08	91357.64	OK	735.76	OK
						17.37	15.65	12.32
						OK	OK	9.29
						OK	OK	OK

7/7/17