# ENGINEERING MANAGEMENT SUPPORT INC.

7220 West Jefferson Avenue, Suite 406
Lakewood, CO 80235

Telephone (303) 940-3426
Telecopier (303) 940-3422

October 10, 2014

VIA: Electronic Mail

U.S. Environmental Protection Agency
Region VII SUPR/MOKS
11201 Renner Boulevard
Lenexa, KS 66219

**ATTENTION:** Mr. Dan Gravatt

**SUBJECT: Monthly Status Report – September 2014**
**West Lake Landfill Operable Unit 1, Bridgeton, Missouri**

Dear Mr. Gravatt,

On behalf of Cotter Corporation (N.S.L.), Bridgeton Landfill, LLC., Rock Road Industries, Inc., and the United Sates Department of Energy (the "Respondents"), Engineering Management Support Inc. (EMSI) submits the attached status report for the month of September 2014 as required by paragraph 56 of the West Lake Landfill Administrative Order on Consent, Docket No. VII-93-F-005. If you have any questions or desire additional information related to this status report or any other aspect of the project, please do not hesitate to contact me.

Sincerely,
**ENGINEERING MANAGEMENT SUPPORT, Inc.**

Paul V. Rosasco, P.E.

Distribution:

Shawn Muenks - Missouri Dept of Natural Resources
Victoria Warren – Republic Services, Inc.
Ward Herst - Herst & Associates, Inc.
Jessie Merrigan – Lathrop & Gage
Bill Beck – Lathrop & Gage
Dale Guariglia – Bryan Cave HRO
John McGahren – Morgan Lewis
Steven Miller - U. S. Department of Energy
Philip Dupre – U.S. Department of Justice
Dan Feezor – Feezor Engineering
Mike Bollenbacher – Auxier & Associates

0714 40474832 3.0
Superfund
0401

**Monthly Status Report – September 2014**
**West Lake Landfill Operable Unit 1**
**Bridgeton, Missouri**

This status report has been prepared by Engineering Management Support Inc. (EMSI) on behalf of Cotter Corporation (N.S.L.), Bridgeton Landfill, LLC (formerly known as Laidlaw Waste Systems [Bridgeton] Inc.), Rock Road Industries, Inc., and the United States Department of Energy (the "Respondents") for Operable Unit - 1 (OU-1) at the West Lake Landfill as required by paragraph 56 of the West Lake Landfill Administrative Order on Consent, Docket No. VII-93-F-005.

## 1. Work Performed During September 2014

Project Planning

A draft of the Core Sampling (Phase 1B, 1C and 2) Work Plan for the isolation barrier investigation was submitted to EPA and MDNR on December 18, 2013. EPA comments on the draft work plan were received on December 26, 2013. The final Phase 1B, 1C and 2 Core Sampling Work Plan was submitted on January 8, 2014.

EPA comments on the various work plans prepared for the additional Supplemental Feasibility Study evaluations were received on August 16, 2013. A meeting was held with EPA and MDNR on September 24, 2013 to discuss comments on the work plans for the additional SFS evaluations. Revisions to the work plans for evaluations of alternative Area 2 depths and volumes, apatite treatment technologies and additional discount rate were prepared and submitted to EPA and MDNR on October 31, 2013. A revised work plan for evaluation of alternative landfill cover designs was submitted to EPA and MDNR on February 21, 2014. A revised work plan for performance of fate and transport evaluations was submitted to EPA and MDNR on September 4, 2014. EPA approval of the work plans for additional discount rate evaluations and evaluation of alternative landfill cover designs was received on September 19, 2014.

A draft Remedial Design Work Plan was submitted to EPA in November 2008. In accordance with direction from EPA, all work on design of the ROD-selected remedy has been put on hold.

Fieldwork - Sample Collection/Analysis

Other than continuation of the air monitoring activities associated with Phase 1 of the Thermal Isolation Barrier investigation, no field work was conducted.

Report Preparation

The monthly progress report for August 2014 was prepared and submitted to EPA and MDNR on September 10, 2014.

During September, the following work was performed:

- Evaluations of volume estimates for the three partial excavation options identified by EPA;
- Preparation of a comprehensive groundwater report; and
- Preparation of a summary report for the Phase 1 drilling and sampling investigation of potential areas for locating a thermal/isolation barrier between the North Quarry area of the Bridgeton Landfill and West Lake Landfill Area 1.

Pursuant to EPA approval of the work plans for additional discount rates evaluations and evaluation of alternative landfill cover designs, work was initiated on these evaluations during September.

Project Management

None.

Meetings

None.

Correspondence

None.

## 2. Analytical Data Collected During This Reporting Period

An analytical report for samples collected as part of the Isolation Barrier investigations was received during this period. Specifically, the laboratory report (Eberline nos. 14-08008) for the results of ongoing air monitoring was received. This report is included with the submittal of this status report.

## 3. Work Scheduled to be Performed during October and November 2014

The following activities will be performed during October and November 2014:

- Preparation of a summary report that presents the data from the four additional groundwater monitoring events (July/August 2012, April 2013, July 2013, and October 2013) and provides interpretation of the results for the four events;

- Evaluations to estimate volumes for the partial excavation options identified by EPA;

- Evaluations of present worth cost estimates for the alternatives in the SFS using additional discount rates;

- Evaluation of the potential application of an alternative landfill cover that incorporates a geosynthetic clay liner (GCL) into the design of the cover for OU-1; and

- Preparation of the Bridgeton Landfill Thermal Isolation Barrier Investigation Phase 1 Report that summaries the results of the Phase 1 drilling and sampling associated with investigation of potential areas for locating a thermal/isolation barrier.

## 4. Problems Encountered

On September 29, 2014, it was discovered that one of the two air samplers being operated voluntary as a continuation of the air monitoring activities associated with the Phase 1 drilling and sampling activities (completed in April 2014) had ceased operating. Specifically, the air sampler located adjacent to the Transfer Station had ceased operating sometime during September. The filter in this sampler was collected and submitted for analyses, although the exact length of time the sampler operated during this period is uncertain. EPA provided final comments on the Air Monitoring, Sampling and QA/QC Plan for the Isolation Barrier Preconstruction Activities (discussed in the separate monthly progress report for the Isolation Barrier Preconstruction Work) on September 23, 2014 and therefore, implementation of the comprehensive air monitoring plan, which includes a permanent air monitoring station adjacent to the transfer station, appears imminent. Consequently, a decision was made not to order replacement equipment for the failed sampling device but instead to move forward with implementation of the comprehensive air monitoring program installation and operation upon receipt of EPA approval of the plan.

# FEEZOR ENGINEERING, INC.

## FEE/BRI

## STANDARD LEVEL IV
## REPORT OF ANALYSIS

## WORK ORDER #14-08008-OR

**September 2, 2014**

**EBERLINE ANALYTICAL/OAK RIDGE LABORATORY**
**OAK RIDGE, TN**

## TABLE OF CONTENTS


| SECTION | DESCRIPTION | PAGE |
|---|---|---|
| I | Chain of Custody | 0004 |
| II | Sample Acknowledgement | 0008 |
| III | Case Narrative | 0011 |
| IV | Analytical Results Summary | 0014 |
| V | Analytical Standard | 0016 |
| VI | Quality Control Sample Results Summary | 0030 |
| VII | Laboratory Technician's Notes | 0035 |
| VIII | Analytical Data (Isotopic Thorium) | 0045 |
| IX | Analytical Data (Gross Alpha/Beta) | 0089 |
| | Last Page Number | 0108 |

**Eberline Services – Oak Ridge Laboratory**

**LABORATORY DATA SUPPORT CHECKLIST**

MP-001-3

Eberline Services Work Order # 14-08008

The checklist items listed below are to be initialed by appropriate staff upon completion/verification.

| Date for Partial | Initials | Date | Initials | Checklist Items |
|---|---|---|---|---|
| | | 8/4/14 | KC | Sample Log-In |
| | | 8/12/14 | KBS | Data Compilation |
| | | 8-26-14 | nLT | First Technical Data Review |
| | | 8/26/14 | MSK | Second Technical Data Review |
| | | 8/28/14 | [illegible] | Data Entry/Electronic Deliverable |
| | | 8/28/14 | [illegible] | Case Narrative |
| | | 08/29/14 | EGJ | Electronic Deliverable Proof |
| | | 8/29/14 | MSK | Samples Analyzed within Holding Time Yes? [X] No? [ ] |
| | | 8/29/14 | MSK | QA/QC Review |
| | | | | Client in Possession of Data Electronic or Hard Copy |
| | | | | Invoiced by Laboratory |

| Technical/Clerical Corrections, Signatures Needed, Problems, Etc | Date/Initials |
|---|---|
| | |
| | |
| | |
| | |

Date package approved by: [signature] 9/2/14

Laboratory Manager Date

Copy No. _____

# SECTION I

# CHAIN OF CUSTODY

14-08008

REC'D AUG 04 2014

Auxier & Associates, Inc.
9821 Cogdill Road
Suite 1
Knoxville, TN 37932
(423) 675-3669

Radiological Health, Safety and Environmental Services
A USA Environment, LP. Company

# CHAIN OF CUSTODY FORM

| | | | |
|---|---|---|---|
| Project Name: | FEE/BRI | Project Manager: | Beth Jansen |
| Location: | Bridgeton, MO | Telephone No.: | 865-675-3669 |
| Sample Custodian: | | Fax No.: | 865-675-3677 |

| SAMPLE IDENTIFICATION | START COLLECTION | STOP COLLECTION | CFM Start | CFM Stop | TOTAL HOURS | SAMPLE DESCRIPTION |
|---|---|---|---|---|---|---|
| 4 OUTSIDE TRAILER | 7/18/14 0840 | 8/1/14 0840 | 3 | 2.5 | 336 | AIR FILTER |
| 5 TRANSFER STATION | 7/18/14 0900 | 8/1/14 0900 | 3 | 2 | 336 | AIR FILTER |
| | | | | | | |
| | | | | | | |
| | ANALYZE FOR GROSS ALPHA, GROSS BETA, + ISOTOPIC THORIUM | | | | | |
| | | STANDARD T.A.T. | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| | | | |
|---|---|---|---|
| Relinquished By/Date: [signature] 8/1/14 1000 | Received In Good Condition By: Kristen Coulston | Time: 900 | Date: 8/4/14 |
| Method Of Shipment/Tracking #: FEDEX 770740423103 | | | |
| Relinquished By: | Received In Good Condition By: | Time: | Date: |
| Method Of Shipment: | | | |

0005

| EBERLINE SERVICES Oak Ridge Laboratory | Internal Chain of Custody | Work Order # | 14-08008 |
|---|---|---|---|
| | | Lab Deadline | 8/25/2014 |
| | | Analysis | ThISO - Level 4 |
| | | Sample Matrix | Air Filter |

| Comments | Sample Fraction | HP 210 / 270 Detector Activity | Storage Location |
|---|---|---|---|
| | 04 | 43 | S1.4 |
| | 05 | 56 | S1.4 |

| | Location (circle one) | | | | | Initials | Date |
|---|---|---|---|---|---|---|---|
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | JWolfe | 8/7/14 1700 |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | JW | 8/7/14 1733 |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | JPA | 8/7/14 1733 |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | [illegible] | 8/11/14 0807 |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | [illegible] | 8/11 [illegible] |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | KB | 8/11/14 1437 |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |



Printed: 8/4/2014 12:17 PM

| EBERLINE SERVICES Oak Ridge Laboratory | Internal Chain of Custody | Work Order # | 14-08008 |
|---|---|---|---|
| | | Lab Deadline | 8/25/2014 |
| | | Analysis | GaGbT_ThSr - Level 4 |
| | | Sample Matrix | Air Filter |

| Comments | Sample Fraction | HP 210 / 270 Detector Activity | Storage Location |
|---|---|---|---|
| | 04 | 43 | S1.4 |
| | 05 | 56 | S1.4 |

| | Location (circle one) | | | | | Initials | Date |
|---|---|---|---|---|---|---|---|
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | JWDB | 8/5/14 1300 |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | JWDB | 8/6/14 0900 |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | [illegible] | 0720 |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | ICB | 8/6/14 1627 |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| Received by | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |
| **Relinquished by** | Sample Storage | Rough Prep | Prep | Separations | Count Room | | |



Printed: 8/4/2014 12:17 PM

## SECTION II

## SAMPLE ACKNOWLEDGEMENT

| Client Name | Contract/PO | Project Type | Date Received | Required Turnaround Days | Eberline Services Work Order |
|---|---|---|---|---|---|
| Feezor Engineering, Inc. | BT-026-PO1 | Environmental | 08/04/2014 | 28 | 14-08008 |
| **Project Name** | **Client WO** | **Sample Disp** | **Lab Deadline** | **Internal Deadline** | **Client Deadline** |
| FEEBRI | FEE/BRI Bridgeton, MO | H | 08/25/2014 | 08/29/2014 | 09/02/2014 |

| Internal ID | Client ID | Sample Date | Matrix | Storage | GaGbT | ThISO | Ttl |
|---|---|---|---|---|---|---|---|
| 01 | LCS | 08/04/14 | AF | S1.4 | X | X | 2 |
| 02 | BLANK | 08/04/14 | AF | S1.4 | X | X | 2 |
| 03 | DUP | 08/04/14 | AF | S1.4 | X | X | 2 |
| 04 | OUTSIDE TRAILER | 08/01/14 08:40 | AF | S1.4 | X | X | 2 |
| 05 | TRANSFER STATION | 08/01/14 09:00 | AF | S1.4 | X | X | 2 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | | | | | | | 0 |
| | Totals Per Analysis (non QA samples) | | | | 2 | 2 | |

EBERLINE SERVICES

Sample Log In Report

Oak Ridge Laboratory
601 Scarboro Rd.
Oak Ridge, TN 37830

Voice: (865) 481-0683
Fax: (865) 483-4621

**Invoice**
Accounts Payable
Feezor Engineering, Inc
406 East Walnut Street
Chatham, IL 62629
Voice 217-483-3118
Fax

**Contact**
Mike Bollenbacher
Voice 865-675-0379
Fax 865-675-3677

**Report Data**
Dan Feezor
Feezor Engineering, Inc
406 East Walnut Street
Chatham, IL 62629
Voice 217-483-3118
Fax

Printed: 8/4/2014 12:17 PM

**Eberline Services – Oak Ridge Laboratory**

SAMPLE RECEIPT CHECKLIST
MP-001-2

WORK ORDER # 14-08003

SAMPLE MATRIX/MATRICES: (CIRCLE ONE OR BOTH)

AQUEOUS NON-AQUEOUS

(CIRCLE EITHER YES, NO, OR N/A)

WERE SAMPLES:

| | | | |
|---|---|---|---|
| Received in good condition? | Y | N | |
| If aqueous, properly preserved | Y | N | N/A |

WERE CHAIN OF CUSTODY SEALS:

| | | |
|---|---|---|
| Present on outside of package? | Y | N |
| Unbroken on outside of package? | Y | N |
| Present on samples? | Y | N |
| Unbroken on samples? | Y | N |
| Was chain of custody present upon sample receipt? | Y | N |

IF THE RESPONSE TO ANY OF THE ABOVE IS **NO**, A DISCREPANT SAMPLE RECEIPT REPORT (DSR) HAS BEEN ISSUED.

REMARKS: _____

SIGNATURE: Kristen Carlston DATE: 8/4/14

# SECTION III

# CASE NARRATIVE

EBERLINE SERVICES

EBERLINE ANALYTICAL CORPORATION
601 SCARBORO ROAD
OAK RIDGE, TENNESSEE 37830
PHONE (865) 481-0683
FAX (865) 483-4621

EBS-OR-37790

September 2, 2014

Dan Feezor
Feezor Engineering, Inc.
406 East Walnut Street
Chatham, IL 62629

CASE NARRATIVE
Work Order # 14-08008-OR

SAMPLE RECEIPT

This work order contains two air filter samples received 08/04/2014. Both samples were analyzed for Isotopic Thorium and Gross Alpha/Beta.

| CLIENT ID | LAB ID |
|---|---|
| OUTSIDE TRAILER | 14-08008-04 |
| TRANSFER STATION | 14-08008-05 |

ANALYTICAL METHODS

Isotopic Thorium was analyzed using Method EML Th-01 Modified. Gross Alpha/Beta was performed using Method LANL MLR-100 Modified.

ANALYTICAL RESULTS

Combined Standard Uncertainty is reported at 2-sigma value.

ISOTOPIC THORIUM

Samples were prepared by digestion of filter media using mixed acids followed by subsequent dilutions. Aliquots from these dilutions were taken and Thorium was selectively extracted by ion exchange. Thorium was eluted, micro-precipitated and mounted on micro-porous filter media. Sample activities were then determined by alpha spectroscopy using energy specific regions of interest for Thorium-228, Thorium-230 and Thorium-232. Chemical recovery was determined by the use of a Thorium-229 tracer. Activity of the Thorium-229 tracer was determined by alpha spectroscopy using an energy specific region of interest.

Samples demonstrated acceptable results for all Thorium analyses. Chemical recovery was acceptable for all samples. The Thorium-228, Thorium-230 and Thorium-232 method blank demonstrated acceptable results. Results for the Thorium-228 and Thorium-230 duplicate demonstrated an acceptable relative percent difference and normalized difference. Results for the Thorium-232 duplicate demonstrated a high relative percent difference; however, normalized difference is within acceptable limits for the analytical technique. Results for the Thorium-228, Thorium-230 and Thorium-232 laboratory control sample demonstrated an acceptable percent recovery.

ANALYTICAL RESULTS CONTINUED

GROSS ALPHA & BETA

An aliquot of each filter analyzed for Gross Alpha and Beta activity was attached directly to a stainless steel planchet and transferred to the counting room for activity determinations by gas-flow proportional counting.

Samples demonstrated acceptable results for all Gross Alpha and Beta analyses. The Gross Alpha and Beta method blank demonstrated acceptable results. Results for the Gross Alpha and Beta replicate demonstrated an acceptable relative percent difference and normalized difference. Results for the Gross Alpha and Beta laboratory control sample demonstrated an acceptable percent recovery.

CERTIFICATION OF ACCURACY

I certify that this data report is in compliance with the terms and conditions of the Purchase Order, both technically and for completeness, for other than the conditions detailed above. Release of the data contained in this hard copy data package has been authorized by the cognizant project manager or his/her designee to be accurate as verified by the following signature.

M.R. McDougall
Laboratory Manager

Date: 9/2/2014

Eberline Analytical wants and encourages your feedback regarding our performance providing radioanalytical services. Please visit http://www.eberlineservices.com/client.htm to provide us with feedback on our services.

# SECTION IV

# ANALYTICAL RESULTS SUMMARY

# Eberline Analytical
## Final Report of Analysis

*Report To:*
Dan Feezor
Feezor Engineering, Inc.
406 East Walnut Street
Chatham, IL 62629

*Work Order Details:*
*SDG:* 14-08008
*Purchase Order:* BT-026-PO1
*Analysis Category:* ENVIRONMENTAL
*Sample Matrix:* AF

| Lab ID | Sample Type | Client ID | Sample Date | Receipt Date | Analysis Date | Batch ID | Analyte | Method | Result | CU | CSU | MDA | CV | Report Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14-08008-01 | LCS | KNOWN | 08/04/14 00:00 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Alpha | LANL MLR-100 Modified | 2.48E-04 | 1.07E-05 | | | | uCi/ml |
| 14-08008-01 | LCS | SPIKE | 08/04/14 00:00 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Alpha | LANL MLR-100 Modified | 2.70E-04 | 3.72E-06 | 2.97E-05 | 3.04E-07 | 3.03E-07 | uCi/ml |
| 14-08008-02 | MBL | BLANK | 08/04/14 00:00 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Alpha | LANL MLR-100 Modified | 1.73E-16 | 2.60E-16 | 2.81E-16 | 5.88E-16 | 5.76E-16 | uCi/ml |
| 14-08008-03 | DUP | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Alpha | LANL MLR-100 Modified | 2.86E-15 | 7.31E-16 | 7.95E-16 | 9.00E-16 | 9.29E-16 | uCi/ml |
| 14-08008-04 | DO | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Alpha | LANL MLR-100 Modified | 3.32E-15 | 7.71E-16 | 8.52E-16 | 9.00E-16 | 9.29E-16 | uCi/ml |
| 14-08008-05 | TRG | TRANSFER STATION | 08/01/14 09:00 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Alpha | LANL MLR-100 Modified | 2.50E-15 | 6.80E-16 | 7.32E-16 | 7.36E-16 | 7.17E-16 | uCi/ml |
| | | | | | | | | | | | | | | |
| 14-08008-01 | LCS | KNOWN | 08/04/14 00:00 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Beta | LANL MLR-100 Modified | 2.78E-04 | 8.34E-06 | | | | uCi/ml |
| 14-08008-01 | LCS | SPIKE | 08/04/14 00:00 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Beta | LANL MLR-100 Modified | 2.54E-04 | 3.00E-06 | 3.52E-05 | 6.51E-07 | 2.31E-06 | uCi/ml |
| 14-08008-02 | MBL | BLANK | 08/04/14 00:00 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Beta | LANL MLR-100 Modified | -2.52E-16 | 7.74E-16 | 7.74E-16 | 1.68E-15 | 5.87E-15 | uCi/ml |
| 14-08008-03 | DUP | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Beta | LANL MLR-100 Modified | 2.85E-14 | 1.69E-15 | 4.28E-15 | 1.63E-15 | 5.71E-15 | uCi/ml |
| 14-08008-04 | DO | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Beta | LANL MLR-100 Modified | 2.79E-14 | 1.67E-15 | 4.20E-15 | 1.63E-15 | 5.71E-15 | uCi/ml |
| 14-08008-05 | TRG | TRANSFER STATION | 08/01/14 09:00 | 8/4/2014 | 8/6/2014 | 14-08008 | Gross Beta | LANL MLR-100 Modified | 2.64E-14 | 1.67E-15 | 4.01E-15 | 1.54E-15 | 5.20E-15 | uCi/ml |
| | | | | | | | | | | | | | | |
| 14-08008-01 | LCS | KNOWN | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-228 | EML Th-01 Modified | 5.09E-06 | 1.83E-07 | | | | uCi/ml |
| 14-08008-01 | LCS | SPIKE | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-228 | EML Th-01 Modified | 5.71E-06 | 8.92E-07 | 1.04E-06 | 7.92E-08 | 1.16E-08 | uCi/ml |
| 14-08008-02 | MBL | BLANK | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-228 | EML Th-01 Modified | 2.17E-17 | 3.69E-17 | 3.69E-17 | 6.24E-17 | 6.29E-18 | uCi/ml |
| 14-08008-03 | DUP | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-228 | EML Th-01 Modified | 2.74E-16 | 1.43E-16 | 1.46E-16 | 7.22E-17 | 5.35E-18 | uCi/ml |
| 14-08008-04 | DO | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-228 | EML Th-01 Modified | 3.04E-16 | 1.64E-16 | 1.67E-16 | 1.12E-16 | 1.61E-17 | uCi/ml |
| 14-08008-05 | TRG | TRANSFER STATION | 08/01/14 09:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-228 | EML Th-01 Modified | 3.91E-16 | 1.42E-16 | 1.47E-16 | 6.81E-17 | 1.38E-17 | uCi/ml |
| | | | | | | | | | | | | | | |
| 14-08008-01 | LCS | KNOWN | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-230 | EML Th-01 Modified | 5.52E-06 | 1.49E-07 | | | | uCi/ml |
| 14-08008-01 | LCS | SPIKE | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-230 | EML Th-01 Modified | 5.63E-06 | 8.83E-07 | 1.12E-06 | 6.72E-08 | 7.63E-09 | uCi/ml |
| 14-08008-02 | MBL | BLANK | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-230 | EML Th-01 Modified | 1.00E-16 | 7.44E-17 | 7.54E-17 | 6.25E-17 | 7.06E-18 | uCi/ml |
| 14-08008-03 | DUP | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-230 | EML Th-01 Modified | 6.34E-16 | 2.30E-16 | 2.43E-16 | 1.03E-16 | 3.46E-18 | uCi/ml |
| 14-08008-04 | DO | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-230 | EML Th-01 Modified | 4.98E-16 | 2.14E-16 | 2.23E-16 | 1.11E-16 | 1.73E-17 | uCi/ml |
| 14-08008-05 | TRG | TRANSFER STATION | 08/01/14 09:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-230 | EML Th-01 Modified | 5.57E-16 | 1.75E-16 | 1.88E-16 | 5.78E-17 | 9.03E-18 | uCi/ml |
| | | | | | | | | | | | | | | |
| 14-08008-01 | LCS | KNOWN | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-232 | EML Th-01 Modified | 5.09E-06 | 1.83E-07 | | | | uCi/ml |
| 14-08008-01 | LCS | SPIKE | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-232 | EML Th-01 Modified | 5.48E-06 | 8.63E-07 | 9.89E-07 | 6.71E-08 | 7.92E-08 | uCi/ml |
| 14-08008-02 | MBL | BLANK | 08/04/14 00:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-232 | EML Th-01 Modified | 8.61E-18 | 2.63E-17 | 2.64E-17 | 6.24E-17 | 7.33E-17 | uCi/ml |
| 14-08008-03 | DUP | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-232 | EML Th-01 Modified | 5.13E-16 | 2.04E-16 | 2.09E-16 | 1.03E-16 | 9.05E-17 | uCi/ml |
| 14-08008-04 | DO | OUTSIDE TRAILER | 08/01/14 08:40 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-232 | EML Th-01 Modified | 2.45E-16 | 1.45E-16 | 1.47E-16 | 1.03E-16 | 1.14E-16 | uCi/ml |
| 14-08008-05 | TRG | TRANSFER STATION | 08/01/14 09:00 | 8/4/2014 | 8/11/2014 | 14-08008 | Thorium-232 | EML Th-01 Modified | 4.40E-16 | 1.52E-16 | 1.56E-16 | 6.13E-17 | 5.41E-17 | uCi/ml |

CU=Counting Uncertainty;CSU=Combined Standard Uncertainty (2-sigma);MDA=Minimal Detected Activity;LCS=Laboratory Control Sample; MBL=Blank; DUP=Duplicate; TRG=Normal Sample; DO=Duplicate Original; CV=Critical Value

EBERLINE SERVICES

EBERLINE ANALYTICAL CORPORATION
601 SCARBORO ROAD OAK RIDGE, TN 37830 865/481-0683 FAX 865/483-4621

0015

# SECTION V

# ANALYTICAL STANDARD

Th-8

# CERTIFICATE OF CALIBRATION
# ALPHA STANDARD SOLUTION

| | | | |
|---|---|---|---|
| Radionuclide: | Th-232 | Customer: | TMA EBERLINE |
| Half Life: | (1.405 ± 0.006) x 10^10 years | P.O.No.: | VH1632 |
| Catalog No.: | 7232 | Reference Date: | November 1 1993 12:00 PST. |
| Source No.: | 435-104-2 | Contained Radioactivity: | (Th-232) 0.0933 µCi. |
| | | Contained Radioactivity: | (Th-232) 3.45 kBq. |

Description of Solution

a. Mass of solution: 11.9712 g (in a 10 ml flame sealed ampoule)

b. Chemical form: Th(NO3)4 in water

c. Carrier content: None added

d. Density: Approx. 1.21 g/ml @ 20°C.

Radioimpurities None detected (other than daughters).

Radioactive Daughters

Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, Tl-208

Radionuclide Concentration

(Th-232) 0.00779 µCi/g.

Method of Calibration

Activity calculations are based upon known specific activity and mass.

Uncertainty of Measurement

a. Systematic uncertainty in instrument calibration: ±3.0%

b. Random uncertainty in assay: ±0.0%

c. Random uncertainty in weighing(s): ±2.0%

d. Total uncertainty at the 99% confidence level: ±3.6%

NIST Traceability

This calibration is implicitly traceable to the National Institute of Standards and Technology.

Leak Test(s)

See reverse side for Leak Test(s) applied to this source.

Notes

1. Nuclear data were taken from "Table of Radioactive Isotopes", edited by Virginia S. Shirley, 1986.
2. IPL participates in an NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).

Anna U. Mna
QUALITY CONTROL

Nov. 8, 1993
Date Signed

ISOTOPE PRODUCTS LABORATORIES
1800 North Keystone Street
Burbank, California 91504
(818) 843 - 7000

EBERLINE SERVICES

# QUALITY CONTROL PROGRAM

MP-009

Rev.8; 1/10/03
Title: Radioactive Reference Standards Solutions & Records

## EBERLINE SERVICES - OAK RIDGE LABORATORY
## RADIOACTIVE REFERENCE SOLUTIONS
## *PRIMARY DILUTION RECERTIFICATION*
## MP 009

CURRENT DATE: 9/23/2013 0:00

SOLUTION REFERENCE #: IPL 435-104-2

SOLUTION #: Th-8

| Principal Radionuclide | Half Life, Years | Half Life, Days |
|---|---|---|
| $^{232}Th$, $^{228}Th$ | 1.405E+10 | 5.132E+12 |

Radionuclide: $^{232\&228}Th$

Reference Date: 11/1/1993 0:00

Certified Activity: 9.330E-02 µCi

Certified Concentration: µCi per gram

Ampoule /Solution Gross: 18.8415 Weight, Grams

Empty Ampoule: 6.9296 Weight, Grams

Solution Net: 11.9119 Weight, Grams

Total Activity in Ampoule: 0.0933 µCi

Chemical Composition of Standard Solution

$Th(NO_3)_4$ in H2O

**Dilution Instructions:**

Dilution Solvent Used: 1% Nitric Acid

Dilute to a volume of 1000.00 milliliters

Certified Total Activity of 0.0933 µCi Which Equals 2.071E+05 dpm at the date listed above

And after dilution the activity of this solution is 2.071E+02 dpm/ml

This activity concentration is based on the original reference date listed above. All activities are corrected to the date and time of analysis by the laboratory data processing software.

Expiration Date: September 23, 2014

Verified & Approved By _____ Date: 9/23/2013 0:00

QC Approval _____ Date: 9/27/13

0018

EBERLINE SERVICES

**QUALITY CONTROL PROGRAM**
MP-009

Rev.8; 1/10/03
Title: Radioactive Reference Standards Solutions & Records

## EBERLINE SERVICES - OAK RIDGE LABORATORY
## RADIOACTIVE REFERENCE STANDARD SOLUTIONS
*SECONDARY DILUTION RECERTIFICATION*

MP-009
Solution Reference # IPL 435-104-2

Date 9/23/2013 0:00
Solution # Th-8b

| Principal Radionuclide | Half Life, Years | Half Life, Days |
|---|---|---|
| $^{228\&232}Th$ | 1.405E+10 | 5.132E+12 |

Radionuclide of Interest $^{228\&232}Th$
Parent Solution Conc. 2.07E+02 dpm/ml

Reference Date 11/1/1993 0:00

Chemical Composition of Standard Solution
$Th(NO_3)_4$ in 1% $HNO_3$

Dilution Instructions:

Dilution Solvent Used 1% Nitric Acid

*SECONDARY VOLUMETRIC DILUTION*

Vol. Parent Solution: 500.0000 ml
Total Activity: 1.0355E+05 dpm
Final Volume: 1000.00 ml

Final Activity Concentration: 1.0355E+02 dpm/ml

NOTES:

This activity concentration is based on the original reference date listed above. All activities are corrected to the date and time of analysis by the laboratory data processing software.

Expiration Date: September 23, 2014

Verified & Approved By _____ Date: 9/23/2013 0:00

QC Approval _____ Date: 9/27/13

QA/QC REVIEWED
Date 10/14/91 Initials

# CERTIFICATE OF CALIBRATION
# ALPHA STANDARD SOLUTION

Received
OCT 14 1991
TMA/Eberline
Oak Ridge Lab

| | | | |
|---|---|---|---|
| Radionuclide | Th-230 | Customer: | TMA EBERLINE |
| Half Life: | (7.54 ± 0.03) x 10^4 years | P.O.No.: | TT4944 |
| Catalog No.: | 7230 | Reference Date: | November 1 1991 12:00 PST. |
| Source No.: | 388-116 | Contained Radioactivity: | 1.036 µCi. |

**Description of Solution**

a. Mass of solution: 5.0042 grams.
b. Chemical form: Th(NO3)4 in 0.1N HNO3
c. Carrier content: None added
d. Density: 1.0016 gram/ml @ 20°C.

**Radioimpurities**

See attached technical data sheet

**Radioactive Daughters**

See attached technical data sheet

**Radionuclide Concentration**

0.207 µCi/gram.

**Method of Calibration**

Weighed aliquots of the solution were assayed using a liquid scintillation counter.

**Uncertainty of Measurement**

a. Systematic uncertainty in instrument calibration: ±2.0%
b. Random uncertainty in assay: ±0.5%
c. Random uncertainty in weighing(s): ±0.2%
d. Total uncertainty at the 99% confidence level: ±2.7%

**NIST Traceability**

This calibration is implicitly traceable to the National Institute of Standards and Technology.

**Notes**

1. Nuclear data were taken from "Table of Isotopes", Seventh Edition, edited by Virginia S. Shirley.
2. IPL participates in an NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay(and later NIST certification) of Standard Reference Materials. (As in NRC Regulatory Guide 4.15)

QUALITY CONTROL

ISOTOPE PRODUCTS LABORATORIES
1800 No. Keystone Street.,
Burbank, California 91504
(818) 843 - 7000

EBERLINE SERVICES

# QUALITY CONTROL PROGRAM

MP-009

Rev.14; 10/10/2012
Title: Radioactive Reference Standards Solutions & Records

## EBERLINE SERVICES - OAK RIDGE LABORATORY
## RADIOACTIVE REFERENCE SOLUTIONS
## *PRIMARY DILUTION RECERTIFICATION*
## MP 009

CURRENT DATE: 3/1/2014 0:00

SOLUTION REFERENCE #: IPL 388-116

SOLUTION #: Th-1

| Principal Radionuclide | Half Life, Years | Half Life, Days |
|---|---|---|
| $^{230}$Th | 7.540E+04 | 2.754E+07 |

Radionuclide: $^{230}$Thorium

Reference Date: 11/1/1991 0:00

Certified Activity: 1.036E+00 µCi

Certified Concentration: µCi per gram

| | | |
|---|---|---|
| Ampoule /Solution Gross | 9.2660 | Weight, Grams |
| Empty Ampoule | 4.6218 | Weight, Grams |
| Solution Net | 4.6442 | Weight, Grams |
| Total Activity In Ampoule | 1.0360 | µCi |

**Chemical Composition of Standard Solution**

$^{230}Th(NO_3)_4$ in 0.1N $HNO_3$

**Dilution Instructions:**

Dilution Solvent Used: 0.1N $HNO_3$

Dilute to a volume of 1000.00 milliliters

Certified Total Activity of 1.0360 µCi Which Equals 2.300E+06 dpm at the date listed above

And after dilution the activity of this solution is 2.300E+03 dpm/ml

This activity concentration is based on the original reference date listed above. All activities are corrected to the date and time of analysis by the laboratory data processing software.

Expiration Date: February 24, 2015

Recertified By _____ Date: 3/1/2014 0:00

QC Approval _____ Date: 3/6/14

EBERLINE SERVICES

**QUALITY CONTROL PROGRAM**
MP-009

Rev.14; 10/10/2012
Title: **Radioactive Reference Standards Solutions & Records**

## EBERLINE SERVICES - OAK RIDGE LABORATORY
## RADIOACTIVE REFERENCE STANDARD SOLUTIONS
*SECONDARY DILUTION RECERTIFICATION*

MP-009
**Solution Reference #** IPL 388-116

**Date** 3/1/2014 0:00
**Solution #** Th-1b

| Principal Radionuclide | Half Life, Years | Half Life, Days |
|---|---|---|
| $^{230}$Th | 7.540E+04 | 2.754E+07 |

**Radionuclide of Interest** $^{230}$Thorium
**Parent Solution Conc.** 2.30E+03 dpm/ml

**Reference Date** 11/1/1991 0:00

**Chemical Composition of Standard Solution**
$^{230}Th(NO_3)_4$ in 0.1N $HNO_3$

**Dilution Instructions:**

**Dilution Solvent Used** 0.1N $HNO_3$

*SECONDARY VOLUMETRIC DILUTION*

**Vol. Parent Solution:** 10.0000 ml
**Total Activity:** 2.2999E+04 dpm
**Final Volume:** 1000.00 ml

**Final Activity Concentration:** 2.2999E+01 dpm/ml

**NOTES:**

**This activity concentration is based on the original reference date listed above. All activities are corrected to the date and time of analysis by the laboratory data processing software.**

**Expiration Date:** February 24, 2015

Recertified By _____ Date: 3/1/2014 0:00

Verified & Approved By _____ Date: 3/1/14

QC Approval _____ Date: 3/6/14

Th-18

Isotope Products Laboratories
An Eckert & Ziegler Company

24937 Avenue Tibbitts
Valencia, California 91355

Tel 661•309•1010
Fax 661•257•8303

# CERTIFICATE OF CALIBRATION
# ALPHA STANDARD SOLUTION

| | | | |
|---|---|---|---|
| **Radionuclide:** | Th-229 | **Customer:** | EBERLINE SERVICES |
| **Half-life:** | 7340 ± 160 years | **P.O. No.:** | 00009633 |
| **Catalog No.:** | 7229 | **Reference Date:** | 15-Jan-02 12:00 PST |
| **Source No.:** | 867-54 | **Contained Radioactivity: (Th-229 only)** | 1.013 µCi 37.48 kBq |

**Physical Description:**

A. Mass of solution: 5.0147 g in 5 mL flame-sealed ampoule
B. Chemical form: $Th(NO_3)_4$ in 0.1M $HNO_3$
C. Carrier content: 10µg Th/mL
D. Density: 1.0016 g/mL @ 20°C.

**Radioimpurities:**

None detected (daughters in equilibrium)

**Radionuclide Concentration:** 0.2020 µCi/g, 7.474 kBq/g

**Method of Calibration:**

This source was prepared from a weighed aliquot of solution whose activity in µCi/g was determined using gamma ray spectrometry.

Peak energy used for integration: 193.5 keV
Branching ratio used: 0.0441 gammas per decay

**Uncertainty of Measurement:**

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

**Notes:**

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Nuclear data was taken from IAEA Technical Report Series No. 261.
- This solution has a working life of 5 years.

Quality Control — Date Signed: 9-Jan-02 — IPL Ref. No.: 867-54

EBERLINE SERVICES

# QUALITY CONTROL PROGRAM

MP-009

Rev.8; 1/10/03
Title: Radioactive Reference Standards Solutions & Records

## EBERLINE SERVICES - OAK RIDGE LABORATORY
## RADIOACTIVE REFERENCE SOLUTIONS
## *PRIMARY DILUTION RECERTIFICATION*
## MP 009

CURRENT DATE: 9/23/2013 0:00

SOLUTION REFERENCE #: IPL 867-54

SOLUTION #: Th-18

| Principal Radionuclide | Half Life, Years | Half Life, Days |
|---|---|---|
| $^{229}Th$ | 7.340E+03 | 2.681E+06 |

Radionuclide: $^{229}Th$

Reference Date: 1/15/2002 0:00

Certified Activity: 1.013E+00 µCi

Certified Concentration: µCi per gram

| | | |
|---|---|---|
| Ampoule /Solution Gross | 8.7752 | Weight, Grams |
| Empty Ampoule | 3.7591 | Weight, Grams |
| Solution Net | 5.0161 | Weight, Grams |
| Total Activity in Ampoule | 1.0130 | µCi |

**Chemical Composition of Standard Solution**

$^{229}Th(NO_3)_4$ in 0.1M $HNO_3$

**Dilution Instructions:**

Dilution Solvent Used: 0.1 M $HNO_3$

Dilute to a volume of 1000.00 milliliters

Certified Total Activity of 1.0130 µCi Which Equals 2.249E+06 dpm at the date listed above

And after dilution the activity of this solution is 2.249E+03 dpm/ml

This activity concentration is based on the original reference date listed above. All activities are corrected to the date and time of analysis by the laboratory data processing software.

Expiration Date: September 23, 2014

Verified & Approved By _____ Date: 9/23/2013 0:00

QC Approval _____ Date: 9/27/13

0024

EBERLINE SERVICES

**QUALITY CONTROL PROGRAM**
MP-009

Rev.7; 9/29/99
Title: Radioactive Reference Standards Solutions & Records

## EBERLINE SERVICES - OAK RIDGE LABORATORY
## RADIOACTIVE REFERENCE STANDARD SOLUTIONS
*SECONDARY DILUTION RECERTIFICATION*

MP-009
Solution Reference # IPL 867-54
Date 9/23/2013 0:00
Solution # Th-18a

| Principal Radionuclide | Half Life, Years | Half Life, Days |
|---|---|---|
| $^{229}Th$ | 7.340E+03 | 2.681E+06 |

Radionuclide of Interest $^{229}Th$
Parent Solution Conc. 2.25E+03 dpm/ml
Reference Date 1/15/2002 0:00

Chemical Composition of Standard Solution
$TH(NO_3)_4$ in 0.1M $HNO_3$

Dilution Instructions:
Dilution Solvent Used 0.1M $HNO_3$

*SECONDARY VOLUMETRIC DILUTION*

Vol. Parent Solution: 10.0000 ml
Total Activity: 2.2490E+04 dpm
Final Volume: 1000.00 ml

Final Activity Concentration: 2.2490E+01 dpm/ml

NOTES:

This activity concentration is based on the original reference date listed above. All activities are corrected to the date and time of analysis by the laboratory data processing software.

Expiration Date: September 23, 2014

Verified & Approved By _____ Date: 9/23/2013 0:00

QC Approval _____ Date: 9/27/13

ANALYTICS

QA/QC REVIEWED
Date 4/30/96 Initials MT

Am-4

1380 Seaboard Industrial Blvd.
Atlanta, Georgia 30318 · U.S.A.

Phone (404) 352-8677
Fax (404) 352-2837

# CERTIFICATE OF CALIBRATION

## Standard Radionuclide Source

52094-416

Am-241 10 mL Liquid in Flame Sealed Vial

This standard radionuclide source was prepared gravimetrically from a calibrated master liquid radionuclide solution source. The master source was calibrated by liquid scintillation counting.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

| | |
|---|---|
| ISOTOPE: | Am-241 |
| ACTIVITY (dps): | 1.975 E+05 |
| HALF-LIFE: | 432.2 years |
| CALIBRATION DATE: | March 19, 1996 12:00 EST |
| TOTAL ERROR: | 3.0% |
| SYSTEMATIC ERROR: | 2.37% |
| RANDOM ERROR: | 0.63% |

10.01177 grams of solution 1M HCl.

P O NUMBER OR3830, Item 1

SOURCE PREPARED BY: Kare O'Brie Beverly
K. O. Beverly, Radiochemist

Q A APPROVED: D M. [illegible] 4-26-96

EBERLINE SERVICES

**QUALITY CONTROL PROGRAM**
MP-009

Rev.8; 1/10/03
Title: Radioactive Reference Standards Solutions & Records

## EBERLINE SERVICES - OAK RIDGE LABORATORY
## RADIOACTIVE REFERENCE STANDARD SOLUTIONS
*SECONDARY DILUTION (RE-CERTIFICATION)*

Date: 9/25/2013 0:00
Solution Reference #: Analytics 52094-416
Solution #: A/B-7 (alpha)

| Principal Radionuclide | Half Life, Years | Half Life, Days |
|---|---|---|
| $^{241}$Americium | 4.322E+02 | 1.579E+05 |

Radionuclide of Interest: $^{241}$Am
Reference Date: 3/19/1996 0:00
Parent Solution Conc.: 1.19E+04 dpm/ml

Chemical Composition of Standard Solution
$^{241}AmCl_3$ in 1M HCL

Dilution Instructions:
Dilution Solvent Used: 1 M $HNO_3$

*SECONDARY VOLUMETRIC DILUTION*

Vol. Parent Solution: 60.0000 ml
Total Activity: 7.1100E+05 dpm
Final Volume: 1000.00 ml

Final Activity Concentration: 7.1100E+02 dpm/ml

This activity concentration is based on the original reference date listed above. All activities are corrected to the date and time of analysis by the laboratory data processing software.

NOTES:

Expiration Date: September 5, 2014

Verified & Approved By: _____ Date: 9/25/13

QC Approval: _____ Date: 9/27/13

Sr-90
13 uCi

# National Institute of Standards & Technology

# Certificate

## Standard Reference Material 4234A
## Strontium-90 Radioactivity Standard

This Standard Reference Material (SRM) consists of radioactive strontium-90 chloride, non-radioactive strontium chloride, non-radioactive yttrium chloride, and hydrochloric acid dissolved in 5 mL of distilled water. The solution is contained in a flame-sealed NIST borosilicate-glass ampoule. The SRM is intended for the calibration of beta-particle counting instruments and for the monitoring of radiochemical procedures.

### Radiological Hazard

The SRM ampoule contains strontium-90 with a total activity of approximately 13 MBq. Strontium-90 decays by beta-particle emission to yttrium-90, which also decays by beta-particle emission. None of the beta particles escape from the SRM ampoule. The beta particles emitted from strontium-90 and yttrium-90 produce bremsstrahlung photons with energies up to 2 MeV. Most of these photons escape from the SRM ampoule and can represent a radiation hazard. Approximate unshielded dose rates at several distances (as of the reference time) are given in note [a]*. Appropriate shielding and/or distance should be used to minimize personnel exposure. The SRM should be used only by persons qualified to handle radioactive material.

### Chemical Hazard

The SRM ampoule contains hydrochloric acid (HCl) with a concentration of 1 mole per liter of water. The solution is corrosive and represents a health hazard if it comes in contact with eyes or skin. If the ampoule is to be opened to transfer the solution, the recommended procedure is given on page 2. The ampoule should be opened only by persons qualified to handle both radioactive material and strong acid solution.

### Storage and Handling

The SRM should be stored and used at a temperature between 5 and 65 °C. The solution in an unopened ampoule should remain stable and homogeneous until at least March 2005.

The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material. If the ampoule is transported it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The solution in the ampoule is a dangerous good (hazardous material) both because of the radioactivity and because of the strong acid.

### Preparation

This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, J.M.R. Hutchinson, Group Leader. The overall technical direction and physical measurements leading to certification were provided by L.L. Lucas of the Radioactivity Group and D.B. Golas, Nuclear Energy Institute Research Associate.

The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program by N.M. Trahey.

Gaithersburg, Maryland 20899
May 1995 (Text only revised November 1997)

Thomas E. Gills, Chief
Standard Reference Materials Program



*Notes and references are on pages 5 and 6.

0028

EBERLINE SERVICES

**QUALITY CONTROL PROGRAM**
QCP-009

Rev.7; 9/29/99
Title: Radioactive Reference Standards Solutions & Records

## EBERLINE SERVICES - OAK RIDGE LABORATORY
## RADIOACTIVE REFERENCE STANDARD SOLUTIONS
*SECONDARY DILUTION (RE-CERTIFICATION)*

QCP-009-1-A

Solution Reference # NIST 4234A

Date 9/25/2013 0:00

Solution # A/B-7 (beta)

| Principal Radionuclide | Half Life, Years | Half Life, Days |
|---|---|---|
| $^{90}$Strontium | 2.878E+01 | 1.051E+04 |

Radionuclide of Interest $^{90}$Sr

Parent Solution Conc. 1.52E+06 dpm/ml

Reference Date 3/13/1995 0:00

The beta activity of solution reflects the original $^{90}$Strontium concentration and an equal concentration of $^{90}$Yttrium.

**Chemical Composition of Standard Solution**
$^{90}SrCl_2$ in 1 M HCl

**Dilution Instructions:**

Dilution Solvent Used 1 M $HNO_3$

*SECONDARY VOLUMETRIC DILUTION*

Vol. Parent Solution: 0.5000 ml
Total Activity: 7.5764E+05 dpm
Final Volume: 1000.00 ml

Final Activity Concentration: 7.5764E+02 dpm/ml

This activity concentration is based on the original reference date listed above. All activities are corrected to the date and time of analysis by the laboratory data processing software.

NOTES:

Expiration Date: September 5, 2014

Verified & Approved By _____ Date: 09/25/13

QC Approval _____ Date: 9/27/13

# SECTION VI

# QUALITY CONTROL SAMPLE RESULTS SUMMARY

| WO | Analysis | Run | Activity Units | Aliquot Units | Client Name |
|---|---|---|---|---|---|
| 14-08008 | ThISO | 1 | uCi | ml | Feezor Engineering, Inc. |

## Laboratory Control Sample

| Analyte | Normalized Difference | LCS Measured | CSU Measured | LCS Expected | Uncert. Expected | Known | Known Error | Result | CSU | Standard ID | Standard ACT (dpm) | Standard Error | Standard Added (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TH-228 | 1.16 | 112.14% | 18.25% | 100.00% | 3.60% | 5.09E-06 | 1.83E-07 | 5.71E-06 | 1.04E-06 | Th-8b | 1.04E+02 | 3.60E+00 | 1.09E-01 |
| TH-230 | 0.19 | 102.02% | 19.96% | 100.00% | 2.70% | 5.52E-06 | 1.49E-07 | 5.63E-06 | 1.12E-06 | Th-1b | 2.35E+01 | 2.70E+00 | 5.21E-01 |
| TH-232 | 0.77 | 107.73% | 18.04% | 100.00% | 3.60% | 5.09E-06 | 1.83E-07 | 5.48E-06 | 9.89E-07 | Th-8b | 1.04E+02 | 3.60E+00 | 1.09E-01 |

## Matrix Spike

| Analyte | Normalized Difference | MS Actual % Rec | Expected MS Result | Expected MS Uncert | Actual MS Result | Actual MS CSU | Sample Result | Sample CSU | Sample Aliquot | Standard ID | Standard ACT (dpm) | Standard Error % | Standard Added (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

## Replicate Sample

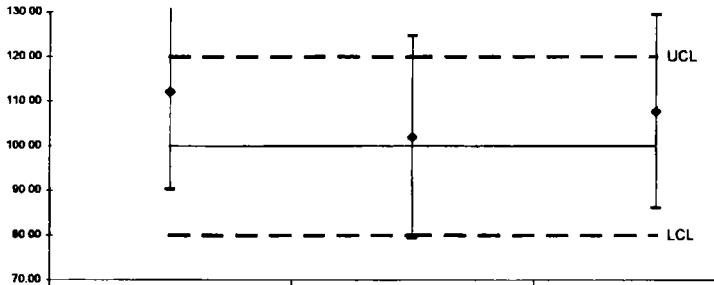
| Analyte | Normalized Difference | RPD | Original Result | Original CSU | Replicate Result | Replicate CSU |
|---|---|---|---|---|---|---|
| TH-228 | 0.27 | 10.52 | 3.04E-16 | 1.67E-16 | 2.74E-16 | 1.45E-16 |
| TH-230 | 0.81 | 24.01 | 4.98E-16 | 2.23E-16 | 6.34E-16 | 2.43E-16 |
| TH-232 | 2.06 | 70.64 | 2.45E-16 | 1.47E-16 | 5.13E-16 | 2.09E-16 |

## QC Summary

| Analyte | LCS Relative Bias | LCS % R | LCS ND | MS % R | MS ND | Rep RPD | Rep ND |
|---|---|---|---|---|---|---|---|
| TH-228 | 1.12 | OK | OK | | | OK | OK |
| TH-230 | 1.02 | OK | OK | | | OK | OK |
| TH-232 | 1.08 | OK | OK | | | INV | OK |

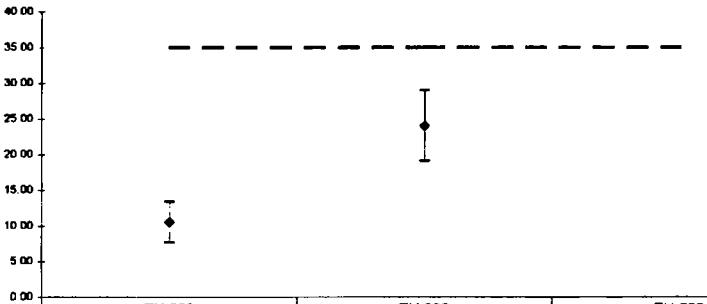
| WO | Analysis | Run | Activity Units | Aliquot Units | Client Name |
|---|---|---|---|---|---|
| 14-08008 | ThISO | 1 | uCi | ml | Feezor Engineering, Inc. |

## LCS % Recovery



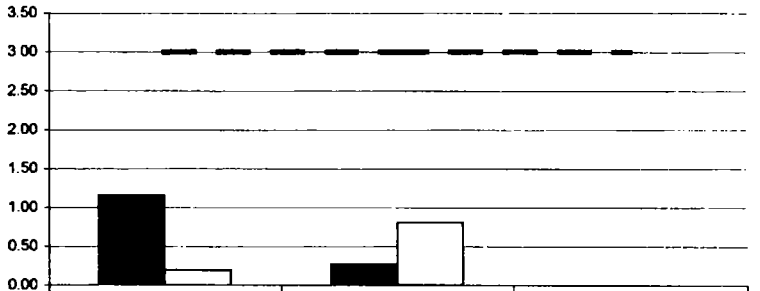

| | TH-228 | TH-230 | TH-232 |
|---|---|---|---|
| Lower Error | 90.30 | 79.36 | 86.09 |
| Upper Error | 133.99 | 124.68 | 129.38 |
| %R | 112.14 | 102.02 | 107.73 |
| LCL | 80 | 80 | 80 |
| Mean | 100 | 100 | 100 |
| UCL | 120 | 120 | 120 |

## Replicate Sample RPD




| | TH-228 | TH-230 | TH-232 |
|---|---|---|---|
| Lower Error | 13.36 | 28.96 | 87.21 |
| Upper Error | 7.68 | 19.07 | 54.08 |
| RPD | 10.52 | 24.01 | 70.64 |
| CL | 35 | 35 | 35 |

## Normalized Difference




| | LCS ND | REP ND | MS ND |
|---|---|---|---|
| TH-228 | 1.16 | 0.27 | 0.00 |
| TH-230 | 0.19 | 0.81 | 0.00 |
| UCL | 3 | 3 | 3 |

## No Matrix Spike

Version

| WO | Analysis | Run | Activity Units | Aliquot Units | Client Name |
|---|---|---|---|---|---|
| 14-08008 | GaGbT_ThSr | 1 | uCi | ml | Feezor Engineering, Inc. |

## Laboratory Control Sample

| Analyte | Normalized Difference | LCS Measured | CSU Measured | LCS Expected | Uncert. Expected | Known | Known Error | Result | CSU | Standard ID | Standard ACT (dpm) | Standard Error | Standard Added (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GROSS ALPHA_TH | 1.37 | 108.60% | 11.01% | 100.00% | 4.30% | 2.48E-04 | 1.07E-05 | 2.70E-04 | 2.97E-05 | A/B-07 | 5.97E+02 | 4.30E+00 | 9.23E-01 |
| GROSS BETA_SR | 1.32 | 91.36% | 13.87% | 100.00% | 3.00% | 2.78E-04 | 8.34E-06 | 2.54E-04 | 3.52E-05 | A/B-07 | 6.69E+02 | 3.00E+00 | 9.23E-01 |
| | | | | | | | | | | | | | |

## Matrix Spike

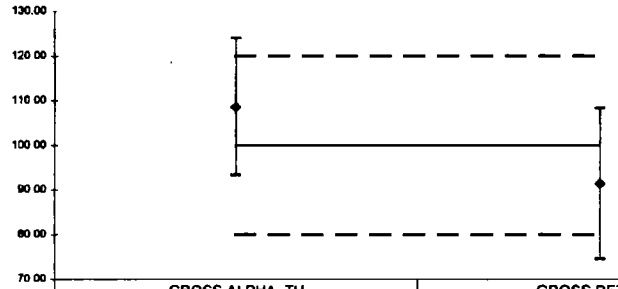
| Analyte | Normalized Difference | MS Actual % Rec | Expected MS Result | Expected MS Uncert | Actual MS Result | Actual MS CSU | Sample Result | Sample CSU | Sample Aliquot | Standard ID | Standard ACT (dpm) | Standard Error % | Standard Added (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

## Replicate Sample / QC Summary

| Analyte | Normalized Difference | RPD | Original Result | Original CSU | Replicate Result | Replicate CSU | LCS Relative Bias | LCS % R | LCS ND | MS % R | MS ND | Rep RPD | Rep ND |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GROSS ALPHA_TH | 0.76 | 14.69 | 3.32E-15 | 8.52E-16 | 2.86E-15 | 7.95E-16 | 1.09 | OK | OK | | | NA | OK |
| GROSS BETA_SR | 0.21 | 2.26 | 2.79E-14 | 4.20E-15 | 2.85E-14 | 4.28E-15 | 0.91 | OK | OK | | | OK | OK |
| | | | | | | | | | | | | | |

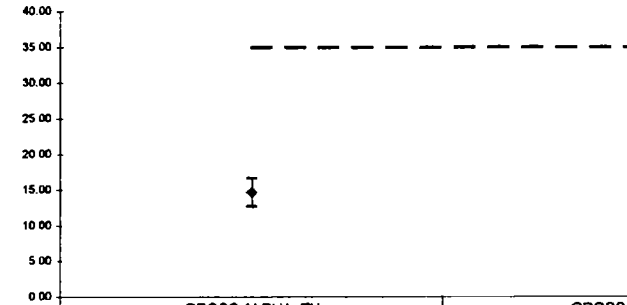
| WO | Analysis | Run | Activity Units | Aliquot Units | Client Name |
|---|---|---|---|---|---|
| 14-08008 | GaGbT_ThSr | 1 | uCi | ml | Feezor Engineering, Inc. |

## LCS % Recovery



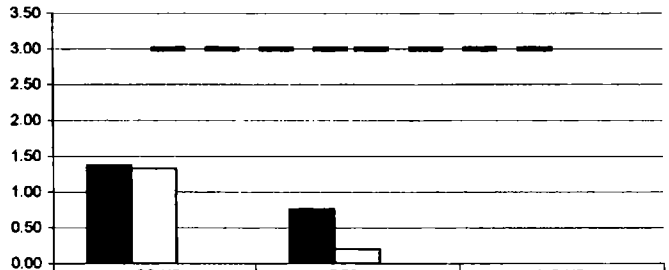

| | GROSS ALPHA_TH | GROSS BETA_SR |
|---|---|---|
| Lower Error | 93.29 | 74.49 |
| Upper Error | 123.91 | 108.22 |
| %R | 108.60 | 91.36 |
| LCL | 80 | 80 |
| Mean | 100 | 100 |
| UCL | 120 | 120 |

## Replicate Sample RPD




| | GROSS ALPHA_TH | GROSS BETA_SR |
|---|---|---|
| Lower Error | 16.65 | 2.43 |
| Upper Error | 12.73 | 2.09 |
| RPD | 14.69 | 2.26 |
| CL | 35 | 35 |

## Normalized Difference




| | LCS ND | REP ND | MS ND |
|---|---|---|---|
| GROSS ALPHA_TH | 1.37 | 0.76 | 0.00 |
| GROSS BETA_SR | 1.32 | 0.21 | 0.00 |
| | 0.00 | 0.00 | 0.00 |
| UCL | 3 | 3 | 3 |

## No Matrix Spike

# SECTION VII

# LABORATORY TECHNICIAN'S NOTES

**ISO-TH NOTES**

| EBERLINE SERVICES<br>Work Order Analysis Notes | Oak Ridge Laboratory<br>601 Scarboro Rd.<br>Oak Ridge, TN 37830<br>Voice: 865.481.0683<br>www.eberlineservices.com | Internal Work Order | 14-08008 |
|---|---|---|---|
| | | Analysis Code | ThISO |
| | | Run Number | 1 |

| # | Date | Dept | User | Notes |
|---|---|---|---|---|
| 1 | 08/07/14 11:34 | PREP | JWOLFE | DISSOLVED SAMPLES WITH HF AND DRIED SAMPLES DOWN- ADDED MIXED ACIDS AND TOOK SAMPLES TO DRYNESS- ADDED HNO3 AND WATER AND CENTRIFUGED- DILUTED AND SPLIT FRACTION 4 FOR QC- ADDED SPIKES AND TRACERS AND DRIED SAMPLES DOWN- SUBMITTED SAMPLES TO SEPARATIONS |

JWolfe
8/7/14

| EBERLINE SERVICES<br>Work Order Analysis Notes | Oak Ridge Laboratory<br>601 Scarboro Rd.<br>Oak Ridge, TN 37830<br>Voice: 865.481.0683<br>www.eberlineservices.com | Internal Work Order | 14-08008 |
|---|---|---|---|
| | | Analysis Code | ThISO |
| | | Run Number | 1 |

| # | Date | Dept | User | Notes |
|---|---|---|---|---|
| 1 | 08/07/14 11:34 | PREP | JWOLFE | DISSOLVED SAMPLES WITH HF AND DRIED SAMPLES DOWN- ADDED MIXED ACIDS AND TOOK SAMPLES TO DRYNESS- ADDED HNO3 AND WATER AND CENTRIFUGED- DILUTED AND SPLIT FRACTION 4 FOR QC- ADDED SPIKES AND TRACERS AND DRIED SAMPLES DOWN- SUBMITTED SAMPLES TO SEPARATIONS |
| 2 | 08/08/14 15:20 | CHEM | JDEMELAS | Added concentrated HNO3 to sample beakers and heated to dryness; Added 20 ml 8N HNO3 to samples and transferred to new, labeled C-Tubes, adding 8N HNO3 to bring volume to ~35 ml; Preconditioned resin columns with 50 ml 8N HNO3; Centrifuged samples as needed, and passed through columns; Rinsed C-Tubes with 20 ml 8N HNO3; Centrifuged rinsates and loaded onto columns; Rinsed columns with 40 ml 8N HNO3; Eluted Thorium with 50 ml of 8N HCl into clean, labeled 100-ml beakers; Dried-down samples on hotplate; Dissolved samples in ~10 ml of concentrated HCl; Transferred to new, labeled C-Tubes with deiononized water, bringing volume to ~15ml. Set samples aside for later precipitation and filtering. |

~~8/8/16~~ JPO 8/8/14

8/8/14

| EBERLINE SERVICES<br>Work Order Analysis Notes | Oak Ridge Laboratory<br>601 Scarboro Rd.<br>Oak Ridge, TN 37830<br>Voice: 865.481.0683<br>www.eberlineservices.com | Internal Work Order | 14-08008 |
|---|---|---|---|
| | | Analysis Code | ThISO |
| | | Run Number | 1 |

| # | Date | Dept | User | Notes |
|---|---|---|---|---|
| 1 | 08/07/14 11:34 | PREP | JWOLFE | DISSOLVED SAMPLES WITH HF AND DRIED SAMPLES DOWN- ADDED MIXED ACIDS AND TOOK SAMPLES TO DRYNESS- ADDED HNO3 AND WATER AND CENTRIFUGED- DILUTED AND SPLIT FRACTION 4 FOR QC- ADDED SPIKES AND TRACERS AND DRIED SAMPLES DOWN- SUBMITTED SAMPLES TO SEPARATIONS |
| 2 | 08/08/14 15:20 | CHEM | JDEMELAS | Added concentrated HNO3 to sample beakers and heated to dryness; Added 20 ml 8N HNO3 to samples and transferred to new, labeled C-Tubes, adding 8N HNO3 to bring volume to ~35 ml; Preconditioned resin columns with 50 ml 8N HNO3; Centrifuged samples as needed, and passed through columns; Rinsed C-Tubes with 20 ml 8N HNO3; Centrifuged rinsates and loaded onto columns; Rinsed columns with 40 ml 8N HNO3; Eluted Thorium with 50 ml of 8N HCl into clean, labeled 100-ml beakers; Dried-down samples on hotplate; Dissolved samples in ~10 ml of concentrated HCl; Transferred to new, labeled C-Tubes with deiononized water, bringing volume to ~15ml. Set samples aside for later precipitation and filtering. |
| 3 | 08/11/14 05:21 | CHEM | TSMITH | Followed steps 12.2.4 to 12.4.5 in AP-005 . ( Precipitated and filtered samples for Thorium ) |

6/1/14

EBERLINE SERVICES

# Reagents Used in an Analysis

| Internal Work Order | |
|---|---|
| 14-08008 | |
| Analysis Code | Run |
| ThISO | 1 |

| Reagent ID | Reagent Name | Reagent Concentration | Analyst ID | Date Recorded |
|---|---|---|---|---|
| 014973P | Hydrofluoric Acid | Reagent Grade | JWOLFE | 8/7/2014 |
| 014954P | Nitric Acid | Reagent Grade | JWOLFE | 8/7/2014 |
| 014832P | Perchloric Acid | Reagent Grade | JWOLFE | 8/7/2014 |
| 009098P | Sulfuric Acid | Reagent Grade | JWOLFE | 8/7/2014 |
| 015294P | Anion Exchange Resin | Reagent Grade | JDEMELAS | 8/8/2014 |
| 015387S | Hydrochloric Acid | 8N | JDEMELAS | 8/8/2014 |
| 014955P | Hydrochloric Acid | Reagent Grade | JDEMELAS | 8/8/2014 |
| 014954P | Nitric Acid | Reagent Grade | JDEMELAS | 8/8/2014 |
| 015392S | Nitric Acid | 8N | JDEMELAS | 8/8/2014 |
| 015375S | Carbon substrate | Solution | TSMITH | 8/11/2014 |
| 015250S | Cerrium Carrier | 0.1mg/ml | TSMITH | 8/11/2014 |
| 014973P | Hydrofluoric Acid | Reagent Grade | TSMITH | 8/11/2014 |
| 015015P | Reagent Alcohol | Reagent Grade | TSMITH | 8/11/2014 |

Alpha #3



| Date | Sample # | Client | Test Time | CT Time | Analyst | Tech |
|---|---|---|---|---|---|---|
| 8/11/14 | 1408025A(4) | UCOR | 0841 | 2h5 | AMZ41 | — |
| 8/11/14 | 1408025A(1-4) | UCOR | 0842 | 2h5 | AMZ47 | — |
| 8/11/14 | 1408024A(1-4) | UCOR | 0842 | 2h5 | PLZ50 | — |
| 8/11/14 | 1408024ANT(4) | UCOR | ~~0843~~ 0843 | 2h5 | PLNT | — |
| 8/11/14 | 1408025A(1-3) | UCOR | 0843 | 2h5 | ULZ50 | — |
| 8/11/14 | 1408025A(4) | UCOR | 1137 | 2h50 | Ull | KB |
| 8/11/14 | 1408008A(1-5) | Feezor | 1138 | 2h50 | Th | KB |
| 8/11/14 | 1408025A(1-4) | UCOR | 1141 | 2h50 | Th | KB |
| 8/11/14 | 1408025A(4) | UCOR | 1138 | 2h50 | ThNT | KB |

**ALPHA/BETA NOTES**

| | | | |
|---|---|---|---|
| EBERLINE SERVICES<br>**Work Order Analysis Notes** | **Oak Ridge Laboratory**<br>**601 Scarboro Rd.**<br>**Oak Ridge, TN 37830**<br>**Voice: 865.481.0683**<br>**www.eberlineservices.com** | Internal Work Order | 14-08008 |
| | | Analysis Code | GaGbT_ThSr |
| | | Run Number | 1 |

| # | Date | Dept | User | Notes |
|---|---|---|---|---|
| 1 | 08/06/14 05:11 | PREP | JWOLFE | TOOK A PIECE OF THE SAMPLES AND GLUED IT ONTO PLANCHETS- PREPARED A SPIKE AND BLANK- COMPLETED PAPERWORK AND SUBMITTED TO THE COUNT ROOM |

JWOLFE
8/6/14

LB4110 RED



| Date | Sample # | Client | Sample Time | CT Time | Analyst | Tech |
|---|---|---|---|---|---|---|
| 8/5 | 1407142RA1(2-4) | UCOR | 0848 | 2h | RAS | ✓ |
| 8/5 | 1407187RA(1) | UCOR | 0919 | 3h | RAS | ✓ |
| 8/5/14 | 1407164Pb(1-4) | UCOR | 1247 | 2hrs | Pb210 | KB |
| 8/5/14 | 1407193Pb(2-4) | UCOR | 1250 | 2hrs | Pb210 | KB |
| 8/5/14 | 1407183Pb1(1) | UCOR | 1250 | 30mins | Pb210 | KB |
| 8/5 | 1407129Pb(2-3) | Geosyntec | 1222 | 2hrs | Pb210 | ✓ |
| 8/5/14 | 1407129Pb1(1) | GeoSyntec | 1449 | 30mins | Pb210 | KB |
| 8/6 | EFYEL | LAB | 0510 | 3h | LAB | C |
| 8/6 | BLEDAC | LAB | 0545 | 4h | LAB | ✓ |
| 8/6/14 | 1407164NP(1-4) | UCOR | 0838 | 10min | β | AG |
| 8/6/14 | 1407089RA(1-7) | Searcy | 1018 | 2hr | Ra-228 | AG |
| 8/6/14 | 1407121RA(1) | Accutest | 1020 | 30min | Ra-228 | AG |
| 8/6/14 | 1407121RA1(2) | Accutest | 1054 | 2hrs | αβ | KB |
| 8/6/14 | 1408008AB(1-3,5) | Feezor | 1222 | 2hrs | αβ | KB |
| 8/6/14 | 1408008AB1(4) | Feezor | 1425 | 2hrs | αβ | KB |

# SECTION VIII

# ANALYTICAL DATA (ISOTOPIC THORIUM)

Eberline Services
Oak Ridge Laboratory
Analysis Sheet

# 14-08008
## ThISO
Run 1



| | |
|---|---|
| Work Order | 14-08008 |
| Analysis Code | ThISO |
| Run | 1 |
| Date Received | 8/4/2014 |
| Lab Deadline | 8/25/2014 |
| Client | Feezor Engineering, Inc. |
| Project | FEEBRI |
| Report Level | 4 |
| Activity Units | uCi |
| Aliquot Units | ml |
| Matrix | AF |
| Method | EML Th-01 Modified |
| Instrument Type | Alpha Spectroscopy |
| Radiometric Tracer | Th-229 |
| Radiometric Sol# | Th-18a |
| Tracer Act (dpm/g) | 22.464 |
| Carrier | |
| Carrier Conc (mg/ml) | |

| Internal Fraction | Sample Desc | Client ID | Login CPM | Sample Date | Sample Aliquot |
|---|---|---|---|---|---|
| 01 | LCS | LCS | | 08/04/14 00:00 | 1.0000E+00 |
| 02 | MBL | BLANK | | 08/04/14 00:00 | 1.0000E+09 |
| 03 | DUP | OUTSIDE TRAILER | 43 | 08/01/14 08:40 | 7.8500E+08 |
| 04 | DO | OUTSIDE TRAILER | 43 | 08/01/14 08:40 | 7.8500E+08 |
| 05 | TRG | TRANSFER STATION | 56 | 08/01/14 09:00 | 1.4300E+09 |

* SAF1 is used for Gross Alpha and all other radionuclides. SAF2 is used for Gross Beta only. ^ Indicates estimated SAF value.
** Actual mass exceeded the calibration curve range. Results should be qualified as appropriate.

0045

# 14-08008
## ThISO
### Run 1



| Internal Fraction | Sample Desc | Tracer Aliquot (g) | Tracer Total ACT (dpm) | Radiometric Tracer (pCi) | Radiometric % Rec | Grav Carrier Added (ml) | Grav Filter Tare (g) | Grav Filter Final (g) | Grav Filter Net (g) | Grav % Rec | Mean % Rec | SAF 1* | SAF 2* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | LCS | 0.4739 | 10.6 | | 0.00 | | | | | | | | |
| 02 | MBL | 0.2373 | 5.3 | | 0.00 | | | | | | | | |
| 03 | DUP | 0.2353 | 5.3 | | 0.00 | | | | | | | | |
| 04 | DO | 0.2346 | 5.3 | | 0.00 | | | | | | | | |
| 05 | TRG | 0.2339 | 5.3 | | 0.00 | | | | | | | | |

* SAF1 is used for Gross Alpha and all other radionuclides. SAF2 is used for Gross Beta only. ^ Indicates estimated SAF value.
** Actual mass exceeded the calibration curve range. Results should be qualified as appropriate.

8847

# 14-08008
## ThISO
Run 1



| Internal Fraction | Sample Desc | Rough Prep Date | Rough Prep By | Prep Date | Prep By | Sep t0 Date/Time | Sep t0 By | Sep t1 Date/Time | Sep t1 By |
|---|---|---|---|---|---|---|---|---|---|
| 01 | LCS | | | 08/07/14 11:30 | JWOLFE | | | | |
| 02 | MBL | | | 08/07/14 11:30 | JWOLFE | | | | |
| 03 | DUP | | | 08/07/14 11:30 | JWOLFE | | | | |
| 04 | DO | | | 08/07/14 11:30 | JWOLFE | | | | |
| 05 | TRG | | | 08/07/14 11:30 | JWOLFE | | | | |

* SAF1 is used for Gross Alpha and all other radionuclides. SAF2 is used for Gross Beta only. ^ Indicates estimated SAF value.
** Actual mass exceeded the calibration curve range. Results should be qualified as appropriate.

Eberline Services
Oak Ridge Laboratory

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-ThISO-1



Client: Feezor Engineering, Inc.
Eberline Services Work Order: 14-08008
Analysis Code: ThISO
Run: 1

| Lab Fraction | Nuclide | Sample Desc | Client Identification | Activity Units | Results | Error Estimate | MDA | LCS Known | LCS %R | LCS Flag | RPD Flag | MDA Flag | Blank Flag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-228 | LCS | LCS | uCi/ml | 5.71E-06 | 8.92E-07 | 7.92E-08 | 5.09E-06 | 112.14 | OK | | INV | |
| 02 | TH-228 | MBL | BLANK | uCi/ml | 2.17E-17 | 3.69E-17 | 6.24E-17 | | | | | OK | OK |
| 03 | TH-228 | DUP | OUTSIDE TRAILER | uCi/ml | 2.74E-16 | 1.43E-16 | 7.22E-17 | | | | OK | OK | |
| 04 | TH-228 | DO | OUTSIDE TRAILER | uCi/ml | 3.04E-16 | 1.64E-16 | 1.12E-16 | | | | | OK | |
| 05 | TH-228 | TRG | TRANSFER STATION | uCi/ml | 3.91E-16 | 1.42E-16 | 6.81E-17 | | | | | OK | |

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-ThISO-1



| Client | Eberline Services Work Order | Analysis Code | Run |
|---|---|---|---|
| Feezor Engineering, Inc. | 14-08008 | ThISO | 1 |

| Lab Fraction | Nuclide | Sample Desc | Sample Date | Sample Aliquot | Radiometric % Rec | Grav % Rec | Mean % Rec | SAF | Sep t0 Date/Time | Sep t1 Date/Time |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-228 | LCS | 08/04/14 00:00 | 1.00E+00 | 103.47 | 0.00 | 0.00 | | | |
| 02 | TH-228 | MBL | 08/04/14 00:00 | 1.00E+09 | 124.75 | 0.00 | 0.00 | | | |
| 03 | TH-228 | DUP | 08/01/14 08:40 | 7.85E+08 | 124.01 | 0.00 | 0.00 | | | |
| 04 | TH-228 | DO | 08/01/14 08:40 | 7.85E+08 | 93.12 | 0.00 | 0.00 | | | |
| 05 | TH-228 | TRG | 08/01/14 09:00 | 1.43E+09 | 99.45 | 0.00 | 0.00 | | | |

0050

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-ThISO-1



| Client | Eberline Services Work Order | Analysis Code | Run |
|---|---|---|---|
| Feezor Engineering, Inc. | 14-08008 | ThISO | 1 |

| Lab Fraction | Nuclide | Sample Desc | Counting Date/Time | Halflife (days) | Detect | Carrier | Count Time | Counts | Bkg CPM | Eff |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-228 | LCS | 08/11/14 11:38 | | A_Spec | Alpha_034 | 170 | 4.06 E+02 | 4.00 E-03 | 18.2 |
| 02 | TH-228 | MBL | 08/11/14 11:38 | | A_Spec | Alpha_037 | 170 | 1.66 E+00 | 2.00 E-03 | 16.3 |
| 03 | TH-228 | DUP | 08/11/14 11:38 | | A_Spec | Alpha_038 | 170 | 1.58 E+01 | 1.00 E-03 | 15.9 |
| 04 | TH-228 | DO | 08/11/14 11:38 | | A_Spec | Alpha_039 | 170 | 1.53 E+01 | 4.00 E-03 | 18.5 |
| 05 | TH-228 | TRG | 08/11/14 11:38 | | A_Spec | Alpha_040 | 170 | 3.78 E+01 | 7.00 E-03 | 18.2 |

Eberline Services
Oak Ridge Laboratory

Preliminary Data Report & Analytical Calculations

# Work Order: 14-08008-ThISO-1



Client: Feezor Engineering, Inc.
Eberline Services Work Order: 14-08008
Analysis Code: ThISO
Run: 1

| Lab Fraction | Nuclide | Sample Desc | Client Identification | Activity Units | Results | Error Estimate | MDA | LCS Known | LCS %R | LCS Flag | RPD Flag | MDA Flag | Blank Flag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-230 | LCS | LCS | uCi/ml | 5.63E-06 | 8.83E-07 | 6.72E-08 | 5.52E-06 | 102.02 | OK | | INV | |
| 02 | TH-230 | MBL | BLANK | uCi/ml | 1.00E-16 | 7.44E-17 | 6.25E-17 | | | | | OK | OK |
| 03 | TH-230 | DUP | OUTSIDE TRAILER | uCi/ml | 6.34E-16 | 2.30E-16 | 1.03E-16 | | | | OK | OK | |
| 04 | TH-230 | DO | OUTSIDE TRAILER | uCi/ml | 4.98E-16 | 2.14E-16 | 1.11E-16 | | | | | OK | |
| 05 | TH-230 | TRG | TRANSFER STATION | uCi/ml | 5.57E-16 | 1.75E-16 | 5.78E-17 | | | | | OK | |

0052

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-ThISO-1



| Client | Eberline Services Work Order | Analysis Code | Run |
|---|---|---|---|
| Feezor Engineering, Inc. | 14-08008 | ThISO | 1 |

| Lab Fraction | Nuclide | Sample Desc | Sample Date | Sample Aliquot | Radiometric % Rec | Grav % Rec | Mean % Rec | SAF | Sep t0 Date/Time | Sep t1 Date/Time |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-230 | LCS | 08/04/14 00:00 | 1.00E+00 | 103.47 | 0.00 | 0.00 | | | |
| 02 | TH-230 | MBL | 08/04/14 00:00 | 1.00E+09 | 124.75 | 0.00 | 0.00 | | | |
| 03 | TH-230 | DUP | 08/01/14 08:40 | 7.85E+08 | 124.01 | 0.00 | 0.00 | | | |
| 04 | TH-230 | DO | 08/01/14 08:40 | 7.85E+08 | 93.12 | 0.00 | 0.00 | | | |
| 05 | TH-230 | TRG | 08/01/14 09:00 | 1.43E+09 | 99.45 | 0.00 | 0.00 | | | |

Eberline Services
Oak Ridge Laboratory

Preliminary Data Report & Analytical Calculations

# Work Order: 14-08008-ThISO-1



Run: 1
Analysis Code: ThISO
Eberline Services Work Order: 14-08008
Client: Feezor Engineering, Inc.

| Lab Fraction | Nuclide | Sample Desc | Counting Date/Time | Halflife (days) | Detect | Carrier | Count Time | Counts | Bkg CPM | Eff |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-230 | LCS | 08/11/14 11:38 | | A_Spec | Alpha_034 | 170 | 4.01 E+02 | 2.00 E-03 | 18.2 |
| 02 | TH-230 | MBL | 08/11/14 11:38 | | A_Spec | Alpha_037 | 170 | 7.66 E+00 | 2.00 E-03 | 16.3 |
| 03 | TH-230 | DUP | 08/11/14 11:38 | | A_Spec | Alpha_038 | 170 | 3.70 E+01 | 0.00 E+00 | 15.9 |
| 04 | TH-230 | DO | 08/11/14 11:38 | | A_Spec | Alpha_039 | 170 | 2.53 E+01 | 4.00 E-03 | 18.6 |
| 05 | TH-230 | TRG | 08/11/14 11:38 | | A_Spec | Alpha_040 | 170 | 5.43 E+01 | 4.00 E-03 | 18.2 |

0054

Eberline Services
Oak Ridge Laboratory

Preliminary Data Report & Analytical Calculations

# Work Order: 14-08008-ThISO-1



Client: Feezor Engineering, Inc.
Eberline Services Work Order: 14-08008
Analysis Code: ThISO
Run: 1

| Lab Fraction | Nuclide | Sample Desc | Client Identification | Activity Units | Results | Error Estimate | MDA | LCS Known | LCS %R | LCS Flag | RPD Flag | MDA Flag | Blank Flag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-232 | LCS | LCS | uCi/ml | 5.48E-06 | 8.63E-07 | 6.71E-08 | 5.09E-06 | 107.73 | OK | | INV | |
| 02 | TH-232 | MBL | BLANK | uCi/ml | 8.61E-18 | 2.63E-17 | 6.24E-17 | | | | | OK | OK |
| 03 | TH-232 | DUP | OUTSIDE TRAILER | uCi/ml | 5.13E-16 | 2.04E-16 | 1.03E-16 | | | | INV | OK | |
| 04 | TH-232 | DO | OUTSIDE TRAILER | uCi/ml | 2.45E-16 | 1.45E-16 | 1.03E-16 | | | | | OK | |
| 05 | TH-232 | TRG | TRANSFER STATION | uCi/ml | 4.40E-16 | 1.52E-16 | 6.13E-17 | | | | | OK | |

0055

# Preliminary Data Report & Analytical Calculations
# Work Order: 14-08008-ThISO-1



Client: Feezor Engineering, Inc.
Eberline Services Work Order: 14-08008
Analysis Code: ThISO
Run: 1

| Lab Fraction | Nuclide | Sample Desc | Sample Date | Sample Aliquot | Radiometric % Rec | Grav % Rec | Mean % Rec | SAF | Sep t0 Date/Time | Sep t1 Date/Time |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-232 | LCS | 08/04/14 00:00 | 1.00E+00 | 103.47 | 0.00 | 0.00 | | | |
| 02 | TH-232 | MBL | 08/04/14 00:00 | 1.00E+09 | 124.75 | 0.00 | 0.00 | | | |
| 03 | TH-232 | DUP | 08/01/14 08:40 | 7.85E+08 | 124.01 | 0.00 | 0.00 | | | |
| 04 | TH-232 | DO | 08/01/14 08:40 | 7.85E+08 | 93.12 | 0.00 | 0.00 | | | |
| 05 | TH-232 | TRG | 08/01/14 09:00 | 1.43E+09 | 99.45 | 0.00 | 0.00 | | | |

0056

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-ThISO-1



Client: Feezor Engineering, Inc.
Eberline Services Work Order: 14-08008
Analysis Code: ThISO
Run: 1

| Lab Fraction | Nuclide | Sample Desc | Counting Date/Time | Halflife (days) | Detect | Carrier | Count Time | Counts | Bkg CPM | Eff |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | TH-232 | LCS | 08/11/14 11:38 | | A_Spec | Alpha_034 | 170 | 3.91 E+02 | 2.00 E-03 | 18.2 |
| 02 | TH-232 | MBL | 08/11/14 11:38 | | A_Spec | Alpha_037 | 170 | 6.60 E-01 | 2.00 E-03 | 16.3 |
| 03 | TH-232 | DUP | 08/11/14 11:38 | | A_Spec | Alpha_038 | 170 | 3.00 E+01 | 0.00 E+00 | 15.9 |
| 04 | TH-232 | DO | 08/11/14 11:38 | | A_Spec | Alpha_039 | 170 | 1.25 E+01 | 3.00 E-03 | 18.5 |
| 05 | TH-232 | TRG | 08/11/14 11:38 | | A_Spec | Alpha_040 | 170 | 4.30 E+01 | 0.00 E+00 | 18.2 |

Count Room Report
Client: Feezor Engineering, Inc.

14-08008-ThISO-1 (uCi/ml) in AF
Tracer ID: Th-18a



X-40

| Internal Fraction | Sample Desc | Client ID | Sample Date | Sample Aliquot | Tracer Aliquot (g) | Tracer ACT (dpm) | Radiometric Tracer (pCi) | Radiometric % Rec | SAF 1* | SAF 2* |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | LCS | LCS | 08/04/14 00:00 | 1.0000 | 0.4739 | 10.6457 | | 0.00 | | |
| 02 | MBL | BLANK | 08/04/14 00:00 | 1000000000.0000 | 0.2373 | 5.3307 | | 0.00 | | |
| 03 | DUP | OUTSIDE TRAILER | 08/01/14 08:40 | 785000000.0000 | 0.2353 | 5.2858 | | 0.00 | | |
| 04 | DO | OUTSIDE TRAILER | 08/01/14 08:40 | 785000000.0000 | 0.2346 | 5.2701 | | 0.00 | | |
| 05 | TRG | TRANSFER STATION | 08/01/14 09:00 | 1430000000.0000 | 0.2339 | 5.2543 | | 0.00 | | |

0058

Eberline Services
Oak Ridge Laboratory

# Spike and Tracer Worksheet


Printed: 8/7/2014 11:30 AM

| Internal Work Order | Run | Analysis Code | Date | Technician | Technician Initials | Witness Initials |
|---|---|---|---|---|---|---|
| 14-08008 | 1 | ThISO | 8/7/2014 11:30 | JWOLFE | JW | |

| LCS & Matrix Spikes | | | | | LCS | MS | LCSD | MSD | LCS | | MS | | LCSD | | MSD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Isotope | Sol # | Activity dpm/g | Solution Date | Approx Addition | Volume Used (g) | Volume Used (g) | Volume Used (g) | Volume Used (g) | Known pCi | Error Estimate | Added pCi | Error Estimate | Known pCi | Error Estimate | Added pCi | Error Estimate |
| Th-228 | Th-8b | 103.560 | 8/7/2014 | 0.100 | 0.1091 | | | | 5.09 | 0.183 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| Th-230 | Th-1b | 23.525 | 8/7/2014 | 0.500 | 0.5211 | | | | 5.52 | 0.149 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| Th-232 | Th-8b | 103.560 | 8/7/2014 | 0.100 | 0.1091 | | | | 5.09 | 0.183 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| Tc-99 MS | Tc-2a | 22043.688 | 10/16/2013 | 0.1 | | | | | | | | | | | | |

## Tracers

| fraction | Isotope | Sol # | Activity dpm/g | Solution Date | Volume Used (g) | Approx Addition |
|---|---|---|---|---|---|---|
| 01 | Th-229 | Th-18a | 22.464 | 8/7/2014 | 0.4739 | 0.2200 |
| 02 | Th-229 | Th-18a | 22.464 | 8/7/2014 | 0.2373 | 0.2200 |
| 03 | Th-229 | Th-18a | 22.464 | 8/7/2014 | 0.2353 | 0.2200 |
| 04 | Th-229 | Th-18a | 22.464 | 8/7/2014 | 0.2346 | 0.2200 |
| 05 | Th-229 | Th-18a | 22.464 | 8/7/2014 | 0.2339 | 0.2200 |

## Balance Printer Tapes

| Tracer | LCS |
|---|---|
| | |

| Matrix Spike |
|---|
| |

Version 2.0 08/99

Eberline Analytical
Oak Ridge Laboratory

# Aliquot Worksheet



| Work Order | Run | Analysis Code | Rpt Units | Lab Deadline | Technician |
|---|---|---|---|---|---|
| 14-08008 | 1 | ThISO | ml | 8/25/2014 | JWOLFE |

| Lab Fraction | Feezor Engineering, Inc. Client ID | Sample Type | Muffle Data Ratio Post/Pre | Dilution Data No of Dils | Dil Factor | Ratio | Aliquot Data Aliquot | Net Equiv | MS Aliquot Data Aliquot | Net Equiv | H-3 Solids Only Water Added (ml) | H3 Dist Aliq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | LCS | LCS | | | | | 1.0000E+00 | 1.0000E+00 | | | | |
| 02 | BLANK | MBL | | | | | 1.0000E+09 | 1.0000E+09 | | | | |
| 03 | OUTSIDE TRAILER | DUP | | | | | 7.8500E+08 | 7.8500E+08 | | | | |
| 04 | OUTSIDE TRAILER | DO | | | | | 7.8500E+08 | 7.8500E+08 | | | | |
| 05 | TRANSFER STATION | TRG | | | | | 1.4300E+09 | 1.4300E+09 | | | | |

| Comments | |
|---|---|

Technician: JWOLFE Date: 8/7/14

0060

KB 9/11/14

# Apex-Alpha™

Sample Description: SPIKE
Spectrum File: \\OR-ALPHA1\Canberra\ApexAlpha\Root\Data\00000946
Batch Identification: 1408008A-TH
Sample Identification: 01
Sample Geometry: Shelf 2
Procedure Description: Th iso

Detector Name: Alpha_034
Chamber Serial Number: 04026479B
Detector Serial Number: 91136
Env. Background: System Bkgd 93501
Reagent Blank: <not performed>

Sample Size: 1.000E+000 +/- 0.000E+000 mL
Sample Date/Time: 8/11/2014 6:47:11 AM
Acquisition Date/Time: 8/11/2014 11:38:06 AM
Acquisition Live Time: 170.0 minutes
Acquisition Real Time: 170.1 minutes

Tracer Certificate: Th229_TH-18A
Tracer Quantity: 0.474 mL
Effective Efficiency: 0.1888 +/- 0.0118
Counting Efficiency: 0.1825 +/- 0.0032 on 4/12/2014 4:05:34 PM
Chem. Recovery Factor: 1.0347 +/- 0.0670

Control Certificate Name: NatTh_Th-8
Chem. Recov. of Control: TH-232 1.077321 +/- 0.092384
Peak Match Tolerance: 0.175 MeV

## PEAK AREA REPORT

| Nuclide | | Energy (MeV) | Net Pk Area | Pk Area Error % | Ambient Backgnd | Reagent Backgnd | FWHM (keV) |
|---|---|---|---|---|---|---|---|
| TH-227 | | 5.761 | 40.00 | 31.38 | 0.00 | 0.00E+000 | 3.5 |
| TH-228 | | 5.366 | 406.32 | 9.73 | 0.68 | 0.00E+000 | 26.9 |
| TH-229 | T | 4.881 | 341.66 | 10.61 | 0.34 | 0.00E+000 | 14.6 |
| TH-230 | | 4.634 | 400.66 | 9.80 | 0.34 | 0.00E+000 | 5.4 |
| TH-232 | | 3.959 | 390.66 | 9.92 | 0.34 | 0.00E+000 | 12.8 |

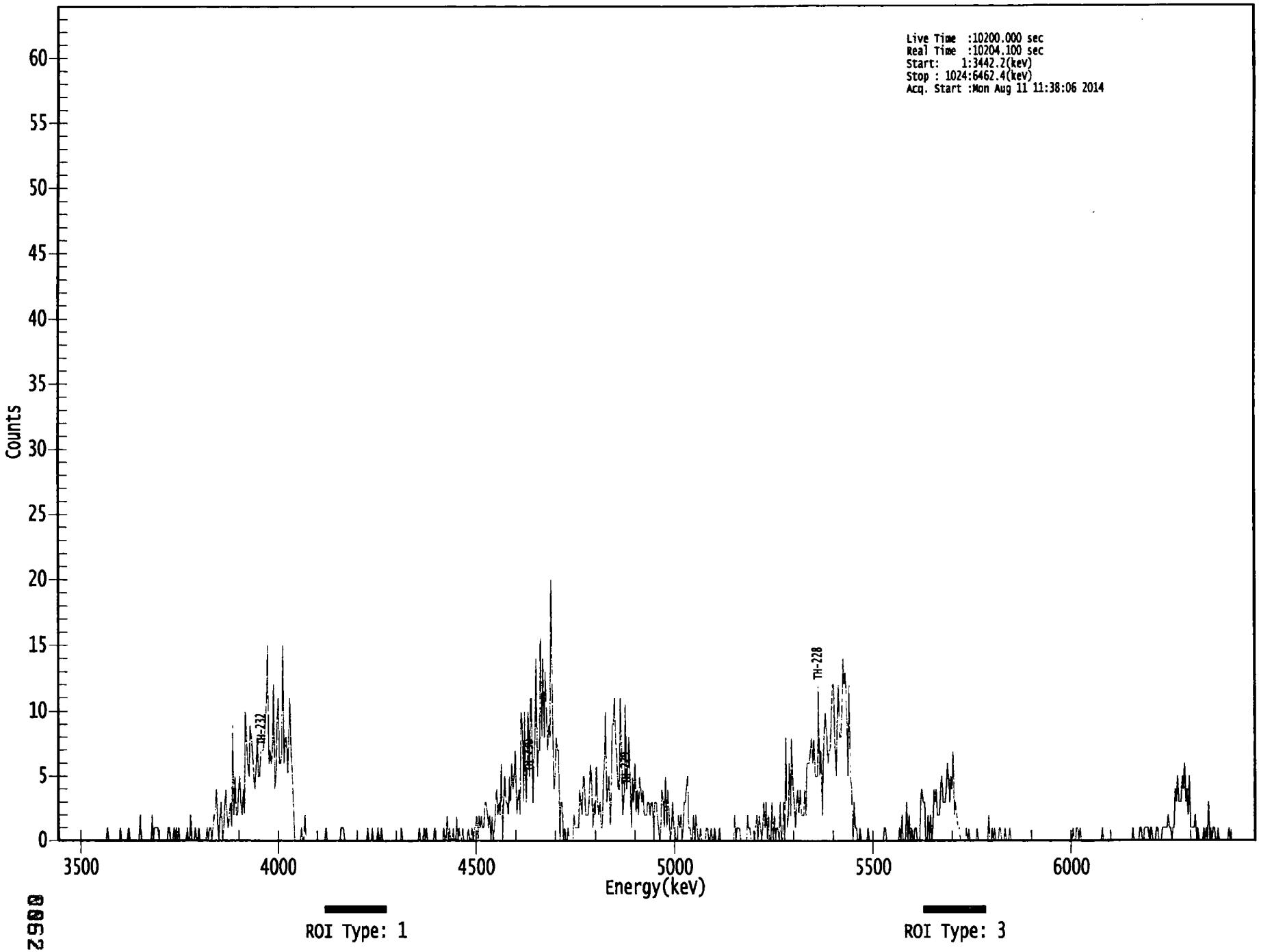
T = Tracer Peak used for Effective Efficiency

## NUCLIDE ANALYSIS RESULTS

| Nuclide | Id Conf. | Energy (keV) | Activity (uCi/mL) | MDA (uCi/mL) |
|---|---|---|---|---|
| TH-227 | 0.959 | 5850.00* | 5.76E-007 +/- 1.94E-007 | 8.63E-008 +/- 1.06E-008 |
| TH-228 | 0.994 | 5400.00* | 5.71E-006 +/- 8.92E-007 | 7.92E-008 +/- 9.69E-009 |
| TH-229 | 1.000 | 4872.00* | 4.82E-006 +/- 5.89E-007 | 6.74E-008 +/- 8.24E-009 |
| TH-230 | 0.993 | 4672.00* | 5.63E-006 +/- 8.83E-007 | 6.72E-008 +/- 8.22E-009 |
| TH-232 | 0.993 | 3997.00* | 5.48E-006 +/- 8.63E-007 | 6.71E-008 +/- 8.20E-009 |

AG 8/12/14

0000094628.CNF




0062

**********
***** S P E C T R A L D A T A R E P O R T *****
**********

Sample Title: 01

Elapsed Live time: 10200
Elapsed Real Time: 10204

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1: | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 49: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 57: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 65: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 73: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81: | 0 | 2 | 0 | 1 | 1 | 1 | 1 | 0 |
| 89: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 97: | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 105: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 113: | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 |
| 121: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 129: | 1 | 0 | 1 | 1 | 0 | 1 | 2 | 2 |
| 137: | 4 | 1 | 0 | 2 | 3 | 0 | 1 | 3 |
| 145: | 4 | 2 | 1 | 2 | 3 | 1 | 9 | 2 |
| 153: | 5 | 2 | 2 | 4 | 5 | 3 | 2 | 4 |
| 161: | 2 | 10 | 8 | 6 | 5 | 9 | 8 | 7 |
| 169: | 5 | 4 | 6 | 8 | 5 | 5 | 7 | 7 |
| 177: | 7 | 8 | 9 | 11 | 15 | 6 | 7 | 6 |
| 185: | 7 | 12 | 4 | 5 | 9 | 11 | 6 | 6 |
| 193: | 7 | 15 | 6 | 8 | 8 | 5 | 8 | 11 |
| 201: | 7 | 5 | 3 | 0 | 0 | 0 | 0 | 0 |
| 209: | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 |
| 217: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 225: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 233: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 241: | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 249: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 257: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 265: | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 273: | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 281: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 289: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 297: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 305: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 313: | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 321: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 329: | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 |
| 337: | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 |
| 345: | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 353: | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 2 |
| 361: | 0 | 2 | 1 | 2 | 1 | 1 | 3 | 3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 369: | 2 | 1 | 2 | 0 | 2 | 0 | 1 | 3 |

Sample Title: 01

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 377: | 4 | 2 | 3 | 2 | 6 | 0 | 3 | 5 |
| 385: | 3 | 3 | 2 | 5 | 3 | 6 | 4 | 5 |
| 393: | 7 | 2 | 3 | 4 | 2 | 10 | 9 | 3 |
| 401: | 10 | 3 | 6 | 10 | 5 | 11 | 11 | 3 |
| 409: | 6 | 8 | 14 | 5 | 7 | 7 | 16 | 8 |
| 417: | 14 | 8 | 13 | 10 | 7 | 9 | 8 | 20 |
| 425: | 10 | 4 | 5 | 8 | 7 | 7 | 0 | 3 |
| 433: | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 441: | 0 | 0 | 2 | 1 | 1 | 1 | 1 | 4 |
| 449: | 3 | 2 | 5 | 5 | 2 | 2 | 2 | 3 |
| 457: | 6 | 5 | 1 | 3 | 2 | 6 | 3 | 2 |
| 465: | 3 | 1 | 1 | 5 | 6 | 10 | 3 | 4 |
| 473: | 5 | 1 | 4 | 9 | 9 | 11 | 8 | 6 |
| 481: | 4 | 4 | 11 | 6 | 2 | 4 | 11 | 4 |
| 489: | 6 | 8 | 5 | 1 | 5 | 3 | 6 | 2 |
| 497: | 4 | 2 | 5 | 4 | 3 | 4 | 2 | 2 |
| 505: | 2 | 3 | 3 | 2 | 3 | 3 | 0 | 3 |
| 513: | 3 | 2 | 1 | 0 | 1 | 4 | 3 | 1 |
| 521: | 5 | 1 | 4 | 2 | 0 | 1 | 3 | 1 |
| 529: | 1 | 0 | 0 | 2 | 1 | 2 | 0 | 1 |
| 537: | 3 | 3 | 4 | 5 | 1 | 1 | 0 | 0 |
| 545: | 2 | 0 | 2 | 1 | 0 | 0 | 1 | 0 |
| 553: | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| 561: | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 569: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 577: | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 1 |
| 585: | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| 593: | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 |
| 601: | 2 | 1 | 0 | 1 | 3 | 1 | 3 | 0 |
| 609: | 2 | 0 | 0 | 3 | 0 | 2 | 0 | 1 |
| 617: | 1 | 0 | 3 | 0 | 0 | 3 | 0 | 8 |
| 625: | 1 | 2 | 6 | 2 | 8 | 4 | 3 | 1 |
| 633: | 3 | 4 | 2 | 4 | 2 | 2 | 2 | 4 |
| 641: | 2 | 6 | 6 | 6 | 7 | 8 | 6 | 8 |
| 649: | 5 | 5 | 5 | 12 | 5 | 7 | 2 | 6 |
| 657: | 9 | 10 | 8 | 6 | 7 | 7 | 10 | 12 |
| 665: | 12 | 7 | 5 | 9 | 12 | 8 | 8 | 10 |
| 673: | 14 | 12 | 13 | 10 | 5 | 12 | 5 | 4 |
| 681: | 0 | 3 | 1 | 1 | 0 | 0 | 1 | 0 |
| 689: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 697: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 705: | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 713: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 721: | 1 | 0 | 2 | 0 | 0 | 0 | 3 | 0 |
| 729: | 2 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 737: | 0 | 0 | 3 | 4 | 3 | 3 | 0 | 0 |
| 745: | 2 | 0 | 2 | 0 | 1 | 4 | 3 | 4 |
| 753: | 2 | 2 | 2 | 4 | 5 | 3 | 3 | 3 |
| 761: | 4 | 6 | 5 | 3 | 5 | 4 | 7 | 2 |
| 769: | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |
| 777: | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 785: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 793: | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 801: | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |

Sample Title: 01

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 809: | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 817: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 825: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 833: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 841: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 849: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 857: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 865: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 873: | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 881: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 889: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 897: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 905: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 913: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 921: | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 929: | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 937: | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 945: | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| 953: | 0 | 1 | 1 | 4 | 3 | 5 | 3 | 3 |
| 961: | 3 | 5 | 4 | 6 | 3 | 4 | 2 | 5 |
| 969: | 1 | 1 | 1 | 1 | 2 | 0 | 1 | 0 |
| 977: | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 3 |
| 985: | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 993: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1001: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1009: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1017: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# Apex-Alpha™

KB 8/11/14

Sample Description: BLANK
Spectrum File: \\OR-ALPHA1\Canberra\ApexAlpha\Root\Data\00000946
Batch Identification: 1408008A-TH
Sample Identification: 02
Sample Geometry: Shelf 2
Procedure Description: Th iso

Detector Name: Alpha_037
Chamber Serial Number: 04026478A
Detector Serial Number: 91133
Env. Background: System Bkgd 93502
Reagent Blank: <not performed>

Sample Size: 1.000E+009 +/- 0.000E+000 mL
Sample Date/Time: 8/11/2014 6:47:11 AM
Acquisition Date/Time: 8/11/2014 11:38:02 AM
Acquisition Live Time: 170.0 minutes
Acquisition Real Time: 170.1 minutes

Tracer Certificate: Th229_TH-18A
Tracer Quantity: 0.237 mL
Effective Efficiency: 0.2030 +/- 0.0163
Counting Efficiency: 0.1628 +/- 0.0029 on 3/8/2014 1:58:03 PM
Chem. Recovery Factor: 1.2475 +/- 0.1024

Peak Match Tolerance: 0.175 MeV

PEAK AREA REPORT

| Nuclide | | Energy (MeV) | Net Pk Area | Pk Area Error % | Ambient Backgnd | Reagent Backgnd | FWHM (keV) |
|---|---|---|---|---|---|---|---|
| TH-227 | | 5.800 | 6.15 | 85.19 | 0.85 | 0.00E+000 | 2.9 |
| TH-228 | | 5.304 | 1.66 | 169.38 | 0.34 | 0.00E+000 | 2.9 |
| TH-229 | T | 4.893 | 184.00 | 14.49 | 0.00 | 0.00E+000 | 7.5 |
| TH-230 | | 4.627 | 7.66 | 72.63 | 0.34 | 0.00E+000 | 2.9 |
| TH-232 | | 4.044 | 0.66 | 305.43 | 0.34 | 0.00E+000 | 2.9 |

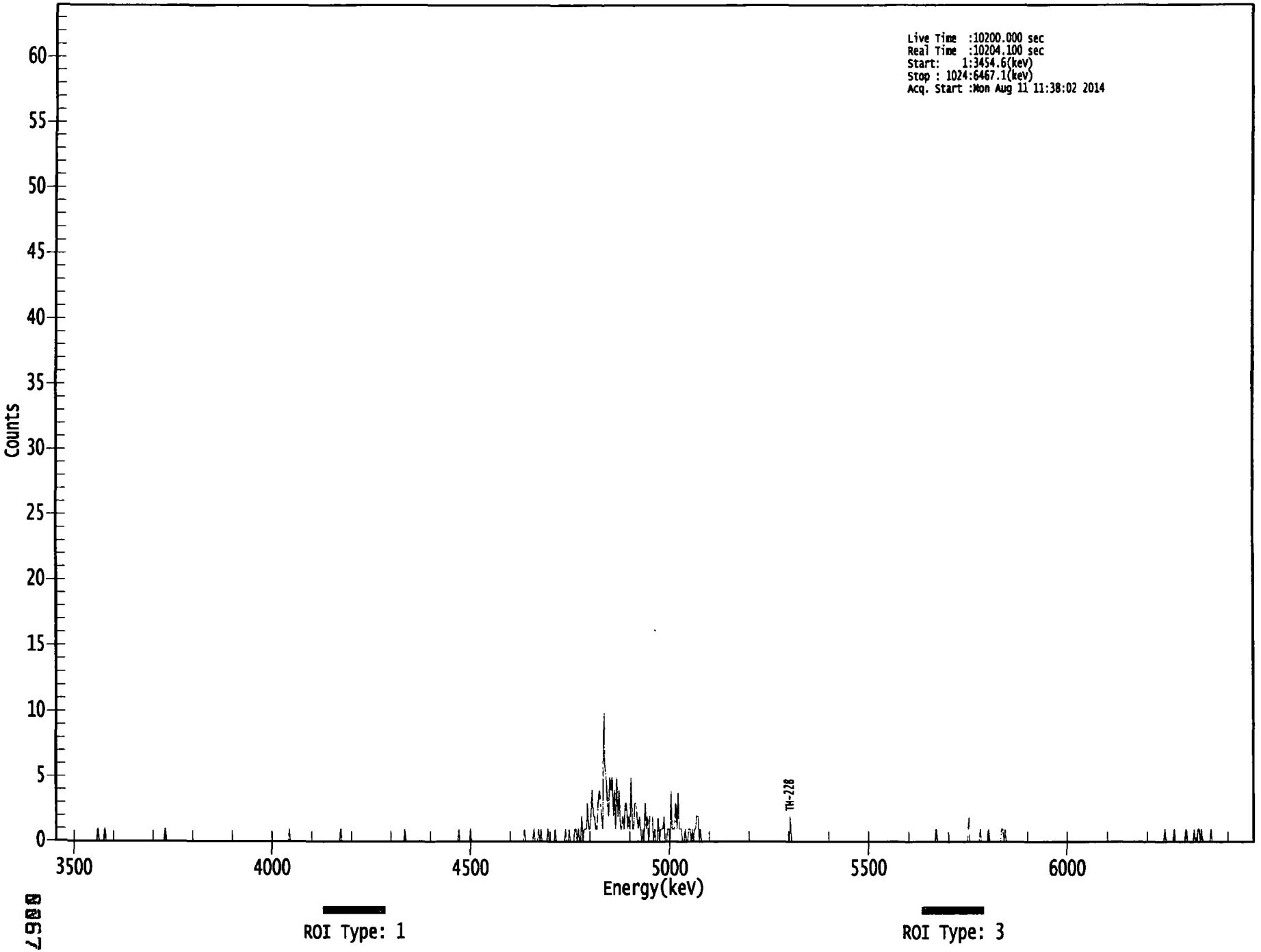
T = Tracer Peak used for Effective Efficiency

NUCLIDE ANALYSIS RESULTS

| Nuclide | Id Conf. | Energy (keV) | Activity (uCi/mL) | MDA (uCi/mL) |
|---|---|---|---|---|
| TH-227 | 0.987 | 5850.00* | 8.23E-017 +/- 7.13E-017 | 8.01E-017 +/- 1.26E-017 |
| TH-228 | 0.953 | 5400.00* | 2.17E-017 +/- 3.69E-017 | 6.24E-017 +/- 9.81E-018 |
| TH-229 | 0.998 | 4872.00* | 2.41E-015 +/- 3.79E-016 | 7.86E-017 +/- 1.24E-017 |
| TH-230 | 0.990 | 4672.00* | 1.00E-016 +/- 7.44E-017 | 6.25E-017 +/- 9.82E-018 |
| TH-232 | 0.989 | 3997.00* | 8.61E-018 +/- 2.63E-017 | 6.24E-017 +/- 9.80E-018 |

AG 8/12/14

0000094632.CNF



**********
***** S P E C T R A L D A T A R E P O R T *****
**********

Sample Title: 02

Elapsed Live time: 10200
Elapsed Real Time: 10204

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 41: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 49: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 57: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 65: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 73: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 89: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 97: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 105: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 113: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 121: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 129: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 137: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 145: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 153: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 161: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 169: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 177: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 185: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 193: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 201: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 209: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 225: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 233: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 241: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 249: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 257: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 265: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 273: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 281: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 289: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 297: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 305: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 313: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 321: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 329: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 337: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 345: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 353: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 361: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 369: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Sample Title: 02

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 377: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 385: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 393: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 401: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 409: | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| 417: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 425: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 433: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 441: | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| 449: | 0 | 0 | 2 | 0 | 1 | 1 | 1 | 3 |
| 457: | 1 | 1 | 2 | 4 | 2 | 2 | 1 | 1 |
| 465: | 3 | 4 | 3 | 2 | 1 | 10 | 6 | 5 |
| 473: | 3 | 2 | 5 | 4 | 5 | 2 | 4 | 1 |
| 481: | 5 | 2 | 4 | 1 | 1 | 2 | 1 | 3 |
| 489: | 3 | 1 | 2 | 1 | 5 | 1 | 1 | 3 |
| 497: | 3 | 2 | 1 | 2 | 1 | 0 | 1 | 0 |
| 505: | 3 | 1 | 2 | 0 | 2 | 2 | 2 | 0 |
| 513: | 1 | 0 | 0 | 2 | 0 | 1 | 1 | 1 |
| 521: | 2 | 0 | 0 | 1 | 1 | 0 | 4 | 1 |
| 529: | 1 | 1 | 3 | 1 | 4 | 1 | 1 | 1 |
| 537: | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 545: | 1 | 0 | 1 | 1 | 2 | 2 | 0 | 1 |
| 553: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 561: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 569: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 577: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 585: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 593: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 601: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 609: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 617: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 625: | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| 633: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 641: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 649: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 657: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 665: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 673: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 681: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 689: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 697: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 705: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 713: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 721: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 729: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 737: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 745: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 753: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 761: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 769: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 777: | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| 785: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 793: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 801: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Sample Title: 02

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 809: | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 817: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 825: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 833: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 841: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 849: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 857: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 865: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 873: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 881: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 889: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 897: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 905: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 913: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 921: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 929: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 937: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 945: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 953: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 961: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 969: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 977: | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 985: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 993: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1001: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1009: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1017: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

KB 8/11/14

# Apex-Alpha™

Sample Description: OUTSIDE TRAILER-DUP
Spectrum File: \\OR-ALPHA1\Canberra\ApexAlpha\Root\Data\00000946
Batch Identification: 1408008A-TH
Sample Identification: 03
Sample Geometry: Shelf 2
Procedure Description: Th iso

Detector Name: Alpha_038
Chamber Serial Number: 04026478B
Detector Serial Number: 91134
Env. Background: System Bkgd 93503
Reagent Blank: <not performed>

Sample Size: 7.850E+008 +/- 0.000E+000 mL
Sample Date/Time: 8/1/2014 6:47:11 AM
Acquisition Date/Time: 8/11/2014 11:38:04 AM
Acquisition Live Time: 170.0 minutes
Acquisition Real Time: 170.1 minutes

Tracer Certificate: Th229_TH-18A
Tracer Quantity: 0.235 mL
Effective Efficiency: 0.1973 +/- 0.0161
Counting Efficiency: 0.1591 +/- 0.0028 on 1/11/2014 6:35:46 PM
Chem. Recovery Factor: 1.2401 +/- 0.1033

Peak Match Tolerance: 0.175 MeV

PEAK AREA REPORT

| Nuclide | | Energy (MeV) | Net Pk Area | Pk Area Error % | Ambient Backgnd | Reagent Backgnd | FWHM (keV) |
|---|---|---|---|---|---|---|---|
| TH-227 | | 5.805 | 7.66 | 72.63 | 0.34 | 0.00E+000 | 3.0 |
| TH-228 | | 5.368 | 15.83 | 49.57 | 0.17 | 0.00E+000 | 4.4 |
| TH-229 | T | 4.857 | 177.32 | 14.75 | 0.68 | 0.00E+000 | 5.9 |
| TH-230 | | 4.626 | 37.00 | 32.65 | 0.00 | 0.00E+000 | 3.7 |
| TH-232 | | 3.943 | 30.00 | 36.38 | 0.00 | 0.00E+000 | 3.0 |

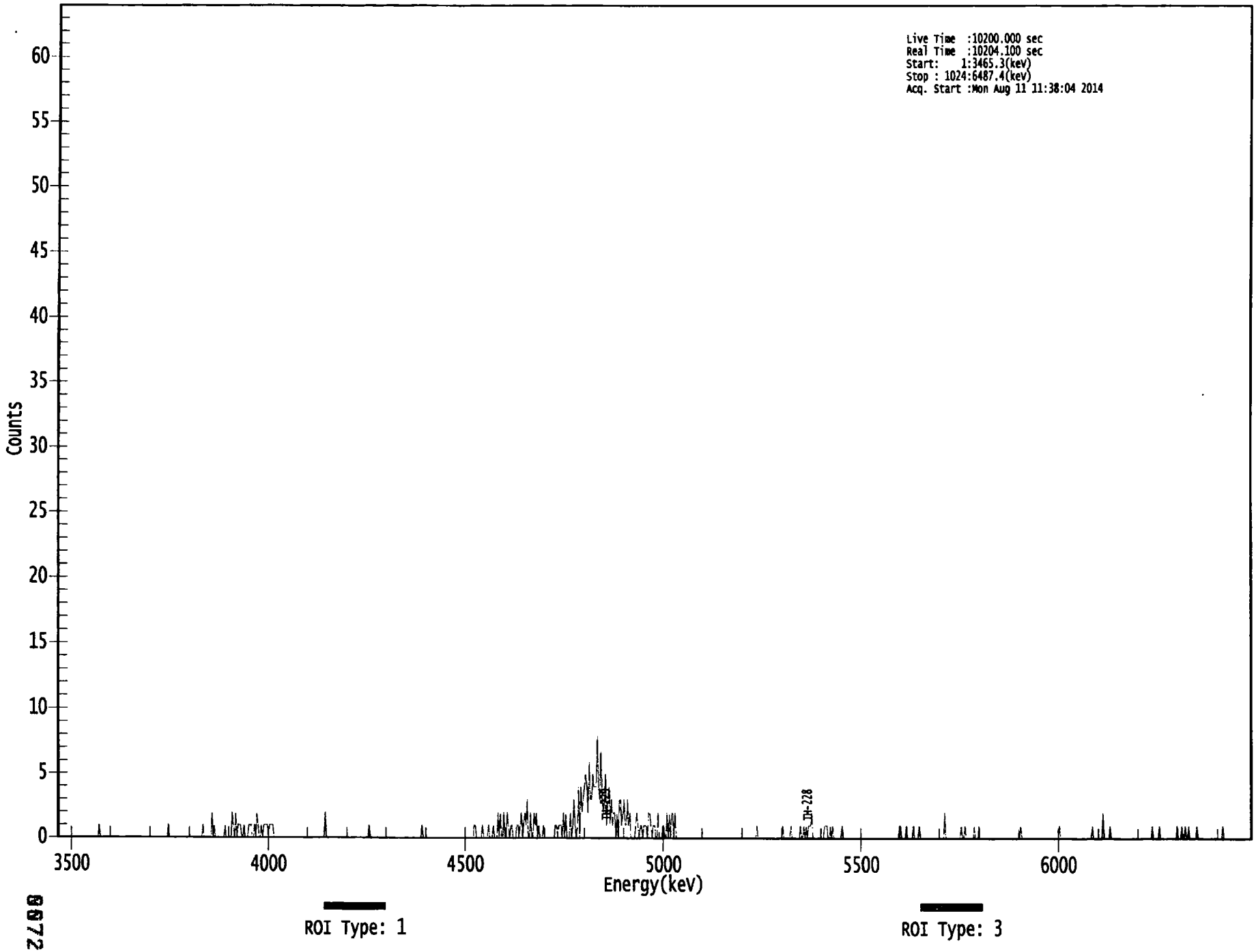
T = Tracer Peak used for Effective Efficiency

NUCLIDE ANALYSIS RESULTS

| Nuclide | Id Conf. | Energy (keV) | Activity (uCi/mL) | MDA (uCi/mL) |
|---|---|---|---|---|
| TH-227 | 0.989 | 5850.00* | 1.35E-016 +/- 1.00E-016 | 8.39E-017 +/- 1.34E-017 |
| TH-228 | 0.995 | 5400.00* | 2.74E-016 +/- 1.43E-016 | 7.22E-017 +/- 1.15E-017 |
| TH-229 | 0.999 | 4872.00* | 3.05E-015 +/- 4.86E-016 | 9.69E-017 +/- 1.55E-017 |
| TH-230 | 0.989 | 4672.00* | 6.34E-016 +/- 2.30E-016 | 1.03E-016 +/- 1.64E-017 |
| TH-232 | 0.985 | 3997.00* | 5.13E-016 +/- 2.04E-016 | 1.03E-016 +/- 1.64E-017 |

AG 8/12/14

0000094633.CNF




0072

**********
***** S P E C T R A L D A T A R E P O R T *****
**********

Sample Title: 03

Elapsed Live time: 10200
Elapsed Real Time: 10204

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 41: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 49: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 57: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 65: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 73: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 89: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 97: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 105: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 113: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 121: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 129: | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 |
| 137: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 145: | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| 153: | 0 | 2 | 0 | 1 | 1 | 1 | 0 | 0 |
| 161: | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 169: | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 1 |
| 177: | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 185: | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 193: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 201: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 209: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 225: | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 233: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 241: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 249: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 257: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 265: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 273: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 281: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 289: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 297: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 305: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 313: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 321: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 329: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 337: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 345: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 353: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 361: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 369: | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |

Sample Title: 03

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 377: | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 2 |
| 385: | 0 | 0 | 2 | 1 | 0 | 1 | 1 | 0 |
| 393: | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 |
| 401: | 1 | 2 | 1 | 3 | 0 | 0 | 2 | 0 |
| 409: | 0 | 2 | 1 | 2 | 0 | 1 | 0 | 0 |
| 417: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 425: | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| 433: | 1 | 0 | 2 | 0 | 2 | 0 | 0 | 0 |
| 441: | 2 | 0 | 1 | 3 | 1 | 0 | 1 | 4 |
| 449: | 0 | 4 | 2 | 3 | 4 | 5 | 4 | 2 |
| 457: | 6 | 3 | 3 | 5 | 4 | 4 | 4 | 8 |
| 465: | 4 | 3 | 7 | 3 | 2 | 3 | 5 | 1 |
| 473: | 3 | 4 | 1 | 3 | 1 | 2 | 2 | 0 |
| 481: | 2 | 0 | 3 | 3 | 1 | 2 | 3 | 1 |
| 489: | 1 | 3 | 1 | 2 | 0 | 0 | 0 | 0 |
| 497: | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 1 |
| 505: | 1 | 1 | 0 | 2 | 2 | 1 | 0 | 1 |
| 513: | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 |
| 521: | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 2 |
| 529: | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 537: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 545: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 553: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 561: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 569: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 577: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 585: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 593: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 601: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 609: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 617: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 625: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 633: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 641: | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 2 |
| 649: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 657: | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| 665: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 673: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 681: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 689: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 697: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 705: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 713: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 721: | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 729: | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 737: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 745: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 753: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 761: | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 769: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 777: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 785: | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 793: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 801: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Sample Title: 03

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 809: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 817: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 825: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 833: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 841: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 849: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 857: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 865: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 873: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 881: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 889: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 897: | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 905: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 913: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 921: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 929: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 937: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 945: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 953: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 961: | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 969: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 977: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 985: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 993: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1001: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1009: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1017: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Apex-Alpha™

VB 8/12/14

Sample Description: OUTSIDE TRAILER
Spectrum File: \\OR-ALPHA1\Canberra\ApexAlpha\Root\Data\00000946
Batch Identification: 1408008A-TH
Sample Identification: 04
Sample Geometry: Shelf 2
Procedure Description: Th iso

Detector Name: Alpha_039
Chamber Serial Number: 06027396A
Detector Serial Number: 83109
Env. Background: System Bkgd 93504
Reagent Blank: <not performed>

Sample Size: 7.850E+008 +/- 0.000E+000 mL
Sample Date/Time: 8/1/2014 6:47:11 AM
Acquisition Date/Time: 8/11/2014 11:38:08 AM
Acquisition Live Time: 170.0 minutes
Acquisition Real Time: 170.1 minutes

Tracer Certificate: Th229_TH-18A
Tracer Quantity: 0.235 mL
Effective Efficiency: 0.1719 +/- 0.0149
Counting Efficiency: 0.1846 +/- 0.0032 on 1/11/2014 6:35:49 PM
Chem. Recovery Factor: 0.9312 +/- 0.0822

Peak Match Tolerance: 0.175 MeV

PEAK AREA REPORT

| Nuclide | | Energy (MeV) | Net Pk Area | Pk Area Error % | Ambient Backgnd | Reagent Backgnd | FWHM (keV) |
|---|---|---|---|---|---|---|---|
| TH-227 | | 5.783 | 6.66 | 78.18 | 0.34 | 0.00E+000 | 3.0 |
| TH-228 | | 5.362 | 15.32 | 51.36 | 0.68 | 0.00E+000 | 3.0 |
| TH-229 | T | 4.868 | 154.00 | 15.85 | 0.00 | 0.00E+000 | 3.3 |
| TH-230 | | 4.633 | 25.32 | 39.56 | 0.68 | 0.00E+000 | 4.5 |
| TH-232 | | 3.949 | 12.49 | 56.77 | 0.51 | 0.00E+000 | 4.5 |

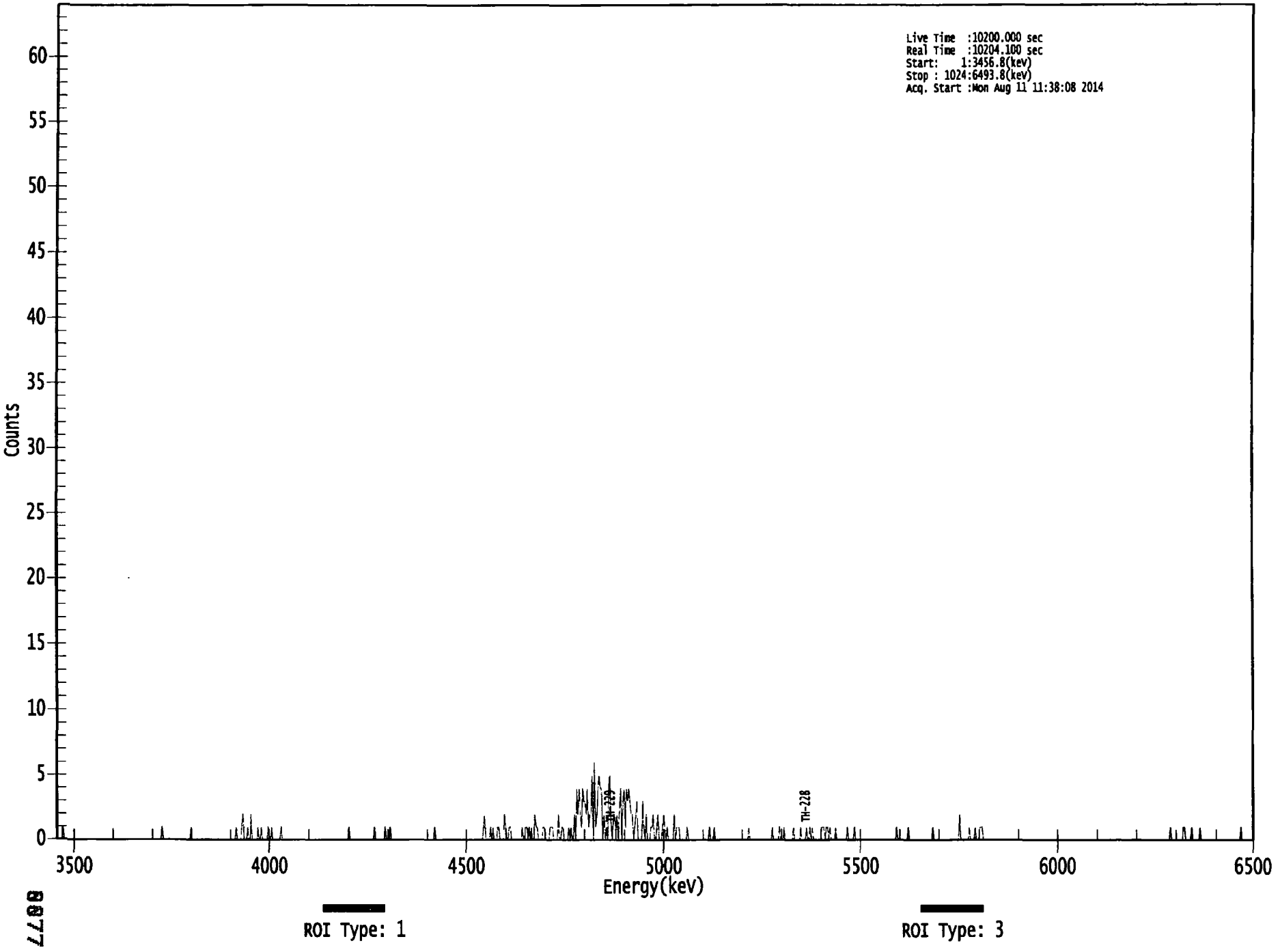
T = Tracer Peak used for Effective Efficiency

NUCLIDE ANALYSIS RESULTS

| Nuclide | Id Conf. | Energy (keV) | Activity (uCi/mL) | MDA (uCi/mL) |
|---|---|---|---|---|
| TH-227 | 0.977 | 5850.00* | 1.34E-016 +/- 1.07E-016 | 9.64E-017 +/- 1.64E-017 |
| TH-228 | 0.992 | 5400.00* | 3.04E-016 +/- 1.64E-016 | 1.12E-016 +/- 1.90E-017 |
| TH-229 | 1.000 | 4872.00* | 3.04E-015 +/- 5.16E-016 | 1.18E-016 +/- 2.01E-017 |
| TH-230 | 0.992 | 4672.00* | 4.98E-016 +/- 2.14E-016 | 1.11E-016 +/- 1.88E-017 |
| TH-232 | 0.988 | 3997.00* | 2.45E-016 +/- 1.45E-016 | 1.03E-016 +/- 1.75E-017 |

AG 8/12/14

0000094630.CNF




0077

**********
***** S P E C T R A L D A T A R E P O R T *****
**********

Sample Title: 04

Elapsed Live time: 10200
Elapsed Real Time: 10204

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 49: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 57: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 65: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 73: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 89: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 97: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 105: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 113: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 121: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 129: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 137: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 145: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 153: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 161: | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| 169: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 177: | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 185: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 193: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 201: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 209: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 225: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 233: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 241: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 249: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 257: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 265: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 273: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 281: | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 289: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 297: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 305: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 313: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 321: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 329: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 337: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 345: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 353: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 361: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 369: | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

Sample Title: 04

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 377: | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 385: | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 393: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 401: | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| 409: | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 |
| 417: | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 425: | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 |
| 433: | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 441: | 0 | 1 | 0 | 0 | 2 | 0 | 4 | 2 |
| 449: | 4 | 2 | 1 | 4 | 3 | 3 | 2 | 4 |
| 457: | 1 | 2 | 2 | 5 | 0 | 6 | 1 | 2 |
| 465: | 4 | 5 | 4 | 4 | 0 | 2 | 0 | 1 |
| 473: | 0 | 4 | 5 | 1 | 0 | 2 | 2 | 0 |
| 481: | 2 | 0 | 2 | 4 | 0 | 3 | 4 | 1 |
| 489: | 4 | 3 | 4 | 3 | 2 | 2 | 0 | 1 |
| 497: | 2 | 3 | 0 | 0 | 0 | 0 | 3 | 1 |
| 505: | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 2 |
| 513: | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 1 |
| 521: | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 529: | 0 | 2 | 0 | 1 | 1 | 1 | 0 | 0 |
| 537: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 545: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 553: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 561: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 569: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 577: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 585: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 593: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 601: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 609: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 617: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 625: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 633: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 641: | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 649: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 657: | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| 665: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 673: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 681: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 689: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 697: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 705: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 713: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 721: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 729: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 737: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 745: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 753: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 761: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 769: | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| 777: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 785: | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 793: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 801: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Sample Title: 04

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 809: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 817: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 825: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 833: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 841: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 849: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 857: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 865: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 873: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 881: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 889: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 897: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 905: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 913: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 921: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 929: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 937: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 945: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 953: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 961: | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 969: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 977: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 985: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 993: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1001: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1009: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 1017: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

ICB 9/11/14

# Apex-Alpha™

Sample Description: TRANSFER STATION
Spectrum File: \\OR-ALPHA1\Canberra\ApexAlpha\Root\Data\00000946
Batch Identification: 1408008A-TH
Sample Identification: 05
Sample Geometry: Shelf 2
Procedure Description: Th iso

Detector Name: Alpha_040
Chamber Serial Number: 06027396B
Detector Serial Number: 91135
Env. Background: System Bkgd 93505
Reagent Blank: <not performed>

Sample Size: 1.430E+009 +/- 0.000E+000 mL
Sample Date/Time: 8/1/2014 6:47:11 AM
Acquisition Date/Time: 8/11/2014 11:38:10 AM
Acquisition Live Time: 170.0 minutes
Acquisition Real Time: 170.1 minutes

Tracer Certificate: Th229_TH-18A
Tracer Quantity: 0.234 mL
Effective Efficiency: 0.1812 +/- 0.0153
Counting Efficiency: 0.1822 +/- 0.0032 on 1/11/2014 6:35:50 PM
Chem. Recovery Factor: 0.9945 +/- 0.0858

Peak Match Tolerance: 0.175 MeV

## PEAK AREA REPORT

| Nuclide | | Energy (MeV) | Net Pk Area | Pk Area Error % | Ambient Backgnd | Reagent Backgnd | FWHM (keV) |
|---|---|---|---|---|---|---|---|
| TH-227 | | 5.839 | 9.49 | 65.59 | 0.51 | 0.00E+000 | 3.0 |
| TH-228 | | 5.356 | 37.81 | 32.46 | 1.19 | 0.00E+000 | 3.7 |
| TH-229 | T | 4.874 | 161.83 | 15.42 | 0.17 | 0.00E+000 | 5.5 |
| TH-230 | | 4.640 | 54.32 | 26.79 | 0.68 | 0.00E+000 | 7.4 |
| TH-232 | | 3.960 | 43.00 | 30.24 | 0.00 | 0:00E+000 | 7.4 |

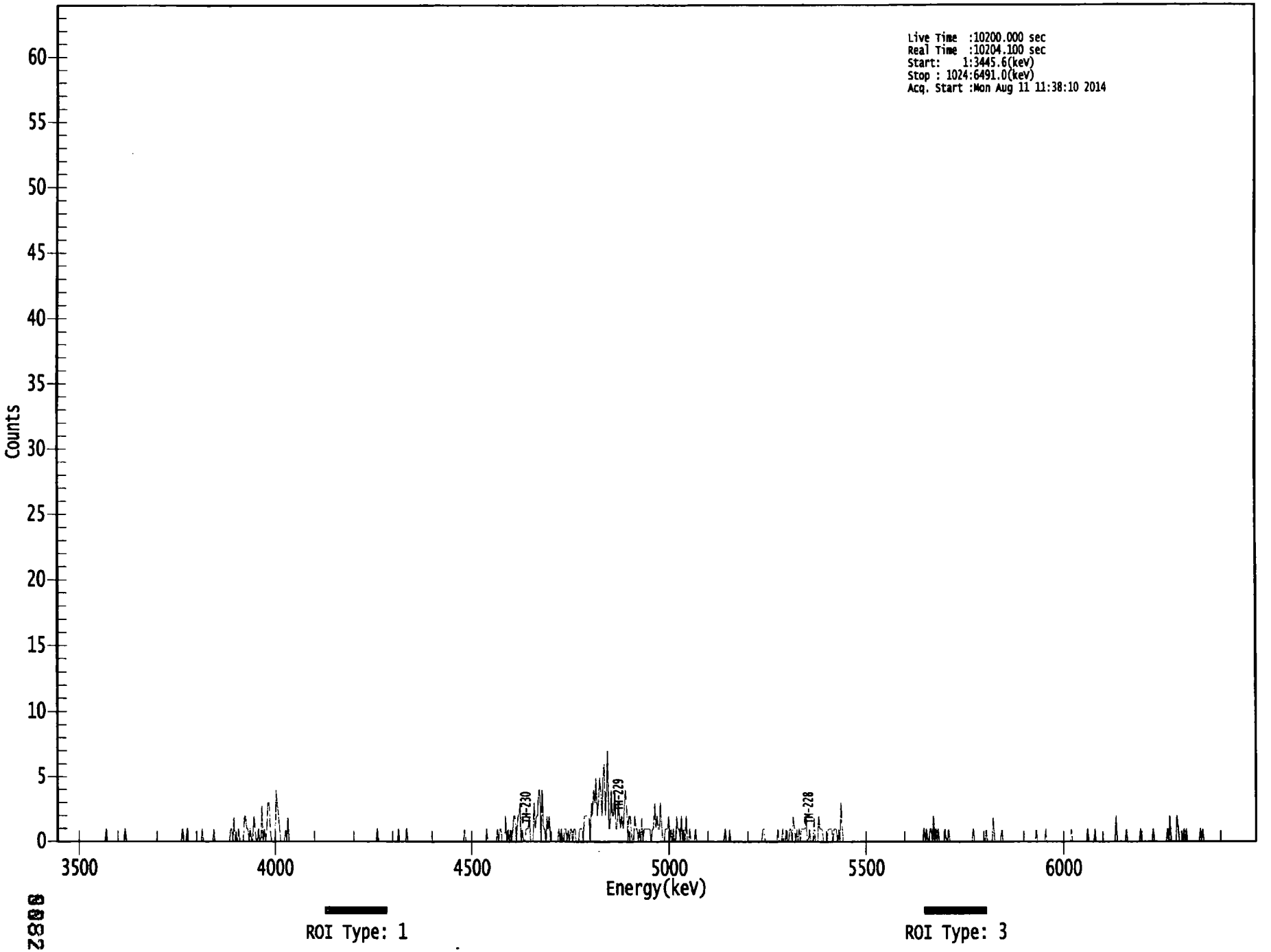
T = Tracer Peak used for Effective Efficiency

## NUCLIDE ANALYSIS RESULTS

| Nuclide | Id Conf. | Energy (keV) | Activity (uCi/mL ) | MDA (uCi/mL ) |
|---|---|---|---|---|
| TH-227 | 0.999 | 5850.00* | 9.96E-017 +/- 6.74E-017 | 5.51E-017 +/- 9.13E-018 |
| TH-228 | 0.990 | 5400.00* | 3.91E-016 +/- 1.42E-016 | 6.81E-017 +/- 1.13E-017 |
| TH-229 | 1.000 | 4872.00* | 1.66E-015 +/- 2.76E-016 | 4.29E-017 +/- 7.11E-018 |
| TH-230 | 0.995 | 4672.00* | 5.57E-016 +/- 1.75E-016 | 5.78E-017 +/- 9.58E-018 |
| TH-232 | 0.993 | 3997.00* | 4.40E-016 +/- 1.52E-016 | 6.13E-017 +/- 1.02E-017 |

AG 8/6/14

# 0000094629.CNF



**********
***** S P E C T R A L D A T A R E P O R T *****
**********

Sample Title: 05

Elapsed Live time: 10200
Elapsed Real Time: 10204

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 49: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 57: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 65: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 73: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 89: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 97: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 105: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 113: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 121: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 129: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 137: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 145: | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| 153: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 161: | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 0 |
| 169: | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 3 |
| 177: | 0 | 1 | 0 | 1 | 3 | 3 | 1 | 0 |
| 185: | 0 | 0 | 0 | 4 | 3 | 2 | 1 | 0 |
| 193: | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 |
| 201: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 209: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 225: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 233: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 241: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 249: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 257: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 265: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 273: | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 281: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 289: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 297: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 305: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 313: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 321: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 329: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 337: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 345: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 353: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 361: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 369: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Sample Title: 05

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 377: | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 2 |
| 385: | 0 | 1 | 0 | 1 | 0 | 1 | 2 | 2 |
| 393: | 0 | 2 | 2 | 3 | 0 | 1 | 0 | 0 |
| 401: | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 3 |
| 409: | 1 | 2 | 2 | 4 | 4 | 0 | 4 | 1 |
| 417: | 1 | 0 | 2 | 1 | 2 | 0 | 0 | 0 |
| 425: | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 433: | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| 441: | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 449: | 1 | 0 | 2 | 2 | 2 | 2 | 2 | 0 |
| 457: | 3 | 2 | 4 | 3 | 5 | 2 | 3 | 5 |
| 465: | 4 | 2 | 5 | 6 | 2 | 4 | 7 | 1 |
| 473: | 1 | 4 | 2 | 2 | 4 | 1 | 1 | 3 |
| 481: | 2 | 1 | 2 | 1 | 2 | 4 | 3 | 0 |
| 489: | 2 | 2 | 1 | 0 | 0 | 2 | 1 | 1 |
| 497: | 0 | 1 | 0 | 2 | 0 | 1 | 1 | 1 |
| 505: | 1 | 1 | 1 | 0 | 1 | 1 | 3 | 1 |
| 513: | 2 | 1 | 1 | 3 | 1 | 0 | 0 | 1 |
| 521: | 1 | 1 | 2 | 0 | 1 | 0 | 1 | 0 |
| 529: | 0 | 2 | 1 | 1 | 0 | 2 | 0 | 1 |
| 537: | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 |
| 545: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 553: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 561: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 569: | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 577: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 585: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 593: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 601: | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 609: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 617: | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 625: | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 1 |
| 633: | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 2 |
| 641: | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 |
| 649: | 0 | 0 | 2 | 1 | 1 | 1 | 0 | 0 |
| 657: | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| 665: | 1 | 1 | 0 | 1 | 0 | 3 | 1 | 0 |
| 673: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 681: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 689: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 697: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 705: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 713: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 721: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 729: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 737: | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 745: | 0 | 1 | 1 | 0 | 2 | 0 | 1 | 0 |
| 753: | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 761: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 769: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 777: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 785: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 793: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 801: | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

Sample Title: 05

| Channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 809: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 817: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 825: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 833: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 841: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 849: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 857: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 865: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 873: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 881: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 889: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 897: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 905: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 913: | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 921: | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 929: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 937: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 945: | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 |
| 953: | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 |
| 961: | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 969: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 977: | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 985: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 993: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1001: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1009: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1017: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

8/11/2014 5:30:56 AM

Apex-Alpha™

# QA SUMMARY REPORT
## Review Of QA Results - Pulser Check

Date : 8/11/2014
Time : 5:30:56 AM

| CHAMBER | DEVICE | PARAMETER | FLAG | DATE |
|---|---|---|---|---|
| Alpha_001 | 21f | ALL | Not Done | |
| Alpha_002 | 21f | ALL | Not Done | |
| Alpha_003 | 21f | ALL | Passed | 8/11/2014 5:17:32 AM |
| Alpha_004 | 21f | ALL | Passed | 8/11/2014 5:17:33 AM |
| Alpha_005 | 21f | ALL | Not Done | |
| Alpha_006 | 21f | ALL | Not Done | |
| Alpha_007 | 21f | ALL | Not Done | |
| Alpha_008 | 21f | ALL | Not Done | |
| Alpha_009 | 21f | ALL | Not Done | |
| Alpha_010 | 21f | ALL | Passed | 8/11/2014 5:17:34 AM |
| Alpha_011 | 21f | ALL | Passed | 8/11/2014 5:17:35 AM |
| Alpha_012 | 21f | ALL | Passed | 8/11/2014 5:17:36 AM |
| Alpha_013 | 21f | ALL | Not Done | |
| Alpha_014 | 21f | ALL | Passed | 8/11/2014 5:17:37 AM |
| Alpha_015 | 21f | Peak FWHM | Action | 8/11/2014 5:17:38 AM |
| Alpha_016 | 21f | ALL | Not Done | |
| Alpha_017 | AIM730 | ALL | Not Done | |
| Alpha_018 | AIM730 | ALL | Not Done | |
| Alpha_019 | AIM730 | ALL | Not Done | |
| Alpha_020 | AIM730 | ALL | Not Done | |
| Alpha_021 | AIM730 | ALL | Not Done | |
| Alpha_022 | AIM730 | ALL | Not Done | |
| Alpha_023 | AIM730 | ALL | Not Done | |
| Alpha_024 | AIM730 | ALL | Passed | 8/11/2014 5:17:38 AM |
| Alpha_025 | AIM730 | ALL | Passed | 8/11/2014 5:17:39 AM |
| Alpha_026 | AIM730 | ALL | Not Done | |
| Alpha_027 | AIM730 | ALL | Not Done | |
| Alpha_028 | AIM730 | ALL | Not Done | |
| Alpha_029 | AIM730 | ALL | Passed | 8/11/2014 5:17:40 AM |
| Alpha_030 | AIM730 | ALL | Not Done | |
| Alpha_031 | AIM730 | ALL | Passed | 8/11/2014 5:17:41 AM |
| Alpha_032 | AIM730 | ALL | Not Done | |
| Alpha_033 | Alpha Analyst100DC | Peak CPS | Action | 8/11/2014 5:17:42 AM |
| Alpha_034 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:43 AM |
| Alpha_035 | Alpha Analyst100DC | ALL | Not Done | |
| Alpha_036 | Alpha Analyst100DC | ALL | Not Done | |
| Alpha_037 | Alpha Analyst100DC | Peak CPS | Action | 8/11/2014 5:17:45 AM |
| Alpha_038 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:46 AM |
| Alpha_039 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:47 AM |
| Alpha_040 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:49 AM |
| Alpha_041 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:50 AM |
| Alpha_042 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:52 AM |

Review of QA Results - Pulser Check

8/11/2014 5:30:56 AM

| CHAMBER | DEVICE | PARAMETER | FLAG | DATE |
|---|---|---|---|---|
| Alpha_043 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:53 AM |
| Alpha_044 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:56 AM |
| Alpha_045 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:57 AM |
| Alpha_046 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:17:59 AM |
| Alpha_047 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:18:01 AM |
| Alpha_048 | Alpha Analyst100DC | ALL | Passed | 8/11/2014 5:18:02 AM |

**APPROVED BY:** _____

**APPROVAL DATE:** 8/11

```
*************************************************************************
*****          L I B R A R Y   L I S T I N G   R E P O R T          *****
*************************************************************************
```

Nuclide Library Title: Thorium

Nuclide Library Description: Th-227,-228,-229,-230,-232

| Nuclide Name | Half-Life (Seconds) | Energy (keV ) | Energy Uncert. (keV ) | Yield (%) | Yield Uncert.(Abs.+-) |
|---|---|---|---|---|---|
| TH-227 | 6.873E+008 | 5850.000* | 0.000 | 97.5000 | 0.0000 |
| TH-228 | 6.034E+007 | 5400.000* | 0.000 | 99.9400 | 0.0000 |
| TH-229 | 2.487E+011 | 4872.000* | 0.000 | 99.5200 | 0.0000 |
| TH-230 | 2.379E+012 | 4672.000* | 0.000 | 99.8200 | 0.0000 |
| TH-232 | 4.434E+017 | 3997.000* | 0.000 | 100.0000 | 0.0000 |

* = key line

TOTALS: 5 Nuclides 5 Energy Lines

# SECTION IX

# ANALYTICAL DATA (GROSS ALPHA/BETA)

# 14-08008
## GaGbT_ThSr
Run 1



| | |
|---|---|
| Work Order | 14-08008 |
| Analysis Code | GaGbT_ThSr |
| Run | 1 |
| Date Received | 8/4/2014 |
| Lab Deadline | 8/25/2014 |
| Client | Feezor Engineering, Inc. |
| Project | FEEBRI |
| Report Level | 4 |
| Activity Units | uCi |
| Aliquot Units | ml |
| Matrix | AF |
| Method | LANL MLR-100 Modified |
| Instrument Type | Alpha/Beta GPC |
| Radiometric Tracer | |
| Radiometric Sol# | |
| Tracer Act (dpm/g) | |
| Carrier | |
| Carrier Conc (mg/ml) | |

| Internal Fraction | Sample Desc | Client ID | Login CPM | Sample Date | Sample Aliquot |
|---|---|---|---|---|---|
| 01 | LCS | LCS | | 08/04/14 00:00 | 1.0000E+00 |
| 02 | MBL | BLANK | | 08/04/14 00:00 | 3.7500E+08 |
| 03 | DUP | OUTSIDE TRAILER | 43 | 08/01/14 08:40 | 3.9300E+08 |
| 04 | DO | OUTSIDE TRAILER | 43 | 08/01/14 08:40 | 3.9300E+08 |
| 05 | TRG | TRANSFER STATION | 56 | 08/01/14 09:00 | 3.5800E+08 |

* SAF1 is used for Gross Alpha and all other radionuclides. SAF2 is used for Gross Beta only. ** Actual mass exceeded the calibration curve range. Results should be qualified as appropriate.

# 14-08008
## GaGbT_ThSr
Run 1



| Internal Fraction | Sample Desc | Tracer Aliquot (g) | Tracer Total ACT (dpm) | Radiometric Tracer (pCi) | Radiometric % Rec | Grav Carrier Added (ml) | Grav Filter Tare (g) | Grav Filter Final (g) | Grav Filter Net (g) | Grav % Rec | Mean % Rec | SAF 1* | SAF 2* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | LCS | | | | 0.00 | | 7.6296 | 7.6299 | 0.0003 | | | 1.00 | 1.00 |
| 02 | MBL | | | | 0.00 | | 7.6146 | 7.6147 | 0.0001 | | | 1.00 | 1.00 |
| 03 | DUP | | | | 0.00 | | 1.0000 | 1.0001 | 0.0001 | | | 1.00 | 1.00 |
| 04 | DO | | | | 0.00 | | 1.0000 | 1.0001 | 0.0001 | | | 1.00 | 1.00 |
| 05 | TRG | | | | 0.00 | | 1.0000 | 1.0001 | 0.0001 | | | 1.00 | 1.00 |

* SAF1 is used for Gross Alpha and all other radionuclides. SAF2 is used for Gross Beta only. ** Actual mass exceeded the calibration curve range. Results should be qualified as appropriate.

# 14-08008
## GaGbT_ThSr
### Run 1



| Internal Fraction | Sample Desc | Rough Prep Date | Rough Prep By | Prep Date | Prep By | Sep t0 Date/Time | Sep t0 By | Sep t1 Date/Time | Sep t1 By |
|---|---|---|---|---|---|---|---|---|---|
| 01 | LCS | | | 08/06/14 05:07 | JWOLFE | | | | |
| 02 | MBL | | | 08/06/14 05:07 | JWOLFE | | | | |
| 03 | DUP | | | 08/06/14 05:07 | JWOLFE | | | | |
| 04 | DO | | | 08/06/14 05:07 | JWOLFE | | | | |
| 05 | TRG | | | 08/06/14 05:07 | JWOLFE | | | | |

* SAF1 is used for Gross Alpha and all other radionuclides. SAF2 is used for Gross Beta only. ** Actual mass exceeded the calibration curve range. Results should be qualified as appropriate.

Eberline Services
Oak Ridge Laboratory

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-GaGbT-1



Client: Feezor Engineering, Inc.
Eberline Services Work Order: 14-08008
Analysis Code: GaGbT
Run: 1

| Lab Fraction | Nuclide | Sample Desc | Client Identification | Activity Units | Results | Error Estimate | MDA | LCS Known | LCS %R | LCS Flag | RPD Flag | MDA Flag | Blank Flag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | GROSS ALPHA | LCS | LCS | uCi/ml | 2.70E-04 | 3.72E-06 | 3.04E-07 | 2.48E-04 | 108.60 | OK | | INV | |
| 02 | GROSS ALPHA | MBL | BLANK | uCi/ml | 1.73E-16 | 2.80E-16 | 5.88E-16 | | | | | OK | OK |
| 03 | GROSS ALPHA | DUP | OUTSIDE TRAILER | uCi/ml | 2.86E-15 | 7.31E-16 | 9.00E-16 | | | | NA | OK | |
| 04 | GROSS ALPHA | DO | OUTSIDE TRAILER | uCi/ml | 3.32E-15 | 7.71E-16 | 9.00E-16 | | | | | OK | |
| 05 | GROSS ALPHA | TRG | TRANSFER STATION | uCi/ml | 2.50E-15 | 6.80E-16 | 7.36E-16 | | | | | OK | |

0093

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-GaGbT-1



| Client | Eberline Services Work Order | Analysis Code | Run |
|---|---|---|---|
| Feezor Engineering, Inc. | 14-08008 | GaGbT | 1 |

| Lab Fraction | Nuclide | Sample Desc | Sample Date | Sample Aliquot | Radiometric % Rec | Grav % Rec | Mean % Rec | SAF | Sep t0 Date/Time | Sep t1 Date/Time |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | GROSS ALPHA | LCS | 08/04/14 00:00 | 1.00E+00 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| 02 | GROSS ALPHA | MBL | 08/04/14 00:00 | 3.75E+08 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| 03 | GROSS ALPHA | DUP | 08/01/14 08:40 | 3.93E+08 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| 04 | GROSS ALPHA | DO | 08/01/14 08:40 | 3.93E+08 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| 05 | GROSS ALPHA | TRG | 08/01/14 09:00 | 3.58E+08 | 0.00 | 0.00 | 0.00 | 1.00 | | |

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-GaGbT-1



| Client | Eberline Services Work Order | Analysis Code | Run |
|---|---|---|---|
| Feezor Engineering, Inc. | 14-08008 | GaGbT | 1 |

| Lab Fraction | Nuclide | Sample Desc | Counting Date/Time | Halflife (days) | Detect | Carrier | Count Time | Counts | Bkg CPM | Eff |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | GROSS ALPHA | LCS | 08/06/14 12:22 | | LB4110R | C1 | 120 | 20167 | 0.1 | 0.2806 |
| 02 | GROSS ALPHA | MBL | 08/06/14 12:22 | | LB4110R | C2 | 120 | 11 | 0.05 | 0.2886 |
| 03 | GROSS ALPHA | DUP | 08/06/14 12:22 | | LB4110R | C3 | 120 | 98 | 0.133333333 | 0.2736 |
| 04 | GROSS ALPHA | DO | 08/06/14 14:25 | | LB4110R | C3 | 120 | 111 | 0.133333333 | 0.2736 |
| 05 | GROSS ALPHA | TRG | 08/06/14 12:22 | | LB4110R | C4 | 120 | 73 | 0.066666667 | 0.2722 |

Eberline Services
Oak Ridge Laboratory

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-GaGbT-1



Client: Feezor Engineering, Inc.
Eberline Services Work Order: 14-08008
Analysis Code: GaGbT
Run: 1

| Lab Fraction | Nuclide | Sample Desc | Client Identification | Activity Units | Results | Error Estimate | MDA | LCS Known | LCS %R | LCS Flag | RPD Flag | MDA Flag | Blank Flag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | GROSS BETA | LCS | LCS | uCi/ml | 2.54E-04 | 3.00E-06 | 6.51E-07 | 2.78E-04 | 91.36 | OK | | INV | |
| 02 | GROSS BETA | MBL | BLANK | uCi/ml | -2.52E-16 | 7.74E-16 | 1.88E-15 | | | | | OK | OK |
| 03 | GROSS BETA | DUP | OUTSIDE TRAILER | uCi/ml | 2.85E-14 | 1.69E-15 | 1.63E-15 | | | | OK | OK | |
| 04 | GROSS BETA | DO | OUTSIDE TRAILER | uCi/ml | 2.79E-14 | 1.67E-15 | 1.63E-15 | | | | | OK | |
| 05 | GROSS BETA | TRG | TRANSFER STATION | uCi/ml | 2.64E-14 | 1.67E-15 | 1.54E-15 | | | | | OK | |

0096

**Preliminary Data Report & Analytical Calculations**

# Work Order: 14-08008-GaGbT-1



| Client | Eberline Services Work Order | Analysis Code | Run |
|---|---|---|---|
| Feezor Engineering, Inc. | 14-08008 | GaGbT | 1 |

| Lab Fraction | Nuclide | Sample Desc | Sample Date | Sample Aliquot | Radiometric % Rec | Grav % Rec | Mean % Rec | SAF | Sep t0 Date/Time | Sep t1 Date/Time |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | GROSS BETA | LCS | 08/04/14 00:00 | 1.00E+00 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| 02 | GROSS BETA | MBL | 08/04/14 00:00 | 3.75E+08 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| 03 | GROSS BETA | DUP | 08/01/14 08:40 | 3.93E+08 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| 04 | GROSS BETA | DO | 08/01/14 08:40 | 3.93E+08 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| 05 | GROSS BETA | TRG | 08/01/14 09:00 | 3.58E+08 | 0.00 | 0.00 | 0.00 | 1.00 | | |

0097

# Preliminary Data Report & Analytical Calculations
# Work Order: 14-08008-GaGbT-1



| Client | Eberline Services Work Order | Analysis Code | Run |
|---|---|---|---|
| Feezor Engineering, Inc. | 14-08008 | GaGbT | 1 |

| Lab Fraction | Nuclide | Sample Desc | Counting Date/Time | Halflife (days) | Detect | Carrier | Count Time | Counts | Bkg CPM | Eff | A to B, Cor |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | GROSS BETA | LCS | 08/06/14 12:22 | | LB4110R | C1 | 120 | 38027 | 1.65 | 0.4795 | 271.98648 |
| 02 | GROSS BETA | MBL | 08/06/14 12:22 | | LB4110R | C2 | 120 | 170 | 1.516666667 | 0.4758 | 1.416666667 |
| 03 | GROSS BETA | DUP | 08/06/14 12:22 | | LB4110R | C3 | 120 | 1613 | 1.533333333 | 0.4705 | 13.232845 |
| 04 | GROSS BETA | DO | 08/06/14 14:25 | | LB4110R | C3 | 120 | 1585 | 1.533333333 | 0.4705 | 12.97181083 |
| 05 | GROSS BETA | TRG | 08/06/14 12:22 | | LB4110R | C4 | 120 | 1361 | 1.166666667 | 0.4781 | 11.18611583 |

**Count Room Report**
**Client: Feezor Engineering, Inc.**

**14-08008-GaGbT_ThSr-1 (uCi/ml) in AF**
**Tracer ID:**



| Internal Fraction | Sample Desc | Client ID | Sample Date | Sample Aliquot | Tracer Aliquot (g) | Tracer ACT (dpm) | Radiometric Tracer (pCi) | Radiometric % Rec | SAF 1* | SAF 2* |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | LCS | LCS | 08/04/14 00:00 | 1.0000 | | | | 0.00 | 1.00 | 1.00 |
| 02 | MBL | BLANK | 08/04/14 00:00 | 375000000.0000 | | | | 0.00 | 1.00 | 1.00 |
| 03 | DUP | OUTSIDE TRAILER | 08/01/14 08:40 | 393000000.0000 | | | | 0.00 | 1.00 | 1.00 |
| 04 | DO | OUTSIDE TRAILER | 08/01/14 08:40 | 393000000.0000 | | | | 0.00 | 1.00 | 1.00 |
| 05 | TRG | TRANSFER STATION | 08/01/14 09:00 | 358000000.0000 | | | | 0.00 | 1.00 | 1.00 |

Eberline Services
Oak Ridge Laboratory

# Spike and Tracer Worksheet


Printed: 8/6/2014 5:07 AM

| Internal Work Order | Run | Analysis Code | Date | Technician | Technician Initials | Witness Initials |
|---|---|---|---|---|---|---|
| 14-08008 | 1 | GaGbT_ThSr | 8/6/2014 5:07 | JWOLFE | JW | |

| LCS & Matrix Spikes | | | | | LCS | MS | LCSD | MSD | LCS | | MS | | LCSD | | MSD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Isotope | Sol # | Activity dpm/g | Solution Date | Approx Addition | Volume Used (g) | Volume Used (g) | Volume Used (g) | Volume Used (g) | Known pCi | Error Estimate | Added pCi | Error Estimate | Known pCi | Error Estimate | Added pCi | Error Estimate |
| Am-241 | A/B-07 | 597.150 | 8/6/2014 | 0.790 | 0.9230 | | | | 248.27 | 10.676 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| SrY-90 | A/B-07 | 668.623 | 8/6/2014 | 0.820 | 0.9230 | | | | 277.99 | 8.340 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| Tc-99 MS | Tc-2a | 22043.688 | 10/16/2013 | 0.1 | | | | | | | | | | | | |

## Tracers

| fraction | Isotope | Sol # | Activity dpm/g | Solution Date | Volume Used (g) | Approx Addition |
|---|---|---|---|---|---|---|

## Balance Printer Tapes

| Tracer | LCS |
|---|---|
| | |

| Matrix Spike |
|---|
| |

Eberline Analytical
Oak Ridge Laboratory

# Aliquot Worksheet



| Work Order | Run | Analysis Code | Rpt Units | Lab Deadline | Technician |
|---|---|---|---|---|---|
| 14-08008 | 1 | GaGbT_ThSr | ml | 8/25/2014 | JWOLFE |

| Lab Fraction | Feezor Engineering, Inc. Client ID | Sample Type | Muffle Data Ratio Post/Pre | Dilution Data No of Dils | Dil Factor | Ratio | Aliquot Data Aliquot | Net Equiv | MS Aliquot Data Aliquot | Net Equiv | H-3 Solids Only Water Added (ml) | H3 Dist Aliq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | LCS | LCS | | | | | 1.0000E+00 | 1.0000E+00 | | | | |
| 02 | BLANK | MBL | | | | | 3.7500E+08 | 3.7500E+08 | | | | |
| 03 | OUTSIDE TRAILER | DUP | | | | | 3.9300E+08 | 3.9300E+08 | | | | |
| 04 | OUTSIDE TRAILER | DO | | | | | 3.9300E+08 | 3.9300E+08 | | | | |
| 05 | TRANSFER STATION | TRG | | | | | 3.5800E+08 | 3.5800E+08 | | | | |

| Comments | |
|---|---|

Technician: JWOLFE Date: 8/6/14

Eberline Services - Oak Ridge
Version 1.0 9/1999

# Gravimetric Worksheet



| Work Order | Run | Analysis Code | Gravimetric Carrier | Carrier Conc (mg/ml) | Technician |
|---|---|---|---|---|---|
| 14-08008 | 1 | GaGbT_ThSr | | | JWOLFE |

| TRetec Fraction | Feezor Engineering, Inc. Client ID | Sample Type | Carrier Data: Carrier Added (ml) | Filter Data: Filter Tare (g) | Filter Data: Filter Final (g) | Filter Data: Filter Net (g) | Gravimetric: % Recovery |
|---|---|---|---|---|---|---|---|
| 01 | LCS | LCS | | 7.6296 | 7.6299 | 0.0003 | |
| 02 | BLANK | MBL | | 7.6146 | 7.6147 | 0.0001 | |
| 03 | DUP | DUP | | 1.0000 | 1.0001 | 0.0001 | |
| 04 | OUTSIDE TRAILER | DO | | 1.0000 | 1.0001 | 0.0001 | |
| 05 | TRANSFER STATION | TRG | | 1.0000 | 1.0001 | 0.0001 | |

Technician: JWOLFE Date: 8/6/14

0182

R 9/6/14 KB

| Detector ID | Sample ID | Alpha | Beta | Count Time | Voltage | TOD |
|---|---|---|---|---|---|---|
| C1 | 1408008-01 | 20167 | 38027 | 120 | 1400 | 8/6/14 14:22 |
| C2 | 1408008-02 | 11 | 170 | 120 | 1400 | 8/6/14 14:22 |
| C3 | 1408008-03 | 98 | 1613 | 120 | 1400 | 8/6/14 14:22 |
| C4 | 1408008-05 | 73 | 1361 | 120 | 1400 | 8/6/14 14:22 |

R
8/6/14
KCB

| Detector ID | Sample ID | Alpha | Beta | Count Time | Voltage | TOD |
|---|---|---|---|---|---|---|
| C3 | 1408008-04 | 111 | 1585 | 120 | 1400 | 8/6/14 16:25 |



0104

# GPC Detector Report
(ALL Backgrounds)



AG
8/6/14

| Detector | Alpha/Beta | Calibration Date | Count Date | Bkg CPM | PFW | LCL | Mean | UCL |
|---|---|---|---|---|---|---|---|---|
| LB4110A - A1 | Alpha | 11/18/2007 | 8/6/2014 | 2.00E-01 | P | -1.98E+01 | 2.49E-01 | 2.03E+01 |
| LB4110A - A2 | Alpha | 11/18/2007 | 8/6/2014 | 3.33E-02 | P | -1.68E+01 | 2.25E-01 | 1.72E+01 |
| LB4110A - A3 | Alpha | 11/18/2007 | 8/6/2014 | 6.67E-02 | P | -1.63E+01 | 1.95E-01 | 1.67E+01 |
| LB4110A - A4 | Alpha | 11/18/2007 | 8/6/2014 | 5.00E-02 | P | -1.74E+01 | 2.09E-01 | 1.78E+01 |
| LB4110A - B1 | Alpha | 11/18/2007 | 8/6/2014 | 8.33E-02 | P | -9.28E-02 | 7.27E-02 | 2.38E-01 |
| LB4110A - B2 | Alpha | 11/18/2007 | 8/6/2014 | 5.00E-02 | P | -7.33E-02 | 7.27E-02 | 2.19E-01 |
| LB4110A - B3 | Alpha | 11/18/2007 | 8/6/2014 | 1.50E-01 | W | -6.17E-02 | 5.44E-02 | 1.71E-01 |
| LB4110A - B4 | Alpha | 11/18/2007 | 8/6/2014 | 1.33E-01 | P | -1.31E-01 | 7.75E-02 | 2.86E-01 |
| LB4110A - C1 | Alpha | 11/18/2007 | 8/6/2014 | 2.17E-01 | P | -1.39E-01 | 8.71E-02 | 3.13E-01 |
| LB4110A - C2 | Alpha | 11/18/2007 | 8/6/2014 | 8.33E-02 | P | -1.68E-01 | 8.13E-02 | 3.31E-01 |
| LB4110A - C3 | Alpha | 11/18/2007 | 8/6/2014 | 1.00E-01 | P | -1.63E-01 | 9.51E-02 | 3.54E-01 |
| LB4110A - C4 | Alpha | 11/18/2007 | 8/6/2014 | 1.17E-01 | P | -6.39E-02 | 6.87E-02 | 2.01E-01 |
| LB4110A - D1 | Alpha | 11/18/2007 | 8/6/2014 | 8.33E-02 | P | -5.45E-02 | 8.12E-02 | 2.17E-01 |
| LB4110A - D2 | Alpha | 11/18/2007 | 8/6/2014 | 3.33E-02 | P | -7.07E-02 | 6.08E-02 | 1.92E-01 |
| LB4110A - D3 | Alpha | 11/18/2007 | 8/6/2014 | 5.00E-02 | P | -4.99E-02 | 6.87E-02 | 1.87E-01 |
| LB4110A - D4 | Alpha | 11/18/2007 | 8/6/2014 | 5.00E-02 | P | -6.80E-02 | 7.07E-02 | 2.09E-01 |
| LB4110R - A1 | Alpha | 11/24/2006 | 8/6/2014 | 1.50E-01 | P | -9.35E-02 | 9.86E-02 | 2.91E-01 |
| LB4110R - A2 | Alpha | 11/24/2006 | 8/6/2014 | 6.67E-02 | P | -8.64E-02 | 7.27E-02 | 2.32E-01 |
| LB4110R - A3 | Alpha | 11/24/2006 | 8/6/2014 | 2.67E-01 | F | -7.18E-02 | 8.07E-02 | 2.33E-01 |
| LB4110R - A4 | Alpha | 11/24/2006 | 8/6/2014 | 3.33E-02 | P | -5.21E-02 | 6.91E-02 | 1.90E-01 |
| LB4110R - B1 | Alpha | 11/24/2006 | 8/6/2014 | 1.00E-01 | P | -9.06E-02 | 6.15E-02 | 2.14E-01 |
| LB4110R - B2 | Alpha | 11/24/2006 | 8/6/2014 | 0.00E+00 | P | -6.92E-02 | 6.03E-02 | 1.90E-01 |
| LB4110R - B3 | Alpha | 11/24/2006 | 8/6/2014 | 1.50E-01 | P | -6.50E-02 | 7.18E-02 | 2.09E-01 |
| LB4110R - B4 | Alpha | 11/24/2006 | 8/6/2014 | 1.33E-01 | P | -6.20E-02 | 6.82E-02 | 1.98E-01 |
| LB4110R - C1 | Alpha | 11/24/2006 | 8/6/2014 | 1.00E-01 | P | -7.57E-02 | 7.29E-02 | 2.22E-01 |
| LB4110R - C2 | Alpha | 11/24/2006 | 8/6/2014 | 5.00E-02 | P | -7.56E-02 | 6.84E-02 | 2.12E-01 |
| LB4110R - C3 | Alpha | 11/24/2006 | 8/6/2014 | 1.33E-01 | P | -8.32E-02 | 8.41E-02 | 2.51E-01 |
| LB4110R - C4 | Alpha | 11/24/2006 | 8/6/2014 | 6.67E-02 | P | -6.02E-02 | 7.87E-02 | 2.17E-01 |
| LB4110R - D1 | Alpha | 11/24/2006 | 12/12/2013 | 0.00E+00 | P | -1.06E-01 | 6.71E-02 | 2.40E-01 |
| LB4110R - D2 | Alpha | 11/24/2006 | 12/12/2013 | 0.00E+00 | P | -8.22E-02 | 6.66E-02 | 2.15E-01 |
| LB4110R - D3 | Alpha | 11/24/2006 | 12/12/2013 | 0.00E+00 | P | -8.70E-02 | 6.63E-02 | 2.20E-01 |
| LB4110R - D4 | Alpha | 11/24/2006 | 12/12/2013 | 0.00E+00 | P | -8.03E-02 | 7.09E-02 | 2.22E-01 |
| LB5100 - 1 | Alpha | 7/10/2006 | 10/26/2007 | 5.00E-02 | P | -1.56E-02 | 9.58E-02 | 2.07E-01 |

# GPC Detector Report
(ALL Backgrounds)



AG
8/6/14

| Detector | Alpha/Beta | Calibration Date | Count Date | Bkg CPM | PFW | LCL | Mean | UCL |
|---|---|---|---|---|---|---|---|---|
| LB4110A - A1 | Beta | 11/18/2007 | 8/6/2014 | 1.68E+00 | P | -2.68E+02 | 7.46E+00 | 2.83E+02 |
| LB4110A - A2 | Beta | 11/18/2007 | 8/6/2014 | 1.63E+00 | P | -2.80E+01 | 2.78E+00 | 3.35E+01 |
| LB4110A - A3 | Beta | 11/18/2007 | 8/6/2014 | 2.17E+00 | P | -4.64E+01 | 2.60E+00 | 5.17E+01 |
| LB4110A - A4 | Beta | 11/18/2007 | 8/6/2014 | 7.40E+00 | P | -2.96E+01 | 3.90E+00 | 3.74E+01 |
| LB4110A - B1 | Beta | 11/18/2007 | 8/6/2014 | 1.67E+00 | P | -9.58E+00 | 3.12E+00 | 1.58E+01 |
| LB4110A - B2 | Beta | 11/18/2007 | 8/6/2014 | 1.30E+00 | P | -7.01E+00 | 1.93E+00 | 1.09E+01 |
| LB4110A - B3 | Beta | 11/18/2007 | 8/6/2014 | 1.98E+00 | P | -4.20E-01 | 1.40E+00 | 3.22E+00 |
| LB4110A - B4 | Beta | 11/18/2007 | 8/6/2014 | 1.57E+00 | P | -7.61E+00 | 1.97E+00 | 1.16E+01 |
| LB4110A - C1 | Beta | 11/18/2007 | 8/6/2014 | 1.70E+00 | P | -4.95E+00 | 2.03E+00 | 9.01E+00 |
| LB4110A - C2 | Beta | 11/18/2007 | 8/6/2014 | 1.58E+00 | P | 3.01E-01 | 1.28E+00 | 2.26E+00 |
| LB4110A - C3 | Beta | 11/18/2007 | 8/6/2014 | 2.30E+00 | P | 2.79E-01 | 1.52E+00 | 2.76E+00 |
| LB4110A - C4 | Beta | 11/18/2007 | 8/6/2014 | 1.42E+00 | P | -1.63E+00 | 2.01E+00 | 5.64E+00 |
| LB4110A - D1 | Beta | 11/18/2007 | 8/6/2014 | 1.68E+00 | P | -2.30E+00 | 2.52E+00 | 7.34E+00 |
| LB4110A - D2 | Beta | 11/18/2007 | 8/6/2014 | 6.12E+00 | W | -3.66E+00 | 1.79E+00 | 7.24E+00 |
| LB4110A - D3 | Beta | 11/18/2007 | 8/6/2014 | 2.77E+00 | P | 9.02E-01 | 4.40E+00 | 7.90E+00 |
| LB4110A - D4 | Beta | 11/18/2007 | 8/6/2014 | 6.62E+00 | P | -7.52E+00 | 1.72E+00 | 1.10E+01 |
| LB4110R - A1 | Beta | 11/24/2006 | 8/6/2014 | 2.00E+00 | P | -5.70E+01 | 3.37E+00 | 6.38E+01 |
| LB4110R - A2 | Beta | 11/24/2006 | 8/6/2014 | 2.38E+00 | P | -4.52E+01 | 1.91E+00 | 4.90E+01 |
| LB4110R - A3 | Beta | 11/24/2006 | 8/6/2014 | 2.22E+00 | P | -4.19E+01 | 2.56E+00 | 4.70E+01 |
| LB4110R - A4 | Beta | 11/24/2006 | 8/6/2014 | 3.78E+00 | P | -4.17E+01 | 1.96E+00 | 4.56E+01 |
| LB4110R - B1 | Beta | 11/24/2006 | 8/6/2014 | 1.62E+00 | P | -4.39E+01 | 1.94E+00 | 4.77E+01 |
| LB4110R - B2 | Beta | 11/24/2006 | 8/6/2014 | 9.30E+01 | F | -4.72E+01 | 2.41E+00 | 5.20E+01 |
| LB4110R - B3 | Beta | 11/24/2006 | 8/6/2014 | 1.37E+00 | P | -4.37E+01 | 2.51E+00 | 4.87E+01 |
| LB4110R - B4 | Beta | 11/24/2006 | 8/6/2014 | 9.83E-01 | P | -4.40E+01 | 1.85E+00 | 4.77E+01 |
| LB4110R - C1 | Beta | 11/24/2006 | 8/6/2014 | 1.65E+00 | P | -4.39E+01 | 2.76E+00 | 4.94E+01 |
| LB4110R - C2 | Beta | 11/24/2006 | 8/6/2014 | 1.52E+00 | P | -4.38E+01 | 2.58E+00 | 4.89E+01 |
| LB4110R - C3 | Beta | 11/24/2006 | 8/6/2014 | 1.53E+00 | P | -4.42E+01 | 2.39E+00 | 4.90E+01 |
| LB4110R - C4 | Beta | 11/24/2006 | 8/6/2014 | 1.17E+00 | P | -4.99E+01 | 2.76E+00 | 5.54E+01 |
| LB4110R - D1 | Beta | 11/24/2006 | 12/12/2013 | 0.00E+00 | P | -4.37E+01 | 5.31E+00 | 5.43E+01 |
| LB4110R - D2 | Beta | 11/24/2006 | 12/12/2013 | 0.00E+00 | P | -4.67E+01 | 1.79E+00 | 5.03E+01 |
| LB4110R - D3 | Beta | 11/24/2006 | 12/12/2013 | 0.00E+00 | P | -5.02E+01 | 5.29E+00 | 6.08E+01 |
| LB4110R - D4 | Beta | 11/24/2006 | 12/12/2013 | 0.00E+00 | P | -4.65E+01 | 2.13E+00 | 5.07E+01 |
| LB5100 - 1 | Beta | 7/10/2006 | 10/26/2007 | 4.52E+00 | F | -3.19E-01 | 1.58E+00 | 3.48E+00 |

# GPC Detector Report
(ALL Efficiencies)



AG
8/6/14

| Detector | Alpha/Beta | Calibration Date | Count Date | Eff | PFW | LCL | Mean | UCL |
|---|---|---|---|---|---|---|---|---|
| LB4110A - A1 | Alpha | 11/18/2007 | 8/6/2014 | 0.2337 | P | 0.0056 | 0.2183 | 0.4309 |
| LB4110A - A2 | Alpha | 11/18/2007 | 8/6/2014 | 0.2002 | P | -0.0317 | 0.1777 | 0.3871 |
| LB4110A - A3 | Alpha | 11/18/2007 | 8/6/2014 | 0.1992 | P | -0.0537 | 0.1685 | 0.3907 |
| LB4110A - A4 | Alpha | 11/18/2007 | 8/6/2014 | 0.2271 | P | -0.0326 | 0.1886 | 0.4098 |
| LB4110A - B1 | Alpha | 11/18/2007 | 8/6/2014 | 0.2189 | P | 0.1951 | 0.2237 | 0.2522 |
| LB4110A - B2 | Alpha | 11/18/2007 | 8/6/2014 | 0.2062 | P | 0.1897 | 0.2194 | 0.2491 |
| LB4110A - B3 | Alpha | 11/18/2007 | 8/6/2014 | 0.2373 | P | 0.1356 | 0.2326 | 0.3295 |
| LB4110A - B4 | Alpha | 11/18/2007 | 8/6/2014 | 0.2277 | P | 0.2064 | 0.2347 | 0.2630 |
| LB4110A - C1 | Alpha | 11/18/2007 | 8/6/2014 | 0.2154 | P | 0.1980 | 0.2203 | 0.2425 |
| LB4110A - C2 | Alpha | 11/18/2007 | 8/6/2014 | 0.2244 | P | 0.1985 | 0.2250 | 0.2515 |
| LB4110A - C3 | Alpha | 11/18/2007 | 8/6/2014 | 0.2436 | P | 0.2241 | 0.2491 | 0.2740 |
| LB4110A - C4 | Alpha | 11/18/2007 | 8/6/2014 | 0.2224 | P | 0.1980 | 0.2251 | 0.2523 |
| LB4110A - D1 | Alpha | 11/18/2007 | 8/6/2014 | 0.2151 | P | 0.1796 | 0.2309 | 0.2822 |
| LB4110A - D2 | Alpha | 11/18/2007 | 8/6/2014 | 0.2468 | P | 0.2013 | 0.2562 | 0.3111 |
| LB4110A - D3 | Alpha | 11/18/2007 | 8/6/2014 | 0.2475 | P | 0.2047 | 0.2615 | 0.3183 |
| LB4110A - D4 | Alpha | 11/18/2007 | 8/6/2014 | 0.1940 | P | 0.1482 | 0.1976 | 0.2471 |
| LB4110R - A1 | Alpha | 11/24/2006 | 8/6/2014 | 0.2323 | P | 0.1998 | 0.2378 | 0.2759 |
| LB4110R - A2 | Alpha | 11/24/2006 | 8/6/2014 | 0.2141 | P | 0.1847 | 0.2188 | 0.2530 |
| LB4110R - A3 | Alpha | 11/24/2006 | 8/6/2014 | 0.2220 | P | 0.1922 | 0.2232 | 0.2543 |
| LB4110R - A4 | Alpha | 11/24/2006 | 8/6/2014 | 0.2410 | P | 0.2127 | 0.2447 | 0.2767 |
| LB4110R - B1 | Alpha | 11/24/2006 | 8/6/2014 | 0.1942 | P | 0.1707 | 0.2230 | 0.2754 |
| LB4110R - B2 | Alpha | 11/24/2006 | 8/6/2014 | 0.1775 | W | 0.1691 | 0.2152 | 0.2613 |
| LB4110R - B3 | Alpha | 11/24/2006 | 8/6/2014 | 0.2330 | P | 0.1968 | 0.2434 | 0.2900 |
| LB4110R - B4 | Alpha | 11/24/2006 | 8/6/2014 | 0.2016 | P | 0.1812 | 0.2292 | 0.2771 |
| LB4110R - C1 | Alpha | 11/24/2006 | 8/6/2014 | 0.2069 | P | 0.1794 | 0.2141 | 0.2488 |
| LB4110R - C2 | Alpha | 11/24/2006 | 8/6/2014 | 0.2134 | P | 0.1901 | 0.2232 | 0.2564 |
| LB4110R - C3 | Alpha | 11/24/2006 | 8/6/2014 | 0.2286 | P | 0.2034 | 0.2383 | 0.2733 |
| LB4110R - C4 | Alpha | 11/24/2006 | 8/6/2014 | 0.2033 | P | 0.1784 | 0.2201 | 0.2617 |
| LB4110R - D1 | Alpha | 11/24/2006 | 12/12/2013 | 0.0000 | W | -0.0274 | 0.1906 | 0.4086 |
| LB4110R - D2 | Alpha | 11/24/2006 | 12/12/2013 | 0.0000 | W | -0.0306 | 0.2168 | 0.4641 |
| LB4110R - D3 | Alpha | 11/24/2006 | 12/12/2013 | 0.0000 | W | -0.0300 | 0.2129 | 0.4559 |
| LB4110R - D4 | Alpha | 11/24/2006 | 12/12/2013 | 0.0000 | W | -0.0254 | 0.1716 | 0.3686 |
| LB5100 - 1 | Alpha | 7/10/2006 | 10/26/2007 | 0.3368 | P | 0.3332 | 0.3455 | 0.3578 |

# GPC Detector Report
(ALL Efficiencies)



AG
8/6/14

| Detector | Alpha/Beta | Calibration Date | Count Date | Eff | PFW | LCL | Mean | UCL |
|---|---|---|---|---|---|---|---|---|
| LB4110A - A1 | Beta | 11/18/2007 | 8/6/2014 | 0.5636 | P | 0.2370 | 0.5629 | 0.8888 |
| LB4110A - A2 | Beta | 11/18/2007 | 8/6/2014 | 0.4661 | P | 0.1863 | 0.4679 | 0.7495 |
| LB4110A - A3 | Beta | 11/18/2007 | 8/6/2014 | 0.4947 | P | 0.1201 | 0.4622 | 0.8043 |
| LB4110A - A4 | Beta | 11/18/2007 | 8/6/2014 | 0.5628 | P | 0.1704 | 0.5003 | 0.8302 |
| LB4110A - B1 | Beta | 11/18/2007 | 8/6/2014 | 0.5498 | P | 0.4654 | 0.5326 | 0.5998 |
| LB4110A - B2 | Beta | 11/18/2007 | 8/6/2014 | 0.5276 | P | 0.4669 | 0.5273 | 0.5876 |
| LB4110A - B3 | Beta | 11/18/2007 | 8/6/2014 | 0.6008 | P | 0.3327 | 0.5395 | 0.7464 |
| LB4110A - B4 | Beta | 11/18/2007 | 8/6/2014 | 0.5667 | P | 0.4945 | 0.5556 | 0.6166 |
| LB4110A - C1 | Beta | 11/18/2007 | 8/6/2014 | 0.5574 | P | 0.4362 | 0.5100 | 0.5839 |
| LB4110A - C2 | Beta | 11/18/2007 | 8/6/2014 | 0.5758 | P | 0.3975 | 0.5141 | 0.6307 |
| LB4110A - C3 | Beta | 11/18/2007 | 8/6/2014 | 0.6286 | P | 0.5246 | 0.5967 | 0.6687 |
| LB4110A - C4 | Beta | 11/18/2007 | 8/6/2014 | 0.5779 | P | 0.4522 | 0.5313 | 0.6104 |
| LB4110A - D1 | Beta | 11/18/2007 | 8/6/2014 | 0.7461 | F | 0.4002 | 0.5570 | 0.7139 |
| LB4110A - D2 | Beta | 11/18/2007 | 8/6/2014 | 0.6948 | P | 0.4363 | 0.5872 | 0.7382 |
| LB4110A - D3 | Beta | 11/18/2007 | 8/6/2014 | 0.6548 | P | 0.4777 | 0.6136 | 0.7495 |
| LB4110A - D4 | Beta | 11/18/2007 | 8/6/2014 | 0.4984 | P | 0.3484 | 0.4703 | 0.5921 |
| LB4110R - A1 | Beta | 11/24/2006 | 8/6/2014 | 0.5735 | P | 0.4800 | 0.5697 | 0.6594 |
| LB4110R - A2 | Beta | 11/24/2006 | 8/6/2014 | 0.5271 | P | 0.4217 | 0.5108 | 0.5998 |
| LB4110R - A3 | Beta | 11/24/2006 | 8/6/2014 | 0.5383 | P | 0.4553 | 0.5386 | 0.6219 |
| LB4110R - A4 | Beta | 11/24/2006 | 8/6/2014 | 0.6227 | P | 0.5083 | 0.5944 | 0.6804 |
| LB4110R - B1 | Beta | 11/24/2006 | 8/6/2014 | 0.4693 | P | 0.4289 | 0.5404 | 0.6518 |
| LB4110R - B2 | Beta | 11/24/2006 | 8/6/2014 | 0.4484 | P | 0.4139 | 0.5188 | 0.6236 |
| LB4110R - B3 | Beta | 11/24/2006 | 8/6/2014 | 0.6084 | P | 0.4809 | 0.5954 | 0.7099 |
| LB4110R - B4 | Beta | 11/24/2006 | 8/6/2014 | 0.5130 | P | 0.4427 | 0.5486 | 0.6544 |
| LB4110R - C1 | Beta | 11/24/2006 | 8/6/2014 | 0.5051 | P | 0.4126 | 0.5018 | 0.5910 |
| LB4110R - C2 | Beta | 11/24/2006 | 8/6/2014 | 0.5452 | P | 0.4317 | 0.5355 | 0.6392 |
| LB4110R - C3 | Beta | 11/24/2006 | 8/6/2014 | 0.5910 | P | 0.4802 | 0.5737 | 0.6673 |
| LB4110R - C4 | Beta | 11/24/2006 | 8/6/2014 | 0.5307 | P | 0.4298 | 0.5258 | 0.6217 |
| LB4110R - D1 | Beta | 11/24/2006 | 12/12/2013 | 0.0000 | W | -0.0662 | 0.4558 | 0.9778 |
| LB4110R - D2 | Beta | 11/24/2006 | 12/12/2013 | 0.0000 | W | -0.0738 | 0.5122 | 1.0982 |
| LB4110R - D3 | Beta | 11/24/2006 | 12/12/2013 | 0.0000 | W | -0.0718 | 0.4974 | 1.0667 |
| LB4110R - D4 | Beta | 11/24/2006 | 12/12/2013 | 0.0000 | W | -0.0615 | 0.4095 | 0.8805 |
| LB5100 - 1 | Beta | 7/10/2006 | 10/26/2007 | 0.4428 | F | 0.4555 | 0.4731 | 0.4906 |

0108