



facility 149017
project 10243

Radon-222 Case Narrative

COGCC

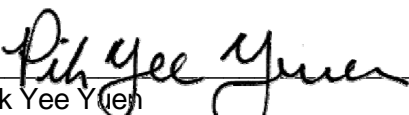
PW NORM 2017 – 10048

Work Order Number: 1705158

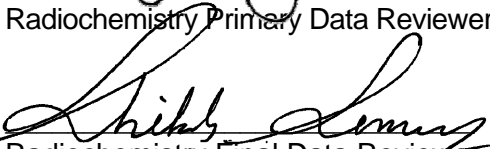
1. This report consists of the analytical results and supporting documentation for one water sample received by ALS on 05/08/2017.
2. This sample was prepared according to the current revision of SOP 799.
3. The sample was analyzed for the presence of ^{222}Rn according to the current revision of SOP 704. The analyses were completed on 05/12/2017.
4. The analysis results for this sample are reported in units of pCi/L. The sample was not filtered prior to analysis.
5. Sample volume was insufficient to allow preparation of a duplicate. A laboratory control sample duplicate (LCSD) was prepared in lieu of a client sample duplicate.
6. The quench factor (H#) for sample 1705158-1 is outside the upper control limit of 57.0, at a value of 58.8. Due to the nature of the preparation of this sample as well as the short half-life of ^{222}Rn ($t_{1/2}=3.8$ days), the sample was not re-analyzed. Data quality is not believed to be affected. The results are submitted without further qualification.
7. No further anomalous situations were encountered during the preparation or analysis of this sample. All remaining quality control criteria were met.



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


Pik Yee Yuen
Radiochemistry Primary Data Reviewer

5/18/17
Date


Radiochemistry Final Data Reviewer

5/18/17
Date

Section 1

CHAIN OF CUSTODY

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 1705158

Client Name: COGCC

Client Project Name: PW NORM 2017

Client Project Number: 10048

Client PO Number: CT 2017-3066


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



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

ALS WORKORDER #

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

Time Zone (Circle):	MST	Matrix:	O = oil	S = soil	NS = non-soil solid	W = water	L = liquid	E = extract	F = filter
NOTES	Form 2029								
GAB prepped (coprecip) and counted within 4 days of sampling	REPORT LEVEL / QC REQUIRED		SIGNATURE		PRINTED NAME		DATE		TIME
224Ra prepped and counted within 4 days of sampling		Summary (Standard QC)	 J. Humber		RACUSEN	5-8-17	11:00		
"Iso U only if 6020 "total" U > 3µg/l		LEVEL II (Standard QC)							
"Iso Th only if 6020 "total" Th > 3µg/l		LEVEL III (Std QC + fumes)							
		LEVEL IV (Std QC + fumes + new date)							
	X								
PRESERVATION KEY	1-HCl	2-HNO3	3-H2SO4	4-HNO3	5-NaOH/ZnAcetate	6-HaHSO4	7-4°C	8-Other	



Chain-of-Custody

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

ALS WORKORDER #

1705158

[illegible]

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

NOTES		REPORT LEVEL / QC REQUIRED
6010 total = B, Be, Ca, Cr, Fe, K, Li, Mg, Na, Ni, P, S, Si, V		
6020 total = Al, Ag, As, Ba, Cd, Co, Cu, Mo, Mn, Na, Pb, Se, Sr, Th, Ti, U, Zn		Summary (Standard QC) LEVEL II (Standard QC)
		LEVEL III (Std QC + forms)
		LEVEL IV (Std QC + forms + raw data)
X		
Dissolved = filter and preserve upon receipt at lab		
PRESERVATION KEY		1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaOH/ZnAcetate 6-NaHSO4 7-4°C 8-Other



ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: COGCC

Workorder No: 1705158

Project Manager: SS

Initials: edv Date: 5-8-17

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

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

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

Project Manager Signature / Date: Shiloh Lemay

Section 2



SAMPLE RESULTS SUMMARY

Radon-222 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: 1705158

Page: 1 of 1
Reported on: Thursday, May 18, 2017
9:05:16 AM

Lab Sample ID	Client Sample ID	Sample Type	Nuclide	Result +/- 2 s TPU	MDC	DL	Units	Matrix	Prep Batch	Date Analyze	Flags
1705158-1	149017 Wellington Rapid Infiltration Basin	Sample	Rn-222	-1.1E+01 +/- 2.5E+01	4.2E+01	NA	pCi/l	WATER	RN170510-1	5/11/2017	U
1705158-1	149017 Wellington Rapid Infiltration Basin	Replicate	Rn-222	-1E+00 +/- 2.5E+01	4.3E+01	NA	pCi/l	WATER	RN170510-1	5/11/2017	U

Comments:

Data Package ID: RN1705158-1

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

Date Printed: Thursday, May 18, 2017

ALS -- Fort Collins
LIMS Version: 6.841

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Section 3

QC RESULTS SUMMARY



Radon-222 by Liquid Scintillation

PAI 704 Rev 11

Method Blank Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: RN170510-1MB1MB

Sample Matrix: WATER

Prep SOP: PAI 799 Rev 4

Date Collected: 10-May-17

Date Prepared: 10-May-17

Date Analyzed: 11-May-17

Prep Batch: RN170510-1

QCBatchID: RN170510-1-1

Run ID: RN170510-1A

Count Time: 60 minutes

Final Aliquot: 10.0 ml

Result Units: pCi/l

File Name: B60_20_051101

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
14859-67-7	Rn-222	-1.3E+01 +/- 1.6E+01	2.8E+01	5E+01	NA	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

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

Y2 - Chemical Yield outside default limits.

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

Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

M - Requested MDC not met.

B - Analyte concentration greater than MDC.

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

DL - Decision Level

Data Package ID: RN1705158-1

Radon-222 by Liquid Scintillation

PAI 704 Rev 11

Method Blank Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: RN170510-1MB2MB

Sample Matrix: WATER

Prep SOP: PAI 799 Rev 4

Date Collected: 10-May-17

Date Prepared: 10-May-17

Date Analyzed: 12-May-17

Prep Batch: RN170510-1

QCBatchID: RN170510-1-1

Run ID: RN170510-1A

Count Time: 60 minutes

Final Aliquot: 10.0 ml

Result Units: pCi/l

File Name: B60_20_051101

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
14859-67-7	Rn-222	6E+00 +/- 1.9E+01	3.1E+01	5E+01	NA	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

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

Y2 - Chemical Yield outside default limits.

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

Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

M - Requested MDC not met.

B - Analyte concentration greater than MDC.

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

DL - Decision Level

Data Package ID: RN1705158-1

Radon-222 by Liquid Scintillation

PAI 704 Rev 11

Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: RN170510-1LCS

Sample Matrix: WATER

Prep SOP: PAI 799 Rev 4

Date Collected: 10-May-17

Date Prepared: 10-May-17

Date Analyzed: 11-May-17

Prep Batch: RN170510-1

QCBatchID: RN170510-1-1

Run ID: RN170510-1A

Count Time: 9.5 minutes

Final Aliquot: 10.0 ml

Result Units: pCi/l

File Name: B60_20_051101

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
14859-67-7	Rn-222	2.23E+04 +/- 2.6E+03	1E+02	2.260E+04	98.9	75 - 125	P,M3

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

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

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

Y2 - Chemical Yield outside default limits.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS Recovery within control limits.

M - The requested MDC was not met.

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

Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Minimum Detectable Concentration

Data Package ID: RN1705158-1

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Radon-222 by Liquid Scintillation

PAI 704 Rev 11

Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Lab ID: RN170510-1LCSD

Sample Matrix: WATER

Prep SOP: PAI 799 Rev 4

Date Collected: 10-May-17

Date Prepared: 10-May-17

Date Analyzed: 12-May-17

Prep Batch: RN170510-1

QCBatchID: RN170510-1-1

Run ID: RN170510-1A

Count Time: 9.35 minutes

Final Aliquot: 10.0 ml

Result Units: pCi/l

File Name: B60_20_051101

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
14859-67-7	Rn-222	2.28E+04 +/- 2.6E+03	1E+02	2.260E+04	101	75 - 125	P,M3

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

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

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

Y2 - Chemical Yield outside default limits.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS Recovery within control limits.

M - The requested MDC was not met.

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

Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Minimum Detectable Concentration

Data Package ID: RN1705158-1

Radon-222 by Liquid Scintillation

PAI 704 Rev 11

Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID:
Lab ID: RN170510-1LCSD

Sample Matrix: WATER

Prep SOP: PAI 799 Rev 4

Date Collected: 10-May-17

Date Prepared: 10-May-17

Date Analyzed: 12-May-17

Prep Batch: RN170510-1

QCBatchID: RN170510-1-1

Run ID: RN170510-1A

Count Time: 9.35 minutes

Final Aliquot: 10.0 ml

Prep Basis: Unfiltered

Moisture(%): NA

Result Units: pCi/l

File Name: B60_20_051101

CASNO	Analyte	Sample				Duplicate				DER	DER Lim
		Result +/-	2 s TPU	MDC	Flags	Result +/-	2 s TPU	MDC	Flags		
14859-67-7	Rn-222	2.23E+04 +/-	2.6E+03	1E+02	P,M3	2.28E+04 +/-	2.6E+03	1E+02	P,M3	0.115	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: RN1705158-1

Section 4

INDIVIDUAL SAMPLE RESULTS



Radon-222 by Liquid Scintillation

PAI 704 Rev 11

Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

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

Sample Matrix: WATER

Prep SOP: PAI 799 Rev 4

Date Collected: 08-May-17

Date Prepared: 10-May-17

Date Analyzed: 11-May-17

Prep Batch: RN170510-1

QCBatchID: RN170510-1-1

Run ID: RN170510-1A

Count Time: 60 minutes

Report Basis: Unfiltered

Final Aliquot: 10.0 ml

Prep Basis: Unfiltered

Moisture(%): NA

Result Units: pCi/l

File Name: B60_20_051101

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
14859-67-7	Rn-222	-1.1E+01 +/- 2.5E+01	4.2E+01	5E+01	NA	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

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

Y2 - Chemical Yield outside default limits.

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

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: RN1705158-1

Radon-222 by Liquid Scintillation

PAI 704 Rev 11

Sample Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1705158

Client Name: COGCC

ClientProject ID: PW NORM 2017 10048

Field ID: 149017 Wellington Rapid In
Lab ID: 1705158-1REP2

Sample Matrix: WATER

Prep SOP: PAI 799 Rev 4

Date Collected: 08-May-17

Date Prepared: 10-May-17

Date Analyzed: 11-May-17

Prep Batch: RN170510-1

QCBatchID: RN170510-1-1

Run ID: RN170510-1A

Count Time: 60 minutes

Report Basis: Unfiltered

Final Aliquot: 10.0 ml

Prep Basis: Unfiltered

Moisture(%): NA

Result Units: pCi/l

File Name: B60_20_051101

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
14859-67-7	Rn-222	-1E+00 +/- 2.5E+01	4.3E+01	5E+01	NA	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

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

Y2 - Chemical Yield outside default limits.

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

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: RN1705158-1

Section 5

RAW DATA

5

Radon-222 by Liquid Scintillation Raw Data Report

Laboratory Name: ALS -- Fort Collins

Prep SOP: PAI 799

Reported on: Friday, May 12, 2017

PAI Work Order: 1705158

Analytical SOP: PAI 704

11:52:40 AM

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	AntRunID File Name	Count Date/Time	GrossCPM BkgCPM	BaseEff ProgEff	CntDur(min) Yield	Activity +/- 2 s TPU	MDC DeclEv	ReportUnits ReportBasis	DER RPD	%Spk. Recov Flags
1705158-1	Rn-222 SMP	5/8/2017 10:40:00 AM	RN170510-1 RN170510-1-1	NA	58.8 0.29	WATER NA	10 ml 10 ml	LS6000 2-4	RN170510-1A B60_20_051101	5/11/2017 1:37 PM	5,220 5,600	276.01% NA	60 NA	-1.1E+01 2.6E+01	4.2E+01	pCi/l Unfiltered	NA NA	U
1705158-1	Rn-222 REP	5/8/2017 10:40:00 AM	RN170510-1 RN170510-1-1	NA	57 0.29	WATER NA	10 ml 10 ml	LS6000 2-5	RN170510-1A B60_20_051101	5/11/2017 2:38 PM	5,570 5,600	276.01% NA	60 NA	-1E+00 2.5E+01	4.3E+01	pCi/l Unfiltered	NA NA	U
RN170510-1MB1	Rn-222 MB	5/10/2017 4:11:26 PM	RN170510-1 RN170510-1-1	NA	49 0.1	WATER NA	10 ml 10 ml	LS6000 2-3	RN170510-1A B60_20_051101	5/11/2017 12:35 PM	4,930 5,600	276.01% NA	60 NA	-1.3E+01 1.6E+01	2.8E+01	pCi/l Unfiltered	NA NA	U
RN170510-1MB2	Rn-222 MB	5/10/2017 4:11:26 PM	RN170510-1 RN170510-1-1	NA	51.4 0.2	WATER NA	10 ml 10 ml	LS6000 33-6	RN170510-1A B60_20_051101	5/12/2017 3:58 AM	5,900 5,600	276.01% NA	60 NA	6E+00 1.9E+01	3.1E+01	pCi/l Unfiltered	NA NA	U
RN170510-1	Rn-222 LCS	5/10/2017 4:11:26 PM	RN170510-1 RN170510-1-1	NA	43.7 0	WATER NA	10 ml 10 ml	LS6000 2-2	RN170510-1A B60_20_051101	5/11/2017 12:24 PM	1374.951 5,600	276.01% NA	9.5 NA	2.23E+04 2.6E+03	1E+02	pCi/l Unfiltered	NA NA	98.9 P,M3
RN170510-1	Rn-222 LCS D	5/10/2017 4:11:26 PM	RN170510-1 RN170510-1-1	NA	43.9 0	WATER NA	10 ml 10 ml	LS6000 33-7	RN170510-1A B60_20_051101	5/12/2017 4:59 AM	1400.640 5,600	276.01% NA	9.35 NA	2.28E+04 2.6E+03	1E+02	pCi/l Unfiltered	0.12 NA	101 P,M3

Comments:

Data Package ID: RN1705158-1

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'

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

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

Notes:

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

Abbreviations:

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

Date Printed: Thursday, May 18, 2017

ALS -- Fort Collins

LIMS Version: 6.841

Page 1 of 1

ID: RN-222

11 MAY 2017 11:17

USER: 20

COMMENT: LS6000

PRESET TIME : 60.00
 DATA CALC : CPM H# : YES SAMPLE REPEATS: 1 PRINTER : STD
 COUNT BLANK : NO IC# : NO REPLICATES : 1 RS232 : EDIT
 TWO PHASE : NO AQC : NO CYCLE REPEATS : 1
 SCINTILLATOR: LIQUID LUMEX: NO LOW SAMPLE REJ: 0
 LOW LEVEL : YES HALF LIFE CORRECTION DATE: none

CHAN: 725.0 - 850.0 ✓ %ERROR: 1.75 FACTOR: 1.000000 BKG. SUB: 0
 WIDE OPEN WINDOW ✓ %ERROR: 20.00 FACTOR: 1.000000 BKG. SUB: 0

ALPHA-BETA DISCRIMINATION: NO

SAM NO	POS	TIME MIN	H#	WIND1		WIDE		LUMEX %	ELAPSED TIME
				CPM	%ERROR	CPM	%ERROR		
1	2-1	60.00	49.5	5.43	11.08	47.10	3.76	0.13	61.27
2	2-2	9.50	43.7	1374.95	1.75	1982.00	1.46	0.00	71.84
3	2-3	60.00	49.0	4.93	11.62	45.23	3.84	0.10	133.30
4	2-4	60.00	58.8↑	5.22	11.30	46.45	3.79	0.29	194.71
5	2-5	60.00	57.0	5.57	10.94	45.90	3.81	0.29	256.12
6	2-6	60.00	56.9	11.00	7.78	58.30	3.38	0.08	317.56
7	2-7	60.00	57.8↑	12.12	7.42	59.47	3.35	0.08	379.03
8	2-8	60.00	60.0↑	12.15	7.41	59.92	3.34	0.09	440.59
9	2-9	60.00	61.0↑	11.57	7.59	56.53	3.43	0.09	501.95
10	2-10	60.00	55.3	8.63	8.79	53.32	3.54	0.13	563.33
11	2-11	60.00	55.8	8.02	9.12	50.75	3.62	0.17	624.81
12	2-12	60.00	54.1	10.03	8.15	54.62	3.49	0.13	686.30
13	33-1	60.00	53.8	10.12	8.12	53.92	3.52	0.15	748.07
14	33-2	60.00	68.9↑	9.47	8.39	51.22	3.61	0.18	809.66
15	33-3	60.00	65.7↑	8.78	8.71	49.73	3.66	0.19	871.15
16	33-4	60.00	63.2↑	9.67	8.30	53.20	3.54	0.17	932.63
17	33-5	60.00	57.6↑	7.92	9.18	51.17	3.61	0.18	994.13
18	33-6	60.00	51.4	5.90	10.63	46.05	3.80	0.20	1055.51
19	33-7	9.35	43.9	1400.64	1.75	1991.98	1.47	0.00	1065.92
20	33-8	60.00	50.8	5.77	10.75	48.70	3.70	0.18	1127.40

B60-20-051101

H# UCL 57.0

02 5/12/17

JP 5/15/17

B60_20_051101.ASC

```

BSF Version      : 3
Instrument Type   : LS 6000
Data Capture Date : 11 May 2017 11:22:32
User Filename     : C:\...\LS WINCONNECTION\DATA\USER20\UN051101.BSF
User Number      : 20
User Id          : RN-222
User Comments     : LS6000
Preset Count Time : 60.00
Calculation Mode  : CPM
H# Selected       : YES
Sample Repeats    : 1
Printer Output Mode : STD
Blank Count       : NO
IC# or SCR Selected : NO
Replicates        : 1
RS232 Output Mode : EDIT
Two-Phase Selected : NO
AQC Choice        : NO
Cycle Repeats     : 1
Scintillator Choice : LIQUID
Lumex Selected    : NO
Low Sample Reject Count : 0
Low Level Selection : YES
Half Life Correction Date : none
Window Limits Window 1 : 725.00
Preset %Error Iso1 : 1.75
Norm Multiplier Iso1 : 1.00000
Background CPM 1 : 0.00
Preset %Error Iso2 : 20.00
Norm Multiplier Iso2 : 1.00000
Background CPM 2 : 0.00
Alpha/Beta Discrimination : NO
  
```

Sam	Rack	Time	H#	CPM	Iso1	%Err1	CPM	Iso2	%Err2	LumEx	ElTime
1	2-1	60.00	49.5	5.43	11.08		47.10	3.76	0.13	61.27	
2	2-2	9.50	43.7	1374.95	1.75		1982.00	1.46	0.00	71.84	
3	2-3	60.00	49.0	4.93	11.62		45.23	3.84	0.10	133.30	
4	2-4	60.00	58.8	5.22	11.30		46.45	3.79	0.29	194.71	
5	2-5	60.00	57.0	5.57	10.94		45.90	3.81	0.29	256.12	
6	2-6	60.00	56.9	11.00	7.78		58.30	3.38	0.08	317.56	
7	2-7	60.00	57.8	12.12	7.42		59.47	3.35	0.08	379.03	
8	2-8	60.00	60.0	12.15	7.41		59.92	3.34	0.09	440.59	
9	2-9	60.00	61.0	11.57	7.59		56.53	3.43	0.09	501.95	
10	2-10	60.00	55.3	8.63	8.79		53.32	3.54	0.13	563.33	
11	2-11	60.00	55.8	8.02	9.12		50.75	3.62	0.17	624.81	
12	2-12	60.00	54.1	10.03	8.15		54.62	3.49	0.13	686.30	
13	33-1	60.00	53.8	10.12	8.12		53.92	3.52	0.15	748.07	
14	33-2	60.00	68.9	9.47	8.39		51.22	3.61	0.18	809.66	
15	33-3	60.00	65.7	8.78	8.71		49.73	3.66	0.19	871.15	
16	33-4	60.00	63.2	9.67	8.30		53.20	3.54	0.17	932.63	
17	33-5	60.00	57.6	7.92	9.18		51.17	3.61	0.18	994.13	
18	33-6	60.00	51.4	5.90	10.63		46.05	3.80	0.20	1055.51	
19	33-7	9.35	43.9	1400.64	1.75		1991.98	1.47	0.00	1065.92	
20	33-8	60.00	50.8	5.77	10.75		48.70	3.70	0.18	1127.40	

JP 5/11/17
5/12/17

LSC Run Log

Instrument ID: LS6000

ALS

Date	Sample ID	Count Time (min.)	Rack & Position	Test	User #	Batch ID	Position Check	Initials	Comments
5/7/17	1704514-12	60	7 - 11	7299	11	7C170501-1	OK	OK	NA
	↓ -13		↓ - 12						
	↓ -14		12 - 1						
	170501-128	37.65	↓ - 2						
	↓ -1633	60	↓ - 3						
5/7/17	Daily QC	10	13 - 13, 1-2		1,3		OK	OK	
5/8/17	1704515-50UP	60	18 - 1	7299	11	7C170501-1	OK	OK	
5/8/17	Daily QC	10	13 - 13, 1-2		1,3		OK	OK	
5/11/17	Daily QC	10	13 - 13, 1-2		1,3		OK	OK	NA
5/11/17	RN170510-1281	60	2 - 1	RN222	20	AN170510-1	OK	OK	
	↓ -125	1.50	↓ - 2						
	↓ -1MB1	60	↓ - 3						
	1705158-1		↓ - 4						
	↓ -1REP		↓ - 5						
	1705177-1		↓ - 6						
	↓ -1REP		↓ - 7						
	↓ -2		↓ - 8						
	↓ -2REP		↓ - 9						
	↓ -3		↓ - 10						
	↓ -3REP		↓ - 11						
	1705191-1		↓ - 12						
	↓ -1REP		93 - 1						
	1705202-1		↓ - 2						
	↓ -1REP		↓ - 3						
	1705203-1		↓ - 4						
	↓ -1REP		↓ - 5						
	RN170510-1MB2		↓ - 6						
	↓ -125D	4.35	↓ - 7						
	↓ -1632	60	↓ - 8						
5/12/17	Daily QC	10	13 - 13, 1-2		1,3		OK	OK	

Analyst / Date AK 5/12/17

FORM 762r6.XLS (3/7/09)

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: RN170510-1

Prep Procedure: Rn222 SP 60 min

Analytical QASS / NCR? Y N NA

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	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	1705158-1	SMP	10	10	ml	pCi/l	LS6000	2-4	Jan							
2	1705158-1	REP	10	10	ml	pCi/l										
1	1705177-1	SMP	10	10	ml	pCi/l		-5								
2	1705177-1	REP	10	10	ml	pCi/l		-6								
1	1705177-2	SMP	10	10	ml	pCi/l		-7								
2	1705177-2	REP	10	10	ml	pCi/l		-8								
1	1705177-3	SMP	10	10	ml	pCi/l		-9								
2	1705177-3	REP	10	10	ml	pCi/l		-10								
1	1705191-1	SMP	10	10	ml	pCi/l		-11								
2	1705191-1	REP	10	10	ml	pCi/l		-12								
1	1705202-1	SMP	10	10	ml	pCi/l		33-1								
2	1705202-1	REP	10	10	ml	pCi/l		-2								
1	1705203-1	SMP	10	10	ml	pCi/l		-3								
2	1705203-1	REP	10	10	ml	pCi/l		-4								
1	1705203-1	REP	10	10	ml	pCi/l		-5								
1	1705203-1	REP	10	10	ml	pCi/l		2-1								
1	1705203-1	REP	10	10	ml	pCi/l		33-8								
1	1705203-1	REP	10	10	ml	pCi/l		-2-3								
1	1705203-1	REP	10	10	ml	pCi/l		33-6								
1	1705203-1	REP	10	10	ml	pCi/l		2-2								
1	1705203-1	REP	10	10	ml	pCi/l		33-7								

AN 5/12/17

Spike Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
S1	Ra-226	916.4095.69	1/4/17	100.339	DPM/ml	05/10/17
S1	Rn-222	916.4095.69		100.339	DPM/ml	05/10/17

Sample Barcodes

1705158-1
RN170510-1PS1

1705158-1REP
RN170510-1PS2

1705177-1
RN170510-1PS3

Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: RN170510-1

Prep Procedure: Rn222

Analytical QASS / NCR? Y *MA*

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
1705177-1REP RN170510-1PS4								1705177-2 RN170510-1PS5						1705177-2REP RN170510-1PS6		
1705177-3 RN170510-1PS7								1705177-3REP RN170510-1PS8						1705191-1 RN170510-1PS9		
1705191-1REP RN170510-1PS10								1705202-1 RN170510-1PS11						1705202-1REP RN170510-1PS12		
1705203-1 RN170510-1PS13								1705203-1REP RN170510-1PS14						RN170510-1CB1MB RN170510-1PS15		
RN170510-1CB2MB RN170510-1PS16								RN170510-1MB1MB RN170510-1PS17						RN170510-1MB2MB RN170510-1PS18		
RN170510-1LCS RN170510-1PS19								RN170510-1LCSD RN170510-1PS20								

Reporting Units

LabID:	IsGrpName:	RptUnits:
1705203-1	Rn222	pCi/l
1705202-1	Rn222	pCi/l
1705191-1	Rn222	pCi/l
1705177-1	Rn222	pCi/l
1705158-1	Rn222	pCi/l
1705177-2	Rn222	pCi/l
1705177-3	Rn222	pCi/l

Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: RN170510-1

Prep Procedure: Rn222

Reviewed By: sdw *sdw* Review Date: 5/10/2017

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

Prep SOP: PAI 799 Rev: 4
Prep SOP: NONE
Matrix Class: liquid

Prep Analyst: Steven D. White *SDW*
Prep Date: 5/10/2017
Prep Dept: RS
Balance: na
Balance: na
Cocktail: 137-15251
Cocktail Pipet: RS401
Aliquot Pipet: na

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1705158-1	SMP	<i>NA</i>	10	10	Unfiltered		5-8-17 1040
2	2	1705158-1	REP		10	10	Unfiltered		5-8-17 1040
3	1	1705177-1	SMP		10	10	Unfiltered		5-8-17 0946
4	2	1705177-1	REP		10	10	Unfiltered		5-8-17 0946
5	1	1705177-2	SMP		10	10	Unfiltered		5-8-17 1002
6	2	1705177-2	REP		10	10	Unfiltered		5-8-17 1002
7	1	1705177-3	SMP		10	10	Unfiltered		5-8-17 1047
8	2	1705177-3	REP		10	10	Unfiltered		5-8-17 1047
9	1	1705191-1	SMP		10	10	Unfiltered		5-8-17 1009
10	2	1705191-1	REP		10	10	Unfiltered		5-8-17 1009
11	1	1705202-1	SMP		10	10	Unfiltered		5-8-17 1250
12	2	1705202-1	REP		10	10	Unfiltered		5-8-17 1250
13	1	1705203-1	SMP		10	10	Unfiltered		5-8-17 0930
14	2	1705203-1	REP		10	10	Unfiltered		5-8-17 0930
15	1	RN170510-1CB1 MB			10	10	Unfiltered		
16	1	RN170510-1CB2 MB			10	10	Unfiltered		
17	1	RN170510-1MB1 MB			10	10	Unfiltered		
18	1	RN170510-1MB2 MB			10	10	Unfiltered		
19	1	RN170510-1 LCS			10	10	Unfiltered	S1	
20	1	RN170510-1 LCSD			10	10	Unfiltered	S1	

Comments

Spiked By: Rebecca L. Merola Date: 12/14/2016

Witnessed By: Andrew R. Sieger Date: 12/14/2016

Spike Solution Information									
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Ra-226	916.4095.69	11/4/17	100.339	DPM/ml	05/10/17	5	ml	RS-032
S1	Rn-222	916.4095.69		100.339	DPM/ml	05/10/17	5	ml	RS-032

Sample Condition Form (Liquid)

Analyst: S. J. White

Analysis Date: 5-10-17

Method: Radon

RN170510-1

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

Work Order	Sample ID	pH	Color	Remarks
1705158	1	6	clear	NO Head Space
1705177	1	↓	↓	small per head space
↓	2			medium per head space
↓	3			small per head space
1705191	1			NO Head Space
1705202	1	↓	cloudy	↓ ↓ ↓
1705203	1	↓	↓	↓ ↓ ↓
<div style="position: relative; height: 100%; width: 100%;"> <div style="position: absolute; top: 0; left: 0; right: 0; border-bottom: 1px solid black; height: 10px;"></div> <div style="position: absolute; bottom: 0; left: 0; right: 0; border-top: 1px solid black; height: 10px;"></div> <div style="position: absolute; top: 50%; left: 50%; transform: translate(-50%, -50%);"> <p>5/10/17</p> </div> </div>				

Section 8

STANDARDS TRACEABILITY DOCUMENTS



916.4095.69

Ra226 working std

Prepare a working dilution of 916.3610.76

12/18/14

1. Density of 0.1M HCl, lot # 0000092116

Mass of 100mL vol. flask:

68.3000g

Balance # 12

Mass of flask & 100mL acid:

168.0372g

Balance# 12

Net Mass:

99.7372g

Density:

0.9974g/mL

2. Mass of 916.3610.76 transferred:

Mass of open empty nalgene:

74.1631g

Balance# 12

Mass of nalgene & standard:

77.5202g

Balance# 12

Net mass of standard transferred:

3.3571g

Balance# NA

3. Dilute to final volume:

Mass of nalgene, standard, & diluent:

1077.5g

Balance# 26

Mass of empty nalgene (from above):

74.1631g

Balance# 12

Net mass of new dilution:

1003.3369g

Balance# NA

4. Final activity calculation:

$$30,156.00 \text{ dpm/g} (0.9974 \text{ g/mL}) \left(\frac{3.3571 \text{ g}}{1003.3369 \text{ g}} \right) = 100.64 \text{ dpm/mL}$$

12/18/14

JP 11/9/15

Std ID: 916.4095.69

Description: Ra-226

Expiration: 1/6/2016

Activity: 100.64 dpm/mL

2s Uncertainty: 4.93 dpm/mL

Ref. Date: 7/1/2010

Ref Time: N/A

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

Matrix/Comp. 0.1M HCl

Half Life (y): 1.60E+03

Reverification Log		
Analysis Date	Initials	Expiration Date
1/4/2016	JP	1/04/2017

JP 11/9/15

Continued on Page

1 Clint

Signed

12/8/14

Date

Read and Understood By

JP

Signed

01/09/2015

Date



Eckert & Ziegler
Analytics

mc
7-6-10
R50#
9/6

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

CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

82563-307

Ra-226 5 mL Liquid in Flame Sealed Vial

Customer: ALS Laboratory Group / Fort Collins
P.O. No.: 73625 08-10-10, Rem 1

This standard radionuclide source was prepared gravimetrically from a master solution calibrated by Eckert & Ziegler Analytics, using a germanium gamma spectrometer system. Radionuclide purity and calibration were checked with a germanium gamma spectrometer system. The nuclear decay rate and reference date for this source are given below. Eckert & Ziegler Analytics (EZA) maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Revision 1, February, 1979, and compliance with ANSI N42.22-1998, "Traceability of Radioactive Sources to NIST." EZA is accredited by the Health Physics Society (HPS) for the production of NIST-traceable sources, and this source was produced in accordance with the HPS accreditation requirements. Customers may report any concerns with the accreditation program to the HPS Secretariat, 1313 Dolley Madison Blvd., Ste. 402, McLean, VA 22101.

Isotope	Half-Life, Days	Activity (Bq)	Uncertainty*, %			Reference Date (12:00 PM EST)
			U _A	U _B	U	
Ra-226	5.844E+08	1.860E+04	0.8	2.4	4.8	07/01/2010

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

Comments:

Impurities: γ -impurities <0.1%. 6.08176 g 0.1M HCl solution with approximately 30 μ g/g Ba carrier.

Source Prepared by: W. Mao
W. Mao, Radiochemist

QA Approved: J. D. McCorvey
J. D. McCorvey, QA Manager Alternate

Date: 6/30/10

ANA Form 005 Rev. 10

Single Isotope Certificate, Rev 1 9/28/2008



Corporate Office
24937 Avenue Tibbitts Valencia, California 91355

Laboratory
1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

Section 9

ADDITIONAL SUPPORTING DOCUMENTATION

Liquid Scintillation Counter

Instrumentation Calibration

Initial Efficiency Calibration Standards Traceability

Rn-222 Background Determination LS6000

Interim control limits are established from the initial calibration for the geometry of interest. Limits are +/- 3 standard deviations from the initial unquenched 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 (15 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 Count Rate (CPM) is within the established control limits.

CURRENTLY UNDER INTERIM LIMITS
UPDATED 04/10/17 JP

COUNT DATE	#	Sample ID	Count Duration (m)	Count Rate (CPM)	Total Cts.	Mean	Individual Reagent Blanks				Average of Reagent Blanks		
							LCL	UCL	Pass ?		LCL	UCL	Pass ?
5/11/2017	15	RN170510-1CB1	60	5.43	325.8		4.92	6.21	PASS		4.92	6.21	PASS
5/12/2017	16	RN170510-1CB2	60	5.77	346.2	5.6	4.92	6.21	PASS		4.92	6.21	PASS

5/12/17

Radon-222 Efficiency Calibration

10ml Sample + 10ml Mineral Oil Cocktail

Beckman LS6000

Date of Calibration : 4/4/2017

Preparation Date : 1/9/2017

LUMEX Correction: OFF

Known Activity of Rn-222 (Ra-226) Standard 907.3610.53

Activity = 1025.87 2/24/2010
 Ra-226 1/2 life = 1.60E+03 yrs.
 Current Activity = 1022.72 dpm/mL
 Spiked = 5.00 mL
 Spike Activity = 5113.58 dpm
 Days Ingrowth = 85.00 days
 Rn-222 1/2 Life = 3.832 days
 Minimum Ingrowth Factor = 1.000

(725-850)			
Sample ID	WIND1 CPM	LUMEX %	H#
RN170109-1AMB	6.08	0.05	41.5
RN170109-1BMB	5.75	0.04	40.9
RN170109-1CMB	5.75	0.05	41.1
1713007-1	14077.89	0.00	42.6
1713007-2	14088.42	0.00	42.6
1713007-3	14193.68	0.00	43.1
Average LCS=	14120.00	0.02	42.0
Average BKG=	5.86		
Net CPM=	14114.14		
/Known DPM=	5113.58		
Calibration Factor (CF)=	2.7601		

LUMEX%	H#	
5.00	57.0	UCL
0.00	27.0	LCL
See Tech Mgr.	See Tech Mgr.	Corr. Action

**WIND 2 is not evaluated for higher energy contamination for this test.

$$\% \text{ Diff} = \left| \left(\frac{2.7601}{2.6561} \right) - 1 \right| \times 100 = 3.9$$

Instrument Technician :

Signature & Date

Supervisory Review :

Signature & Date

222Rn Efficiency Calibration Verification / Method Blank Verification

Calibration Source Check

LS6000

Analysis Date: 4/4/2017
Nuclide: Rn222/Ra226
Half Life: 1.60E+03 yr.

Calibration Check Source:

Spike Standard: 916.4095.69
Reference Date: 7/1/2010
Spiked DPM: 100.64 dpm/mL
Spike Volume: 5.0 mL
Spiked into: 10 mL
Current Spk. Act.: 22.60 pCi/mL

Acceptance Criteria: 75%-125%

Calibration Check Source Count

Sample ID	Rack	Pos	Prep Date	Cnt. Dur.	Anal. Vol.	GrsCPM	BkgCPM	Efficiency	Activity	Units	Chem. Yield	LCS Recovery:	Pass/Fail
1624003-1	32	4	12/17/2016	9.45	10	1382.96	5.16	2.7601	22.49	pCi/mL	100%	99.5%	PASS
1624003-2	32	5	12/17/2016	9.65	10	1353.78	5.16	2.7601	22.01	pCi/mL	100%	97.4%	PASS
1624003-3	32	6	12/17/2016	9.45	10	1386.67	5.16	2.7601	22.55	pCi/mL	100%	99.8%	PASS
1624003-4	32	7	12/17/2016	9.55	10	1373.51	5.16	2.7601	22.33	pCi/mL	100%	98.8%	PASS

Method Blank Check Count

Sample ID	Rack	Pos	Prep Date	Cnt. Dur.	Anal. Vol.	GrsCPM	BkgCPM	Efficiency	Chem. Yield	k (denom.)	activity	MDC	Pass/Fail	Units	2s CU	1σ IU	1σ PU's	2s TPU
RN161214-1MB1	32	2	12/17/2016	120	10	5.49	5.16	2.7601	100%	61.267	0.0055	0.02	PASS	pCi/mL	0.010	0.00061	0.00035	0.010
RN161214-1MB2	32	3	12/17/2016	120	10	5.38	5.16	2.7601	100%	61.267	0.0037	0.02	PASS	pCi/mL	0.010	0.00041	0.00024	0.010
RN161214-1MB3	32	8	12/17/2016	120	10	5.19	5.16	2.7601	100%	61.267	0.0006	0.02	PASS	pCi/mL	0.010	0.00006	0.00011	0.010
RN161214-1MB4	32	9	12/17/2016	120	10	5.33	5.16	2.7601	100%	61.267	0.0029	0.02	PASS	pCi/mL	0.010	0.00032	0.00056	0.010

OK 78 4/10/17

ID: FIN-12212

4 APR 2017 09:24

USER:20

COMMENT:LEA000

PRESET TIME : 120.00

DATA CALC : CPM H# : YES SAMPLE REPEATS: 1 PRINTER : STD
 COUNT BLANK : NO ICN : NO REPLICATES : 1 R5232 : EDIT
 TWO PHASE : NO AGC : NO CYCLE REPEATS : 1
 SCINTILLATOR: LIQUID LUMEX: NO LOW SAMPLE REQ: 0
 LOW LEVEL : YES HALF LIFE CORRECTION DATE: none

CHAN: 725.0 - 850.0 ✓ ZERROR: 1.75 FACTOR: 1.000000 BKG. SUB: 0
 WIDE OPEN WINDOW ✓ ZERROR: 20.00 FACTOR: 1.000000 BKG. SUB: 0

ALPHA-BETA DISCRIMINATION: NO

SAM NO	POS	TIME MIN	H#	WINDJ		WIDE		LUMEX %	ELAPSED TIME
				CPM	ZERROR	CPM	ZERROR		
1	8-1	0.95	42.6	14077.89	1.73	19492.63	1.47	0.00	1.74
2	8-2	0.95	42.6	14088.42	1.73	19661.05	1.46	0.00	3.57
3	8-3	0.95	43.1	14193.68	1.72	19642.11	1.46	0.00	5.51
4	8-4	120.00	41.5	6.08	7.40	50.26	2.53	0.05	127.52
5	8-5	120.00	40.9	5.75	7.61	50.08	2.53	0.04	249.45
6	8-6	120.00	41.1	5.75	7.61	47.88	2.64	0.05	371.34
MISSING SAMPLE									
13	32-1	120.00	43.5	5.03	8.14	47.83	2.64	0.06	493.45
14	32-2	120.00	42.2	5.49	7.79	47.92	2.64	0.05	615.26
15	32-3	120.00	41.6	5.38	7.87	46.13	2.69	0.06	737.19
16	32-4	9.45	44.0	1382.96	1.75	1954.60	1.47	0.00	747.68
17	32-5	9.45	42.5	1353.78	1.75	1940.93	1.46	0.00	758.50
18	32-6	9.45	43.9	1386.67	1.75	1987.62	1.46	0.00	769.12
19	32-7	9.55	42.8	1373.51	1.75	1959.06	1.46	0.00	779.62
20	32-8	120.00	41.4	5.19	8.01	46.03	2.69	0.08	901.87
21	32-9	120.00	45.3	5.33	7.91	47.35	2.65	0.09	1023.51
22	32-10	120.00	42.7	5.28	7.94	46.75	2.67	0.08	1145.45

B60-20-040401

Ar 4/5/17

JP 4/10/17

```

BSF Version          : 3
Instrument Type       : LS 6000
Data Capture Date    : 04 Apr 2017 09:29:16
User Filename        : C:\...\LS WINCONNECTION\DATA\USER20\UN040401.BSF
User Number          : 20
User Id              : RN-222
User Comments        : LS6000
Preset Count Time    : 120.00
Calculation Mode     : CPM
H# Selected          : YES
Sample Repeats       : 1
Printer Output Mode   : STD
Blank Count          : NO
IC# or SCR Selected  : NO
Replicates           : 1
RS232 Output Mode    : EDIT
Two-Phase Selected   : NO
AQC Choice           : NO
Cycle Repeats        : 1
Scintillator Choice  : LIQUID
Lumex Selected       : NO
Low Sample Reject Count : 0
Low Level Selection   : YES
Half Life Correction Date : none
Window Limits Window 1 : 725.00
Preset %Error Iso1   : 1.75
Norm Multiplier Iso1 : 1.00000
Background CPM 1     : 0.00
Preset %Error Iso2   : 20.00
Norm Multiplier Iso2 : 1.00000
Background CPM 2     : 0.00
Alpha/Beta Discrimination : NO

```

Sam	Rack	Time	H#	CPM Iso1	%Err1	CPM Iso2	%Err2	LumEx	ElTime
1	8-1	0.95	42.6	14077.89	1.73	19492.63	1.47	0.00	1.74
2	8-2	0.95	42.6	14088.42	1.73	19661.05	1.46	0.00	3.57
3	8-3	0.95	43.1	14193.68	1.72	19642.11	1.46	0.00	5.51
4	8-4	120.00	41.5	6.08	7.40	50.26	2.58	0.05	127.52
5	8-5	120.00	40.9	5.75	7.61	50.08	2.58	0.04	249.43
6	8-6	120.00	41.1	5.75	7.61	47.88	2.64	0.05	371.34
13	32-1	120.00	43.5	5.03	8.14	47.83	2.64	0.06	493.45
14	32-2	120.00	42.2	5.49	7.79	47.92	2.64	0.05	615.26
15	32-3	120.00	41.6	5.38	7.87	46.13	2.69	0.06	737.19
16	32-4	9.45	44.0	1382.96	1.75	1954.60	1.47	0.00	747.68
17	32-5	9.65	42.5	1353.78	1.75	1940.93	1.46	0.00	758.50
18	32-6	9.45	43.9	1386.67	1.75	1987.62	1.46	0.00	769.12
19	32-7	9.55	42.8	1373.51	1.75	1959.06	1.46	0.00	779.62
20	32-8	120.00	41.4	5.19	8.01	46.03	2.69	0.08	901.57
21	32-9	120.00	45.3	5.33	7.91	47.35	2.65	0.09	1023.51
22	32-10	120.00	42.7	5.28	7.94	46.75	2.67	0.08	1145.45

JP 4/10/17

9/5/17

Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: RN170109-1

Prep Procedure: Rn222

Eff. Cal

Analytical QA/QC / NCR? Y

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	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	1713007-1	SMP	10	10	ml	pCi/l	15006	B-1	na							
1	1713007-2	SMP	10	10	ml	pCi/l		-2								
1	1713007-3	SMP	10	10	ml	pCi/l		-3								
1	RN170109-1MB	MB	10	10	ml	pCi/l		-4								
1	RN170109-1MB	MB	10	10	ml	pCi/l		-5								
1	RN170109-1MB	MB	10	10	ml	pCi/l		-6								

Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Ra-226	907.3610.53		1,022.820	DPM/ml	01/09/17	5	ml	RS-032
S1	Rn-222	907.3610.53		1,022.820	DPM/ml	01/09/17	5	ml	RS-032

Sample Barcodes

1713007-1 RN170109-1PS1	1713007-2 RN170109-1PS2	1713007-3 RN170109-1PS3
RN170109-1MB1MB RN170109-1PS4	RN170109-1MB2MB RN170109-1PS5	RN170109-1MB3MB RN170109-1PS6

Reporting Units

LabID	InstGrpName	RptUnits
1713007-1	Rn222	pCi/l
1713007-2	Rn222	pCi/l
1713007-3	Rn222	pCi/l

Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: RN170109-1

Prep Procedure: Rn222

Reviewed By: *rlm*

Review Date: 1/9/2017

Non-Routine Pre-Treatment? Y *(N)* Batch: *NA*

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

Prep SOP: PAI 799 Rev: 4

Prep Analyst: Rebecca L. Merola

Balance:

Prep SOP: NONE

Prep Date: 1/9/2017

Cocktail Pipet:

Cocktail: 137-16041

Matrix Class: liquid

Prep Dept: RS

Aliquot Pipet:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1713007-1	SMP	<i>MB</i>	10	10	Unfiltered	S1	
2	1	1713007-2	SMP		10	10	Unfiltered	S1	
3	1	1713007-3	SMP		10	10	Unfiltered	S1	
4	1	RN170109-1MB1	MB		10	10	Unfiltered		
5	1	RN170109-1MB2	MB		10	10	Unfiltered		
6	1	RN170109-1MB3	MB		10	10	Unfiltered		

Comments

Spiked By: Rebecca L. Merola Date: 1/9/2017

Witnessed By: Macey S. Hall Date: 1/9/2017

Spike Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
S1	Ra-226	907.3610.53		1,022.820	DPM/ml	RS-032
S1	Rn-222	907.3610.53		1,022.820	DPM/ml	RS-032

Reagent Solution IDs*

137-16041 J26A03

*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: RN170109-1

Prep Procedure: Rn222

Reviewed By: Review Date:

Non-Routine Pre-Treatment? Y / N

Re-Prep? Y / N

Batch: Batch:

Prep SOP: PAI 799 Rev: 4

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 1/9/2017

Prep Dept: RS

Cocktail:

Cocktail Pipet:

Aliquot Pipet:

Prep Notes

Standards

Prep Basis

Fin Aliq

ml

Init Aliq

ml

Dish

No.

QC

Type

LabID

Prep Num

S1

Unfiltered

10

10

10

10

SMP

1713007-1

1

1

1

S1

Unfiltered

10

10

10

10

SMP

1713007-2

2

1

1

S1

Unfiltered

10

10

10

10

SMP

1713007-3

3

1

1

MB

Unfiltered

10

10

10

10

MB

RN170109-1MB1

4

1

1

MB

Unfiltered

10

10

10

10

MB

RN170109-1MB2

5

1

1

MB

Unfiltered

10

10

10

10

MB

RN170109-1MB3

6

1

1

Comments

Spiked By: Date: 1/9/17

Witnessed By: MSH Date: 1/9/17

Spike Solution Information

Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Ra-226	907.3610.53	12/29/17	1,022.820	DPM/ml	01/09/17	5	ml	RS-032
S1	Rn-222	907.3610.53	12/29/17	1,022.820	DPM/ml	01/09/17	5	ml	RS-032

Reagent Solution IDs*

137-16041 J26A03

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

ALS -- Fort Collins

Rn222 Bench Sheet

Page 1 of 1

LIMS Version: 6.836

16:36

1/9/2017

Date Printed:

Supersedes: NA

Radiochemistry Instrument Worksheet

ALS -- Fort Collins

Prep Batch: RN161214-1

Prep Procedure: Rn222 ICB + ICB

Analytical QASS / NCR? Y N Notes NA

Prep Num	LabID	QC Type	Init Aliq	Fin Aliq	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	1624003-1	SMP	10	10	ml	pCi/l	L56000 32-4 AL									
1	1624003-2	SMP	10	10	ml	pCi/l										
1	1624003-3	SMP	10	10	ml	pCi/l										
1	1624003-4	SMP	10	10	ml	pCi/l										
1	N161214-1-1ME MB	MB	10	10	ml	pCi/l										
1	N161214-1-1ME MB	MB	10	10	ml	pCi/l										
1	N161214-1-1CB MB	MB	10	10	ml	pCi/l										
1	N161214-1-1CB MB	MB	10	10	ml	pCi/l										
1	N161214-1-1MB MB	MB	10	10	ml	pCi/l										
1	N161214-1-1MB MB	MB	10	10	ml	pCi/l										

Spike Solution Information

Soln #	Nuclide	SolnID	Expo Date	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	Ra-226	916.4095.69		100.357	DPW/ml	12/14/16	5	ml	RS-032
S1	Rn-222	916.4095.69		100.357	DPW/ml	12/14/16	5	ml	RS-032

Sample Barcodes

1624003-1 RN161214-1PS1	1624003-2 RN161214-1PS2	1624003-3 RN161214-1PS3
1624003-4 RN161214-1PS4	RN161214-1-1MB3MB RN161214-1PS5	RN161214-1-1MB4MB RN161214-1PS6
RN161214-1-1CB1MB RN161214-1PS7	RN161214-1-1CB2MB RN161214-1PS8	RN161214-1-1MB1MB RN161214-1PS9
RN161214-1-1MB2MB RN161214-1PS10		

Reporting Units

LabID	1stGrpName	RptUnits
1624003-1	Rn222	pCi/l
1624003-2	Rn222	pCi/l
1624003-3	Rn222	pCi/l
1624003-4	Rn222	pCi/l

Radiochemistry Prep Worksheet

ALS -- Fort Collins

Prep Batch: RN161214-1

Prep Procedure: Rn222

Reviewed By: rlm Review Date: 1/9/2017

Non-Routine Pre-Treatment? Y (N) Batch: NA

Re-Prep? Y (N) Batch: NA

Prep QASS / NCR? Y (N) NA

Prep SOP: PAI 799 Rev: 4

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 12/14/2016

Prep Dept: RS

Balance:

Balance:

Cocktail: 137-16041

Cocktail Pipet: RS401

Aliquot Pipet: RS032

Sampl	Prep	LabID	QC	Dish	Init Alq	Fin Alq	Prep Basis	Standards	Prep Notes
Num	Num		Type	No.	ml	ml			
1	1	1624003-1	SMP	<u>NA</u>	10	10	Unfiltered	S1	
2	1	1624003-2	SMP		10	10	Unfiltered	S1	
3	1	1624003-3	SMP		10	10	Unfiltered	S1	
4	1	1624003-4	SMP		10	10	Unfiltered	S1	
5	1	1N161214-1-1MB	MB		10	10	Unfiltered		
6	1	1N161214-1-1MB	MB		10	10	Unfiltered		
7	1	1N161214-1-1CB1	MB		10	10	Unfiltered		
8	1	1N161214-1-1CB2	MB		10	10	Unfiltered		
9	1	1N161214-1-1MB1	MB		10	10	Unfiltered		
10	1	1N161214-1-1MB2	MB		10	10	Unfiltered		

Comments

Spiked By: Rebecca L. Merola Date: 12/14/2016

Witnessed By: Andrew R. Steger Date: 12/14/2016

Spike Solution Information						
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Pipet ID
S1	Ra-226	916.4095.69		100.357	DPM/ml	RS-032
S1	Rn-222	916.4095.69		100.357	DPM/ml	RS-032

Reagent Solution IDs*

137-13071 J26A03

*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: RN161214-1

Prep Procedure: Rn222

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 799 Rev: 4

Prep SOP: NONE

Matrix Class: liquid

Prep Analyst: Rebecca L. Merola

Prep Date: 12/14/2016

Prep Dept: RS

Balance:

Balance:

Cocktail: 137-16041

Cocktail Pipet: 123401

Aliquot Pipet: 18032

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Standards	Prep Notes
1	1	1624003-1	SMP		10	10		S1	
2	1	1624003-2	SMP		10	10		S1	
3	1	1624003-3	SMP		10	10		S1	
4	1	1624003-4	SMP		10	10		S1	
5	1	16161214-1-1MB	MB		10	10			
6	1	16161214-1-1MB	MB		10	10			
7	1	16161214-1CB1	MB		10	10			
8	1	16161214-1CB2	MB		10	10			
9	1	16161214-1MB1	MB		10	10			
10	1	16161214-1MB2	MB		10	10			

Comments

Spiked By: Ch Date: 12/14/16

Witnessed By: Adam R. Hays Date: 12/14/16

Spike Solution Information							
Soln #	Nuclide	SolnID	Exp Date	Prep Conc	Units	Prep Date	Pipet ID
S1	Ra-226	916.4095.69	1/4/17	100.357	DPM/ml	12/14/16	RS-032
S1	Rn-222	916.4095.69		100.357	DPM/ml	12/14/16	RS-032

Reagent Solution IDs*

137-13071 J26A03

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

Rn-222 Background Determination LS6000

Interim control limits are established from the initial calibration for the geometry of interest. Limits are +/- 3 standard deviations from the initial unquenched 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 (15 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 Count Rate (CPM) is within the established control limits.

CURRENTLY UNDER INTERIM LIMITS

UPDATED 04/10/17 JP

COUNT DATE	#	Sample ID	Count Duration (m)	Count Rate (CPM)	Total Cts.	Mean	Individual Reagent Blanks			Average of Reagent Blanks		
							LCL	UCL	Pass ?	LCL	UCL	Pass ?
4/4/2017	1	RN161214-1CB1	120	5.03	603.6		4.92	6.21	PASS			
4/5/2017	2	RN161214-1CB2	120	5.28	633.6	5.155	4.92	6.21	PASS	4.92	6.21	PASS

DAILY INSTRUMENT PERFORMANCE CHECKS - LS6000 (LL OFF, LUMEX OFF)

Daily IPCs consist of the following standards;

Efficiency Check -			
Eckert & Ziegler Tritium Standard		Eckert & Ziegler C-14 Standard	
Lot 94960	Lot 94944		
106680.00 dpm	101280.0 dpm		
4/24/2014 REF	4/24/2014 REF		
4/1/2019 EXP	4/1/2019 EXP		

Interim Control Limits		as of 05/26/16 LC
	Decay Corrected Tritium	Carbon-14
UCL (3 sigma)	65935.48	78262.74
UWL (2 sigma)	65793.92	78094.17
Mean Value	65510.81	77757.05
LWL (2 sigma)	65227.69	77419.92
LCL (3 sigma)	65086.14	77251.35

Decay Corrected					
Obs	Date	H-3 CPM	H-CPM	PASS?	PASS?
155	4/4/2017	55557.00	65607.70	OK	OK
156	4/5/2017	55215.00	65213.90	LWL	OK

DAILY CHECK LL ON ⁹⁹Tc SOURCE- LS6000

⁹⁹ Tc standard	SPIKE	
836.3020.70	KNOWN ACTIVITY	
9/17/2016	REF	58000.38 dpm/g
9/17/2017	EXP	58000.38 dpm

Interim Control Limits as of 05/26/16 LC

	<u>blank</u>	<u>Blank Quench #</u>	<u>spike</u>
UCL (3 sigma)	22.08	55.46	11685.82
UWL (2 sigma)	19.95	54.51	11308.47
Mean Value	15.69	52.64	10553.78
LWL (2 sigma)	11.43	50.76	9799.10
LCL (3 sigma)	9.30	49.81	9421.75

Obs #	Date	Blank C.R.	Pass ?	Quench #	Pass	Spiked C.R.	Pass ?
155	4/4/2017	16.7	OK	51.8	OK	9963.5	OK
156	4/5/2017	16.5	OK	52.7	OK	10530.2	OK

Prepare a Calibration Source of ~1000 dpm/ml
of Ra-226 from RSD # 907

Density of 0.1M HCl diluent lot# H42 AOV Bal
mass of Volumetric flask 68.2976 g 17
mass of flask + Acid 168.0675 g 4
Net mass 100 ml diluent 99.7699 g
 $\rho = 0.9977 \text{ g/ml}$

Mass of Parent transferred
mass of source (open) 37.7936 g 12
mass of empty vial 32.7493 g L
Net mass transferred 5.0043 g

Dilute to final Vol
Mass of Nalgene, Parent, & Diluent 1151.5 g 26
Net mass of empty Nalgene 74.7890 g 12
Final Mass = 1076.711 g

Activity Calculation

$$\left((18.75 \times 10^4 \text{ Bq}) \left(\frac{60 \text{ dpm}}{1 \text{ Bq}} \right) \left(\frac{5.0043 \text{ g}}{5.02515 \text{ g}} \right) \left(\frac{0.9977 \text{ g/ml}}{1076.711 \text{ g}} \right) \right) = 1025.87 \frac{\text{dpm}}{\text{ml}}$$

Std ID: 907.3610.53

Description: Ra-226

Expiration: 3/10/2011

Activity: 1025.87 dpm/mL

2s Uncertainty: 50.27 dpm/mL

Ref. Date: 2/24/2010

Ref Time: N/A

Prep Date: 3/5/2010 Prep by: JD

Matrix/Comp. 0.1M HCl

Half Life (y): 1.60E+03

Reverification Log

Analysis Date	Initials	Expiration Date
5/3/2011	RG	5/3/2012
9/23/11	RG	9/23/12
1/25/13	JP	1/25/14
5/08/14	JP	5/08/2015
5/06/15	JP	05/06/2016
6/02/16	JP	06/02/2017
12/29/16	JP	12/29/2017

Continued on Page _____

Read and Understood By

Signed

Date

Signed

Date



Eckert & Ziegler

Analytics

PC
2-26-2010

RSO#
907

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

CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

81680A-307

8 mL Liquid in Flame Sealed Vial

Customer: ALS Lab/Fort Collins, CO
P.O. No.: 73828 02-04-10, Item 1

This standard radionuclide source was prepared gravimetrically from a master solution calibrated by Eckert & Ziegler Analytics, using a germanium gamma spectrometer system. Radionuclide purity and calibration were checked with a germanium gamma spectrometer system. The nuclear decay rate and reference date for this source are given below. Eckert & Ziegler Analytics (EZA) maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.18, Revision 1, February, 1979, and compliance with ANSI N42.22-1998, "Traceability of Radioactive Sources to NIST." EZA is accredited by the Health Physics Society (HPS) for the production of NIST-traceable sources, and this source was produced in accordance with the HPS accreditation requirements. Customers may report any concerns with the accreditation program to the HPS Secretariat, 1313 Dolley Madison Blvd., Ste. 402, McLean, VA 22101.

Isotope	Half-Life, Days	Activity (Bq)	Uncertainty*, %			Reference Date (12:00 PM EST)
			u _A	u _B	U	
Ra-226	8.844E+08	1.875E+04	0.8	2.4	4.8	02/24/2010

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

Comments:

Impurities: γ -impurities < 0.1 %. 8.08815 grams in 0.1M HCl solution with approximately 30 μ g/g Ba carrier.

Source Prepared by:

W. Mao, Radiochemist

QA Approved:

J. D. McCorvey, QA Manager Alternate

Date:

2/24/10



Single Isotope Certificate, Rev 1 9/26/2009

Corporate Office

24937 Avenue Tibbitts Valencia, California 91355

Laboratory

1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

916.4095.69

Ra226 working std

Prepare a working dilution of 916.3610.76

12/18/14

1. Density of 0.1M HCl, lot # 0000092116

Mass of 100mL vol. flask:

68.3000g

Balance # 12

Mass of flask & 100mL acid:

168.0372g

Balance# 12

Net Mass:

99.7372g

Density:

0.9974g/mL

2. Mass of 916.3610.76 transferred:

Mass of open empty nalgene:

74.1631g

Balance# 12

Mass of nalgene & standard:

77.5202g

Balance# 12

Net mass of standard transferred:

3.3571g

Balance# NA

3. Dilute to final volume:

Mass of nalgene, standard, & diluent:

1077.5g

Balance# 26

Mass of empty nalgene (from above):

74.1631g

Balance# 12

Net mass of new dilution:

1003.3369g

Balance# NA

4. Final activity calculation:

$$30,156.00 \text{ dpm/g} (0.9974 \text{ g/mL}) \left(\frac{3.3571 \text{ g}}{1003.3369 \text{ g}} \right) = 100.64 \text{ dpm/mL}$$

Std ID: 916.4095.69

Description: Ra-226

Expiration: 1/6/2016

Activity: 100.64 dpm/mL

2s Uncertainty: 4.93 dpm/mL

Ref. Date: 7/1/2010

Ref Time: N/A

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

Matrix/Comp. 0.1M HCl

Half Life (y): 1.60E+03

Reverification Log		
Analysis Date	Initials	Expiration Date
11/4/2016	JP	10/1/2017

JP 11/9/15

JP 11/9/15

(continued on Page

T. Elert

12/8/14

Read and Understood By

JP

01/09/2015

Signed

Date

Signed

Date

Prepare a intermediate dilution of 250 μ g/16.			
0.1 M HCl diluent lot # H45A12			
Density of diluent			
Mass of 100 ml Vol Flask	68.7982 g	12	
Flask + Acid	168.0565 g	2	
Net	99.2583 g		
$\rho = 0.9976 \text{ g/ml}$			
Mass of parent transferred			
Mass of Open full Ampule + Receptor	38.2022 g	12	
Mass of Open Empty Ampule + Receptor	33.2251 g	6	
Net	4.9771 g		
Dilute to final Vol./Mass			
Mass of Open Empty 40 ml Vol. Vial	2.397 g	12	
Mass of Vial, Std. + diluent	57.9016 g	6	
Net	36.5045 g		

Activity, Calc.

JTB 9/27/10

$$\frac{(1860 \text{ D. } R_p)(10 \text{ dpm})}{(1 R_p)} \cdot \frac{4.9771 \text{ g}}{5.65176 \text{ g}} \cdot \frac{1}{36.5045 \text{ g}} = \frac{30156 \text{ dpm}}{36.5045 \text{ g}} = 826.1 \text{ dpm/g}$$

JTB 9/27/10

Continued on Page _____

Read and Understood By



Signed

9/27/10
Date



Signed

9/27/10
Date



Eckert & Ziegler

Analytics

MC 76-10 R50# 9/6

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

CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

82883-307

Ra-226 5 mL Liquid in Flame Sealed Vial

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

This standard radionuclide source was prepared gravimetrically from a master solution calibrated by Eckert & Ziegler Analytics, using a germanium gamma spectrometer system. Radionuclide purity and calibration were checked with a germanium gamma spectrometer system. The nuclear decay rate and reference date for this source are given below. Eckert & Ziegler Analytics (EZA) maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.18, Revision 1, February, 1979, and compliance with ANSI N42.22-1998, "Traceability of Radioactive Sources to NIST." EZA is accredited by the Health Physics Society (HPS) for the production of NIST-traceable sources, and this source was produced in accordance with the HPS accreditation requirements. Customers may report any concerns with the accreditation program to the HPS Secretariat, 1313 Dolley Madison Blvd., Ste. 402, McLean, VA 22101.

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

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

Comments:

Impurities: γ -impurities <0.1%. 8.08176 g 0.1M HCl solution with approximately 30 μ g/g Ba carrier.

Source Prepared by:

W. Mao, Radiochemist

QA Approved:

J. D. McCorvey, QA Manager Alternate

Date:

6/30/10

ANA Form 05 Rev. --

Single Isotope Certificate, Rev 1 9/28/2008



Corporate Office

24937 Avenue Tibbitts Valencia, California 91355

Laboratory

1380 Seaboard Industrial Blvd. Atlanta, Georgia, 30318

Liquid Scintillation Counter

Quality Control Data

Daily Instrument Performance Checks

DAILY INSTRUMENT PERFORMANCE CHECKS - LS6000 (LL OFF, LUMEX OFF)

Daily IPCs consist of the following standards;

Efficiency Check -

Eckert & Ziegler Tritium Standard		Eckert & Ziegler C-14 Standard	
Lot 94960	Lot 94944		
106680.00 dpm	101280.0 dpm		
4/24/2014 REF	4/24/2014 REF		
4/1/2019 EXP	4/1/2019 EXP		

Interim Control Limits

as of 05/26/16 LC

	<u>Decay Corrected Tritium</u>	<u>Carbon-14</u>
UCL (3 sigma)	65935.48	78262.74
UWL (2 sigma)	65793.92	78094.17
Mean Value	65510.81	77757.05
LWL (2 sigma)	65227.69	77419.92
LCL (3 sigma)	65086.14	77251.35

Decay Corrected

Obs	Date	H-3 CPM	H-CPM	PASS?	C-14 CPM	PASS?
188	5/11/2017	55068.90	65404.20	OK	77852.6	OK
189	5/12/2017	55059.80	65403.50	OK	77697.3	OK

R:\INST\SC\LS6000\DAILY QC\LSQA6000_05.25.16 (DAY QC:LL OFF, LUMEX OFF)

AL
5/12/17

DAILY CHECK LL ON ⁹⁹Tc SOURCE- LS6000

⁹⁹ Tc standard		SPIKE	
836.3020.70		KNOWN ACTIVITY	
9/17/2016	REF	58000.38	dpm/g
9/17/2017	EXP	58000.38	dpm

Interim Control Limits as of 05/26/16 LC

	<u>blank</u>	<u>Blank Quench #</u>	<u>spike</u>
UCL (3 sigma)	22.08	55.46	11685.82
UWL (2 sigma)	19.95	54.51	11308.47
Mean Value	15.69	52.64	10553.78
LWL (2 sigma)	11.43	50.76	9799.10
LCL (3 sigma)	9.30	49.81	9421.75

Obs #	Date	Blank C.R.	Pass ?	Quench #	Pass	Spiked C.R.	Pass ?
188	5/11/2017	14	OK	53.7	OK	10682.1	OK
189	5/12/2017	17	OK	53.4	OK	10548.2	OK

I:\Oprtns\RADI\INST\LSC\LS6000\DAIY QC\LSQA6000_05.25.16

05/12/17