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ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 655139

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental ○ Direct Revision ◉ Change ECN ○ Temporary ○ Standby ○ Supersedure ○ Cancel/Void ○	MG Cantaloub, WRAP Engineering, T4-52, 372-2122	◉ Yes ○ No	02/25/00
	6. Project Title/No./Work Order No. WRAP Facility/AJ60	7. Bldg./Sys./Fac. No. 2336-W	8. Approval Designator Q
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-4051, Rev. 3, All	10. Related ECN No(s). N/A	11. Related PO No. N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Completed	12d. Restored to Original Condition (Temp. or Standby ECNs only)
○ Yes (fill out Blk. 12b) ◉ No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? ○ Yes ◉ No

This document is being revised in it's entirety. All IPAN information has been added back into this document.

14a. Justification (mark one)	14b. Justification Details
Criteria Change ○ Design Improvement ○ Environmental ○ Facility Deactivation ○ As-Found ◉ Facilitate Const. ○ Const. Error/Omission ○ Design Error/Omission ○	Design verification not required Additions made in response to WIPP audit comments USQ WRP-00-050 This document is being revised in it's entirety.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution sheet

RELEASE STAMP

3-24-00

DATE:

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ENGINEERING CHANGE NOTICE

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1. ECN (use no. from pg. 1): ECN-655139

16. Design Verification Required
- ○ Yes
- ◉ No

17. Cost Impact

	ENGINEERING	CONSTRUCTION
Additional	○ $ N/A	○ $ N/A
Savings	○ $ N/A	○ $ N/A

18. Schedule Impact (days)
- Improvement ○ N/A
- Delay ○ N/A

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	☐	Seismic/Stress Analysis	☐	Tank Calibration Manual	☐
Functional Design Criteria	☐	Stress/Design Report	☐	Health Physics Procedure	☐
Operating Specification	☐	Interface Control Drawing	☐	Spares Multiple Unit Listing	☐
Criticality Specification	☐	Calibration Procedure	☐	Test Procedures/Specification	☐
Conceptual Design Report	☐	Installation Procedure	☐	Component Index	☐
Equipment Spec.	☐	Maintenance Procedure	☐	ASME Coded Item	☐
Const. Spec.	☐	Engineering Procedure	☐	Human Factor Consideration	☐
Procurement Spec.	☐	Operating Instruction	☐	Computer Software	☐
Vendor Information	☐	Operating Procedure	☐	Electric Circuit Schedule	☐
OM Manual	☐	Operational Safety Requirement	☐	ICRS Procedure	☐
FSAR/SAR	☐	IEFD Drawing	☐	Process Control Manual/Plan	☐
Safety Equipment List	☐	Cell Arrangement Drawing	☐	Process Flow Chart	☐
Radiation Work Permit	☐	Essential Material Specification	☐	Purchase Requisition	☐
Environmental Impact Statement	☐	Fac. Proc. Samp. Schedule	☐	Tickler File	☐
Environmental Report	☐	Inspection Plan	☐	None	☒
Environmental Permit	☐	Inventory Adjustment Request	☐		☐

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number/Revision
None		

21. Approvals

Signature		Date	Signature		Date
Design Authority			Design Agent		
Cog. Eng.	CE Wills	3/22/00	PE		
Cog. Mgr.	JR Weidert	3-22-00	QA		
QA	WR Thackaberry	3-22-2000	Safety		
Safety			Design		
Environ.			Environ.		
Other	MG Cantaloub	3/22/00	Other		
SQAO	JL Maupin	3/22/00			

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

A-7900-013-3 (10/97)

HNF-4051
Revision 4

Quality Assurance Objectives For Nondestructive Assay at The Waste Receiving and Processing Facility

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200
Fluor Hanford
P.O. Box 1000
Richland, Washington

HNF-4051
Revision 4

Quality Assurance Objectives For Nondestructive Assay at The Waste Receiving and Processing Facility

MG Cantaloub
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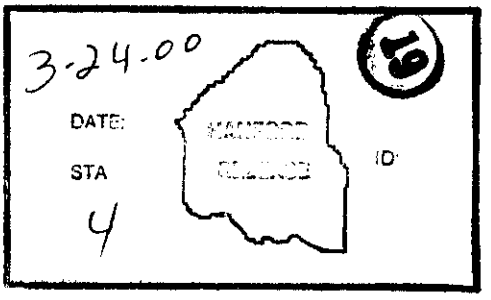

Release Approval

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Fluor Hanford
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Richland, Washington

RECORD OF REVISION

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(2) Title: Quality Assurance Objectives for Non-Destructive Assay at the WRAP Facility

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0	(7) Initial Release, dated 03/03/99 on EDT-623514		
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1-A	Page change for WRAP QAO NDA Replace page iii of the Table of Contents		
	Replace page 4 per ECN-651724		
2	Complete revision per ECN-651739		
3	Complete revision per ECN-655134		
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HNF-4051, Revision 4

Quality Assurance Objectives for Nondestructive Assay at the Waste Receiving and Processing Facility

Craig Wills and Michael G. Cantaloub, Fluor Hanford Inc

Executive Summary

The Waste Receiving and Processing (WRAP) facility, located on the Hanford Site in southeast Washington, is a key link in the certification of transuranic (TRU) waste for shipment to the Waste Isolation Pilot Plant (WIPP). Waste characterization is one of the vital functions performed at WRAP, and nondestructive assay (NDA) measurements of TRU waste containers is one of two required methods used for waste characterization. The Waste Acceptance Criteria for the Waste Isolation Pilot Plant, DOE/WIPP-069 (WIPP-WAC) delineates the quality assurance objectives which have been established for NDA measurement systems. Sites must demonstrate that the quality assurance objectives can be achieved for each radioassay system over the applicable ranges of measurement.

This report summarizes the validation of the WRAP NDA systems against the radioassay quality assurance objectives or QAOs. A brief description of the each test and significant conclusions are included. Variables that may have affected test outcomes and system response are also addressed.

Table of Contents

Introduction

The WRAP facility has four primary NDA systems: two imaging passive/active neutron (IPAN) systems and two gamma energy assay (GEA) systems. The two IPAN units are identical, as are the GEA units, thus the systems are designated as follows: IPAN A, IPAN B, GEA A, and GEA B. This report documents the conformance of GEA-A to the precision and accuracy radioassay QAOs, and reports the minimum detectable concentration (MDC). The QAOs were demonstrated for 55-gallon (208 L) waste containers only. A separate document, HNF-4050 addresses the total measurement uncertainty (TMU) for the GEA system while HNF-5148 addresses system calibration.

WIPP sets forth four nominal testing points for NDA which are in alpha curies and grams of weapons grade (WG) Pu. Due to the nature of available sources, WRAP used the nominal WG Pu gram quantities for testing. This report documents testing of the GEA-A system at the 0.1 g, 1.0 g, 10 g, and 160 g levels for the QAOs with system calibration established in December of 1999, and a supplemental transmission calibration in March of 2000.

The MDC was determined as a function of waste density and Pu-239 transitions of particular interest. Five drums containing non-interfering matrix material covering a density range of 0.046 to 1.56 kg/L were assayed. The MDC reflects the best sensitivity for a particular assay system and specific assay conditions (i.e. count time, sample configuration) when no added radioactivity is present. As such, no radioactive sources were required for the MDC determination. As with the accuracy and precision QAOs, the MDC is valid for 55-gallon waste containers only. The assay data for the MDC calculations was obtained from December 1999 into early January 2000. The instrument response and the documented results are applicable to the current waste stream undergoing analysis at WRAP.

Precision and Accuracy

To comply with QAO requirements, facilities must determine precision and accuracy values obtained for 15 replicate measurements of appropriate-size mock waste containers containing nominal test quantities of TRU isotopes distributed in a non-interfering matrix. This must be done for each system which is to be certified. The equations used to determine these values, tabulated later in this report, are listed below.

Equation 1 calculates precision as the percent relative standard deviation (%RSD) of the distribution of 15 replicate measurements:

$$\%\ RSD = \frac{s}{\bar{y}} * 100$$

where

%RSD = percent relative standard deviation;
s = standard deviation;
$\bar{y}$ = mean of the replicate measurements.

Equation 2 determines the standard deviation:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(y_i - \bar{y})^2}{n-1}}$$

where

s = standard deviation;
$\underline{y}_i$ = the measured value of the i^{th} replicate measurement;
y = the mean of the replicate measurements;
n = the number of replicate measurements.

Equation 3 determines the accuracy as percent recovery for replicate measurements:

$$\%\ R = \frac{C_m}{C_s} * 100$$

where

%R = percent recovery;
C_m = average result of 15 replicate determinations;
C_s = known value for the isotope standard used in the replicate measurements.

Minimum Detectable Concentration

The WIPP-WAC defines the MDC as that radioactivity concentration which, if present, yields a measured value greater than the critical level with 95% probability, where the critical level is defined as that value which measurements of the background will exceed with 5% probability. No value is specified for the MDC. TRU waste destined for WIPP must have a TRU alpha activity concentration greater than 100 nCi/g. The MDC for the waste stream and the assay conditions must be less than the TRU alpha concentration determined in the waste container. Instruments performing TRU/low-level waste discrimination measurements must effectively have an MDC of 100 nCi/g or less. This sets an effective 'minimum' MDC of 100 nCi/g.

Equation 4 gives the base expression used for determining the MDC:

$$MDC = K_1(2.71 + 4.65 * s_b)$$

where

K_1 = proportionality constant relating the detector response (counts) to activity concentration. K_1 incorporates factors such as the detection efficiency and branching ratio for the gamma ray under consideration, the collection live time, waste weight and conversion factors. The magnitude of K_1 is expected to change depending on the characteristics of the waste matrix (e.g. density) as this affects detection efficiency.

s_b = the standard deviation or uncertainty of the background.

With respect to equation 4, the standard deviation of the background is determined as

$$s_b = \sqrt{counts} = \sqrt{CR * T_C}$$

where

counts	=	the total counts acquired in the region of interest for a photon of energy E;
CR	=	count rate in the region of interest for a photon of energy E (cps);
T_C	=	count time (real time) for the assay (second).

Substituting terms appropriate for gamma spectroscopy (GEA) into K_1 yields a final equation (Equation 5) for representing the MDC for the GEA system:

$$MDC = \frac{\left(2.71 + 4.65\sqrt{CR(E\gamma)T_C}\right)}{e(E\gamma)I(E\gamma)(M)T_C 37}$$

where

$CR(E_\gamma)$ =		count rate in the region of interest for a photon of energy E (cps);
T_C	=	count time for the assay (second);
$e(E_\gamma)$	=	the detection efficiency for the photon of energy E (counts/photon);
$I(E_\gamma)$	=	yield or intensity for the photon of energy E(photon/second);
M	=	mass of the drum waste matrix (g);
37	=	conversion factor relating decays per second to nCi (dps/nCi).

While equation 5 is the base equation for MDC calculations, it was not explicitly evaluated in determining the assay MDC values. The GEA system software suite (Canberra Genie PC) calculates and reports a minimum detectable activity (MDA) for nuclides listed in the analysis library, but not identified in the sample spectrum. If a specified peak exceeds the decision level inherent in equation 5, the software reports the nuclide, otherwise the MDA for the nuclide is reported. The system operating manual (Genie-PC Volume Two, Algorithms Appendix B) describes the analysis algorithm. The MDA value reported is determined from expressions identical to equation 4 and 5.) As configured at WRAP, the software report provides an MDA (in μCi) for all 'undetected' radionuclides listed in the search library. The system reported MDA can be converted to a MDC by use of the appropriate waste matrix mass and conversion factor as shown in equation 6:

$$MDC(E_\gamma) = \frac{MDA(E_\gamma) * 1000}{M * 1000}$$

where:

$MDC(E_\gamma)$ = minimum detectable concentration for a specific nuclide based upon emission of a photon of energy E (nCi/g);

$MDA(E_\gamma)$ = system reported minimum detectable activity for the specified nuclide photon of energy E (μCi);
M = mass of the waste matrix (kg);
1000/1000 = conversion factor relating nCi to μCi and kg to grams -1000 nCi/μCi; 1000 g per kg (nCi kg/μCi g).

Description of Tests

Precision and Accuracy

For testing of the NDA systems against the WIPP QAO requirements, the PDP "empty" matrix drum was loaded with sources to approximate the nominal test points. The previous QAO demonstration (HNF-4051 REV 2 and REV 3) utilized the PDP "combustibles" matrix drum. The table below shows the specific sources used in each test configuration and their arrangement within the drum. The test arrangement number (e.g., QAO-A1) is shown in the next section where individual test results are tabulated.

Source ID	Pu Mass (g)	QAO-A1	QAO-A2	QAO-A3	QAO-A4
WRAP100MGPU	0.10	**T1,P10**			
WRAP-1/500MGPU	0.50		**T1,P6**		
WRAP-2/500MGPU	0.50		**T1,P15**		
WRAP-1/5GPU	5.00			**T1,P6**	
WRAP-2/5GPU	5.00			**T1,P15**	**T3,P19**
WRAP-3/5GPU	5.00				**T2,P10**
WRAP10GPU	10.00				**T3,P10**
WRAP20GPU	20.00				**T1,P19**
WRAP30GPU	30.00				**T2,P19**
WRAP40GPU	40.00				**T3.P1**
WRAP50GPU	50.00				**T1,P10**
Pu Totals (g)		**0.10**	**1.00**	**10.00**	**160.00**

Table 1. QAO sample configuration for January and March 2000 tests.

The "T" and "P" references are to tube number and pin height, respectively. Tube 1 is centered in the drum, while tube 2 is located about halfway between the center and the outer wall of the drum. Tube 3 is located near the outer wall of the drum, opposite tube 2. The pin numbers refer to height (in inches) above the bottom of the drum at which the source is placed. The sources are composed of Pu dispersed in diatomaceous earth, doubly enclosed in concentric stainless steel cylinders. They are nine inches long and about two inches in diameter. The nominal Pu-239 content is 94% for all sources. All the sources were 'WRAP' sources, purchased by WRAP for NDA (GEA and IPAN) operations. The sources were not part of the PDP cycle. All assays were performed using the WRAP GEA

operating procedure (WRP1-OP-0906). Two QAO tests were performed. QAO testing was conducted Jaunary 5 – 12 following calibration of the GEA-A unit. The second QAO evaluation was performed March 6 - 9 as a result of the transmission source recalibration of GEA-A. The same test configurations were used in both tests, with the March configurations designated with an 'A' suffix (i.e. QAO-A2A). Only three nominal QAO points were assayed. The 0.1 g WP Pu point (QAO-A1) was not reevaluated as the transmission calibration was not expected to impact system performance or the system results at this point.

MDC

The GEA system MDC was determined from replicate measurements of drums over a matrix density of 0.046 to 1.56 kg/L (g/cm^3). The drum matrix was uniform and contained no distributed radioactive sources or interfering components. Additionally, no radioactive sources were added to the drums. Data was acquired for 15 replicate assays at three different drum densities using a nominal (5 minute) counting time. Additionally, two 60-minute assays were performed on the same set of drums. The system reported MDA values (μCi) were converted to MDC values through equation 6 and the appropriate drum mass. As above, all assays conducted for the MDC determination were performed in accordance with the WRAP GEA operating procedure (WRP1-OP-0906).

QAO Results

Results for the GEA-A system are presented in summary tables for the precision and accuracy QAOs, followed by the MDC determinations. Table 2 gives the precision and accuracy QAO results from the January tests while Table 3 contains the results from early March. The same samples were used in both evaluations. Results are given for the 'Sum Segments' and 'Combine All' algorithms for each of the nominal evaluation points using the 414 keV (Pu-239B) and 129 keV (Pu-239A) emissions of Pu-239. The January results appear first, followed by the March evaluations. Finally, data for the 160 g WG Pu sample includes results with and without the detector shields (collimator per manufacturer's terminology) in place. Data for the 15 replicates runs for each of the QAO assays is contained in Appendix A.

Summary of January GEA A Tests – Accuracy and Precision

Nominal Point (g WG Pu)	Pu Mass Range (g)	Emission	Sum Segments Precision % RSD	Sum Segments Accuracy %R	Combine All Precision % RSD	Combine All Accuracy %R
0.1	0 - 0.25	Pu-239B	33.76	90.95	60.93	69.24
		Pu-239A	7.26	79.71	10.00	79.06
1	0.25 - 2.5	Pu-239B	4.22	96.47	4.44	116.11
		Pu-239A	1.81	73.98	1.98	102.72
10	2.5 - 25	Pu-239B	1.07	97.37	1.07	114.73
		Pu-239A	0.53	71.11	1.63	90.88
160 (No attenuator)	> 25	Pu-239B	202.91	4513.82	1.50	104.67
		Pu-239A	202.90	2059.10	1.67	51.62
160 (Attenuator)	> 25	Pu-239B	0.34	88.57	4.42	110.66
		Pu-239A	3.76	7.53	6.04	19.82

All listed data are the average from 15 replicate assays

Table 2. GEA-A QAO results for January 2000.

Summary of March GEA A Tests – Accuracy and Precision

Nominal Point (g WG Pu)	Pu Mass Range (g)	Emission	Sum Segments Precision % RSD	Sum Segments Accuracy %R	Combine All Precision % RSD	Combine All Accuracy %R
0.1	0 - 0.25	Pu-239B				
		Pu-239A				
1	0.25 - 2.5	Pu-239B	3.82	95.57	3.75	114.38
		Pu-239A	2.74	74.41	3.11	102.64
10	2.5 - 25	Pu-239B	0.74	92.93	0.86	118.04
		Pu-239A	0.74	66.95	1.73	95.38
160 (No attenuator)	> 25	Pu-239B	364.90	1552.74	1.47	108.54
		Pu-239A	364.95	715.06	1.59	54.25
160 (Attenuator)	> 25	Pu-239B	0.51	89.02	3.47	113.42
		Pu-239A	2.70	7.54	6.27	20.17

All listed data are the average from 15 replicate assays. A 0.1 gram evaluation was not conducted. Results from the January tests are applicable.

Table 3. GEA-A QAO results for March 2000.

Summary of GEA A Tests – Minimum Detectable Concentration

Figure 1 shows MDC determinations as a function of a non-interfering matrix density for Pu-239B (414 keV) and Pu-239A (129 keV). Each data point represents the average, software 'sum segments' MDA value for 15 replicate measurements, adjusted per equation 6 to yield an MDC. The smooth curves are power function fits of the data points. The MDC determined using the lightest matrix

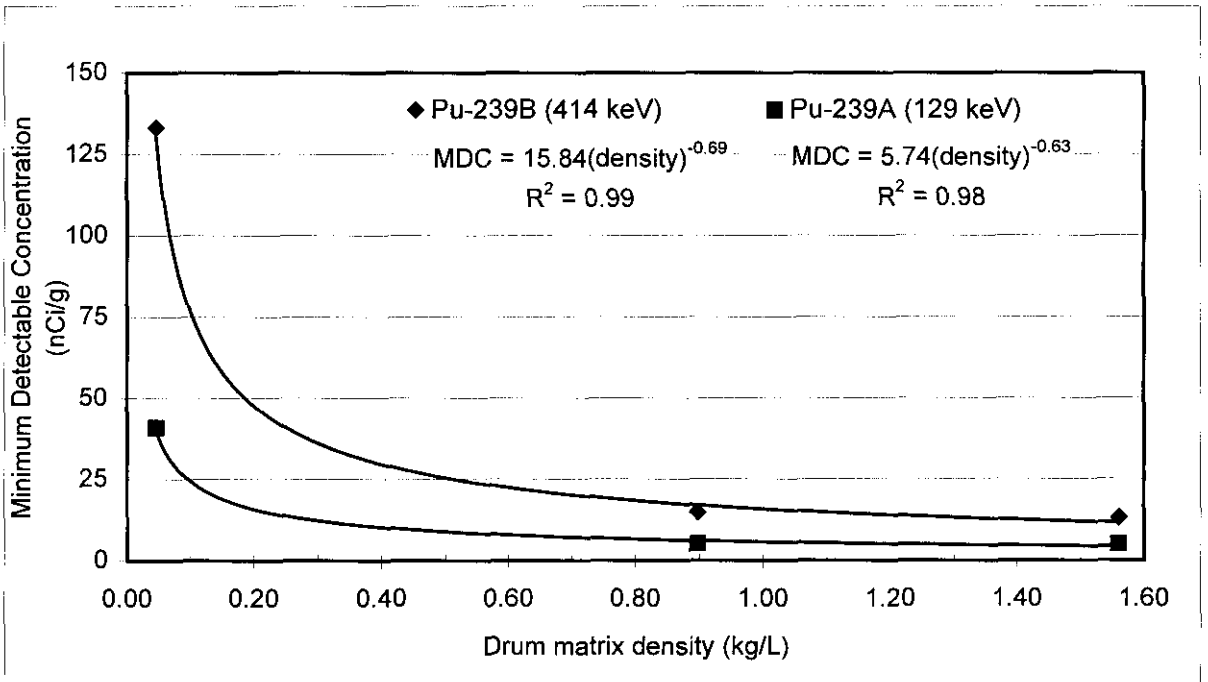


Figure 1. Minimum Detectable Concentration (MDC) as a function of drum matrix density based on Pu-239A (129 keV) and Pu-239B (414 keV) peaks. Data is the average sum segment from 15 replicate measurements at a nominal count time of five minutes.

(0.046 kg/L – first data point) is 40 nCi/g for the 129 keV peak of Pu (Pu-239A) and 130 nCi/g for the 414 keV Pu-239 emission (Pu-239B). It is worth noting that the MDC determined from the 129 keV data is in excellent agreement with the 39 ± 2 nCi/g value reported in revision 2 of this document. The 100 nCi/g effective lower limit for the MDC would clearly be met for all waste densities for assay results based upon the 129 keV Pu-239 emission. For the 414 keV peak, the data indicates that the 100 nCi/g minimum MDC would be met for all but the lightest density waste. Based upon the displayed regression, a waste density of 0.068 or ~ 0.07 kg/L yields a 100 nCi/g, TRU-low level waste MDC cutoff criteria. Based upon a review of over 100 waste stream drums assayed at WRAP, the average waste density is 0.24 kg/L, with a minimum observed density of 0.094 kg/L. More than 95% of the waste drums assayed to date had waste densities greater than 0.10 kg/L.

Using the actual waste densities and the power function determined in Figure 1, the expected MDCs for the current waste stream utilizing the Pu-239B and Pu-239A lines (414 and 129 keV respectively) can be determined. Figure 2 shows this data. The largest MDC of 80 nCi/g would occur at an observed waste density of 0.094 kg/L. For 98% of the waste drums assayed at WRAP to date, the maximum MDC would be 66 and 21 nCi/g as determined from the 414 keV and 129 keV Pu-239 lines respectively.

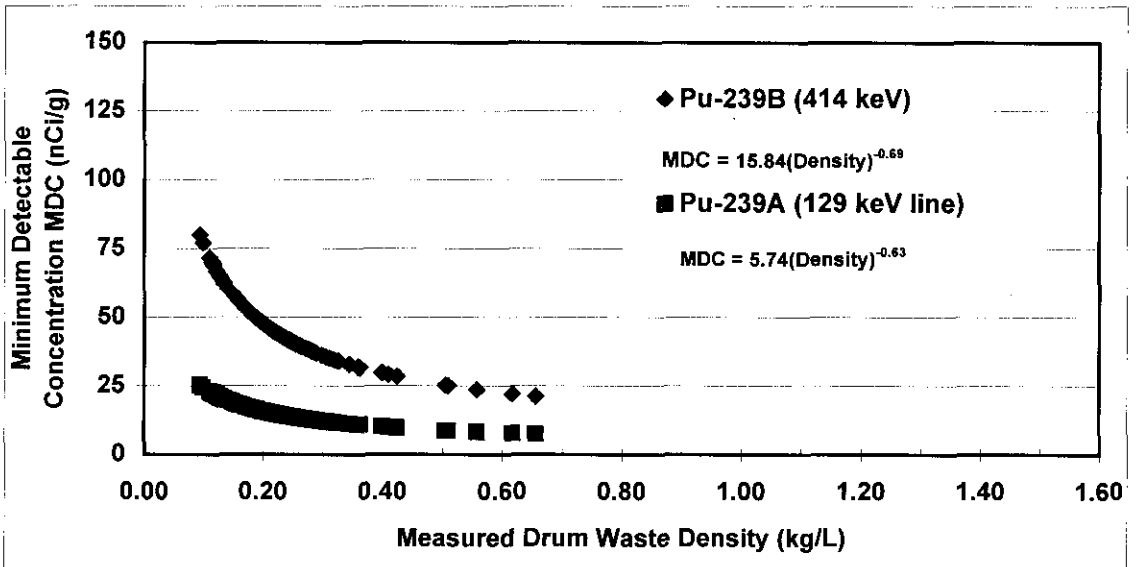


Figure 2. Minimum detectable concentrations for Pu-239B (414 keV) & Pu-239A (129 keV) calculated for processed waste densities using the derived MDC function for 5 minute assays.

Discussion of Results

The following table, taken from Table E-1 of HNF-2600, *Hanford Site Transuranic Waste Certification Plan*, gives the precision and accuracy QAO validation requirements.

Range of waste activity in α-Curies[a]	Nominal compliance Point α-Curies[a] (g WG Pu)[b]	Parameter	
		Precision[c] (%RSD)	Accuracy[d] (%R)
0 to 0.02	0.008 (0.1)	≤20	70-130
>0.02 to 0.2	0.08 (1.0)	≤15	70-130
>0.2 to 2.0	0.8 (10)	≤10	70-130
>2.0	12.8 (160)	≤5	70-130

[a] Applicable range of TRU activity in a 208-L (55-gal.) waste container to which the QAOs apply, units are Curies of alpha-emitting TRU isotopes with half-lives greater than 20 years.

[b] The nominal activity (or weight of Pu) used to demonstrate that QAOs can be achieved for the corresponding range in column 1. Values in parentheses are the appropriate equivalent weights of weapons grade plutonium (WG Pu) 15 years after purification; for purposes of demonstrating QAOs, "nominal" means within ±50 percent, except for the highest range, where "nominal" means ±25 percent.

[c] ± One standard deviation based on 15 replicate measurements of a noninterfering matrix. The calculated standard deviation is compared with the mean measured value of the QAO source to obtain the %RSD.

[d] Percent recovery(%R) determined from the ratio of measured to known values based on the average of 15 replicate measurements of a noninterfering matrix.

It should be noted that a noninterfering matrix is a virtual impossibility. For this QAO test, the empty PDP drum was used. While the interference of this matrix is non existent, the test sources themselves provide interference, particularly for the 129 keV gamma of Pu-239. The two walls of stainless steel surrounding the Pu source material does attenuate gamma flux. The primary energy line used for gamma detection of Pu-239 is 414 keV, but at extremely low mass levels (such as 0.1g) the yield fraction of the 414 keV gamma is too low to be consistently detectable. At these mass values, the primary energy line becomes 129 keV, since it has a significantly higher yield fraction than the 414 keV line. This relatively low (129 keV) energy line can be easily attenuated by the encapsulating steel walls of the source.

Precision and Accuracy

Table 4. provides a comparison of the January QAO results with the required performance. As before (HNF-4051 Rev 3) the GEA-A system satisfied the 1 g and 10 g test points for the 'Combine All' and 'Sum Segment' results using either the 129 keV or 414 keV Pu-239 transition. Neither the Sum Segments nor Combine All results satisfy the QAO requirements at the 0.1 gram nominal point using the 414 keV emission., however both algorithms satisfy the requirements utilizing the 129 keV

peak. As mentioned above, this is a direct result of the high yield fraction for the 129 keV transition. The affect of the stainless steel encapsulation is evident in the lower percent recovery determined from the 129 keV emission in comparison to the recovery determined using the 414 keV emission.

The QAO requirements can not be satisfied at the 160 gram point utilizing the 129 keV emission for either 'Sum Segments' or 'Combine All'. The QAO is satisfied, however, if the 414 keV gamma is used in either the Combine All or Sum Segments algorithms at this mass. Use of the sum segments algorithm at the 160 gram point requires assaying with the collimator (detector shield) in place for best performance.

Nominal Point (g WG Pu)	Pu Mass Range (g)	Emission	Sum Segments Precision % RSD	Sum Segments Accuracy %R	Combine All Precision % RSD	Combine All Accuracy %R
0.1	0 - 0.25	Pu-239B	Fail	Pass	Fail	Fail
		Pu-239A	Pass	Pass	Pass	Pass
1	0.25 - 2.5	Pu-239B	Pass	Pass	Pass	Pass
		Pu-239A	Pass	Pass	Pass	Pass
10	2.5 - 25	Pu-239B	Pass	Pass	Pass	Pass
		Pu-239A	Pass	Pass	Pass	Pass
160 (No attenuator)	> 25	Pu-239B	Fail	Fail	Pass	Pass
		Pu-239A	Fail	Fail	Pass	Fail
160 (Attenuator)	> 25	Pu-239B	Pass	Pass	Pass	Pass
		Pu-239A	Pass	Fail	Fail	Fail

Table 4. GEA-A QAO results for January 2000.

The QAO tests performed in March were a direct result of system maintenance and establishing a new system transmission calibration. The transmission information is used in the Combine All algorithm. Table 5 gives the QAO results for the 1.0, 10 and 160 gram nominal points which were identical to the January QAOs. The 0.1 nominal Pu mass QAO was not reassayed.
The March results are very similar to those obtained in January, though some points are worth mentioning. For the 10 gram point, the 'Sum Segment' results obtained from the 129 keV emission fail the accuracy QAO. Table 3 shows a recovery of 71% from the January evaluation and 67% for

Nominal Point (g WG Pu)	Pu Mass Range (g)	Emission	Sum Segments Precision % RSD	Sum Segments Accuracy %R	Combine All Precision % RSD	Combine All Accuracy %R
0.1	0 - 0.25	Pu-239B				
		Pu-239A				
1	0.25 - 2.5	Pu-239B	Pass	Pass	Pass	Pass
		Pu-239A	Pass	Pass	Pass	Pass
10	2.5 - 25	Pu-239B	Pass	Pass	Pass	Pass
		Pu-239A	Pass	Fail	Pass	Pass
160 (No attenuator)	> 25	Pu-239B	Fail	Fail	Pass	Pass
		Pu-239A	Fail	Fail	Pass	Fail
160 (Attenuator)	> 25	Pu-239B	Pass	Pass	Pass	Pass
		Pu-239A	Pass	Fail	Fail	Fail

Table 5. GEA-A QAO results for March 2000.

the same sample in March.

Overall, the January and March 2000 QAO test results agree with the previous reported QAO results (HNF-4051 Rev 3). The GEA 'Combine All' results failed at the 0.1 g level for both the empty and combustible PDP drum. For GEA A, the 'Combine All Results' algorithm is preferred at the lower gram levels; at approximately 5.0 g Pu the 'Combine All' algorithm is preferred.

All testing was performed using the WRAP GEA operating procedure (WRP1-OP-0906). The standard operating software for the system was used to acquire data and report results. Testing was performed for 55-gallon (208 liter) waste drum configurations only and the QAO results, are therefore, only valid for 55-gallon (208 liter) waste packages.

For these results to be valid, full independence of source materials must be maintained. The QAO tests were performed using plutonium sources, each with its own pedigree and documentation. GEA calibration utilized mixed sources containing Co-60. Ba-133, Cs-137, and Am-241. No sources used in calibration were or are used in QAO validation. Appendix B contains the certificates for the sources used in the January and March QAO validation.

Minimum Detectable Concentration

The MDC curves presented in Figure 1 and Figure 2 demonstrate the effect of matrix density on the

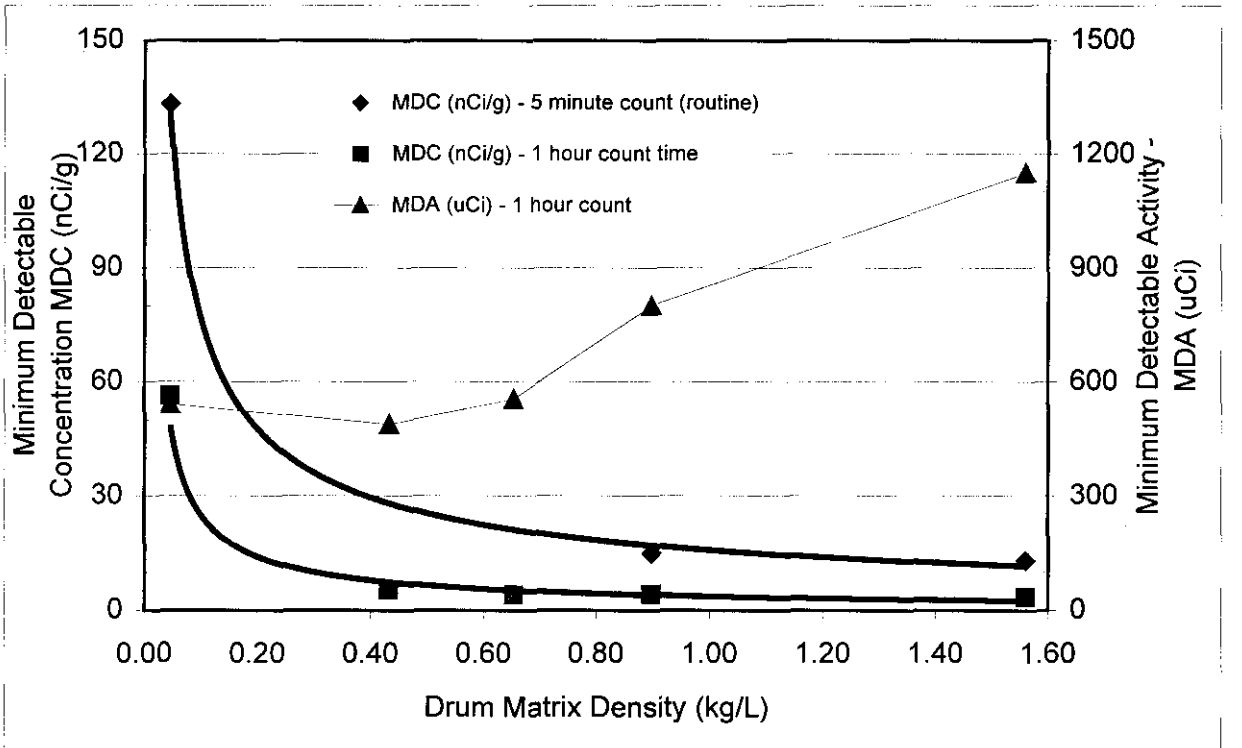


Figure 3. Minimum Detectable Activity (MDA) and MDC as a function of waste density for the 414 keV Pu-239 emission.

minimum detectable concentration (equation 5 and 6). Figure 3 shows minimum detectable activity (MDA – determined and reported directly by the system software) and calculated MDC data for Pu-239B (414 keV) as determined from the 'sum spectrum' or 'sum segments' algorithm. The three data points and power function trend line (MDC - 5 minute count) are the data points from Figure 1. The additional data are a result of 60-minute assays conducted on the three 'original' drums (Figure 1) and two additional drums. The two additional density points at 0.43 and 0.65 kg/L were assayed to better cover the factor of 20 "gap" in the 0.046 to 0.86 kg/L density interval. The data points are the average value from two, 1-hour assays. The additional points re-enforce the previously developed power function trend line.

The curves in figure 3 are consistent with the expected instrument response and equations 5-6 for MDC and MDA. Plotting the MDA (μCi) values along with the MDC for the one-hour assays illustrates several important factors. From the MDC plot, one might conclude that assay sensitivity increases with increasing matrix density. The MDA plot in Figure 4 demonstrates the true response. As drum density increases, the magnitude of the measured MDA increases; which is equivalent to a decrease in assay sensitivity. This is consistent with the factors contributing to MDC and MDA. The first is the drop in detector efficiency with increased matrix density. Efficiency appears in the denominator of equation 5. The detection efficiency drops as a result of increased attenuation by the sample matrix necessitating an increase in the MDA. In other words, more activity is required for the true signal to be reliably recognized as a true signal.

The increase in waste density also contributes to a loss in assay sensitivity as result of increased background. Sources of background at WRAP include the natural radiation in the building materials, including the detector, and materials around the facility. Radiation from manmade radionuclides originating from adjacent waste drums may also contribute to this background. The increase in matrix density does not change the background radiation flux at the detector. Rather, having a more dense matrix increases the probability of these emissions interacting with the matrix and being detected as either discrete lines or contributing to the detector continuum.

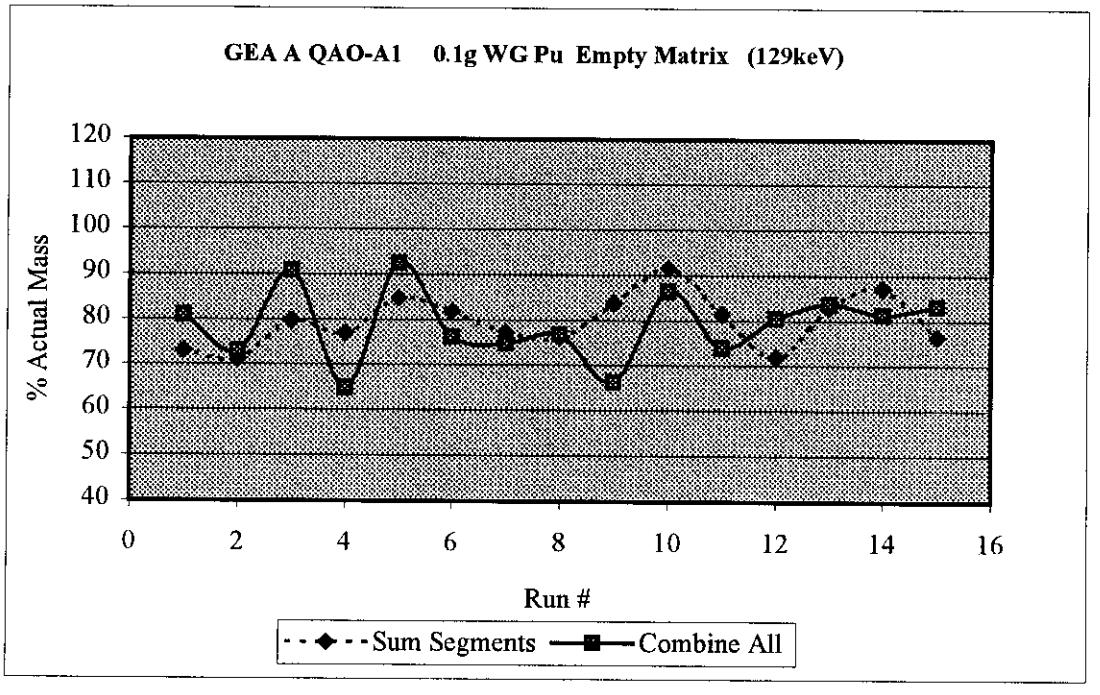
The combined effect of increased interactions of the background radiation and the decreased efficiency associated with a more dense matrix, results in the loss of measurement sensitivity. This is illustrated by the increase in MDA values with density. Yet, the MDC decreases with matrix density. This is a direct result of the MDC being defined as a concentration, having mass (grams) as its basis. Waste mass is directly proportional to waste density, with the net effect being the decrease in the MDC with increasing waste mass despite the loss of assay sensitivity. The power function regressions in figure 1 help illustrate the effect. If the MDC were solely a function of sample density (i.e detection efficiency and background were independent of density) the regression formulae would show an x^{-1} or kg/L^{-1} [1/(kg/L)] dependence.

One final comment on MDC for the GEA systems is prudent. It must be remember that the minimum detectable concentration value is an *a priori* estimate of the minimum activity that would result in a net signal that could be reliably quantified by the GEA system. It is dependent on both the samples being analyzed, and the parameters of the assay (e.g. count time), and is thus specific for the particular assay condition.

GEA A QAO-A1 0.1g WG Pu in Empty Matrix

Pu-239A

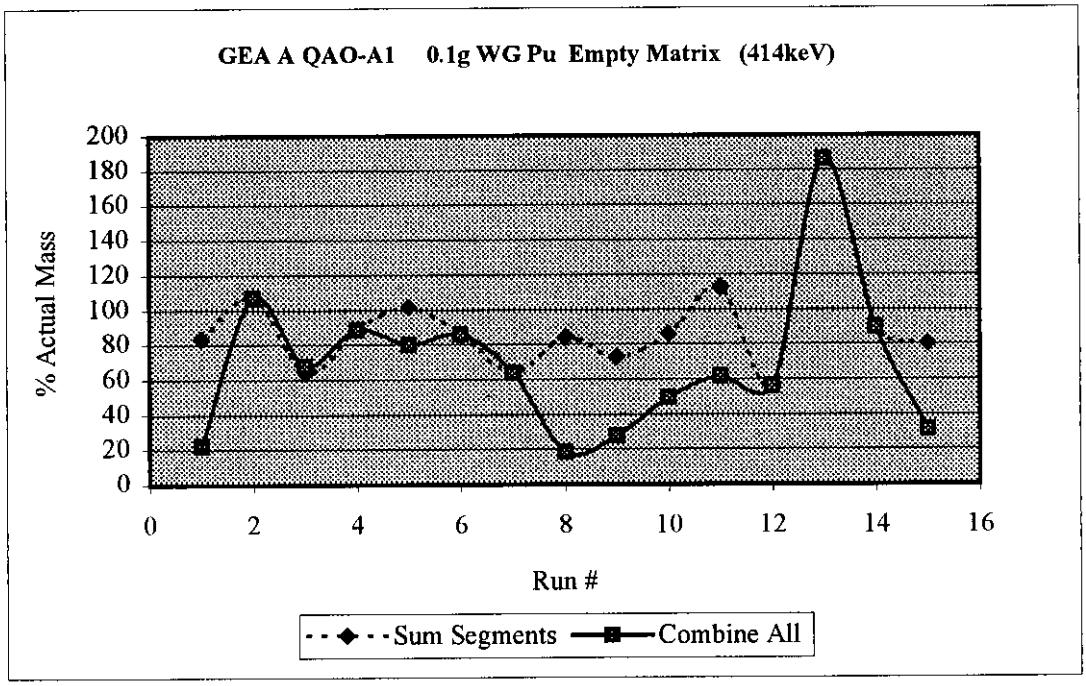
	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	4.31E+03	6.85E-02	73.05	4.77E+03	7.58E-02	80.85
Run 2	4.20E+03	6.68E-02	71.19	4.31E+03	6.85E-02	73.05
Run 3	4.70E+03	7.47E-02	79.66	5.36E+03	8.52E-02	90.85
Run 4	4.54E+03	7.22E-02	76.95	3.83E+03	6.09E-02	64.92
Run 5	5.00E+03	7.95E-02	84.75	5.46E+03	8.68E-02	92.54
Run 6	4.82E+03	7.66E-02	81.69	4.50E+03	7.15E-02	76.27
Run 7	4.56E+03	7.25E-02	77.29	4.42E+03	7.03E-02	74.92
Run 8	4.49E+03	7.14E-02	76.10	4.53E+03	7.20E-02	76.78
Run 9	4.94E+03	7.85E-02	83.73	3.92E+03	6.23E-02	66.44
Run 10	5.40E+03	8.59E-02	91.53	5.10E+03	8.11E-02	86.44
Run 11	4.80E+03	7.63E-02	81.36	4.37E+03	6.95E-02	74.07
Run 12	4.24E+03	6.74E-02	71.86	4.75E+03	7.55E-02	80.51
Run 13	4.89E+03	7.77E-02	82.88	4.94E+03	7.85E-02	83.73
Run 14	5.14E+03	8.17E-02	87.12	4.80E+03	7.63E-02	81.36
Run 15	4.51E+03	7.17E-02	76.44	4.91E+03	7.81E-02	83.22
Average	**4.70E+03**	**7.48E-02**	**7.97E+01**	**4.66E+03**	**7.42E-02**	**7.91E+01**
	standard deviation = 5.43E-03			standard deviation = 7.42E-03		
Precision	% RSD = 7.26		***(Pass)***	% RSD = 10.00		***(Pass)***
Accuracy	% R = 79.71		***(Pass)***	% R = 79.06		***(Pass)***
Total Bias (%)	71.19 to 91.53			64.92 to 92.54		



GEA A QAO-A1 0.1g WG Pu in Empty Matrix

Pu-239B

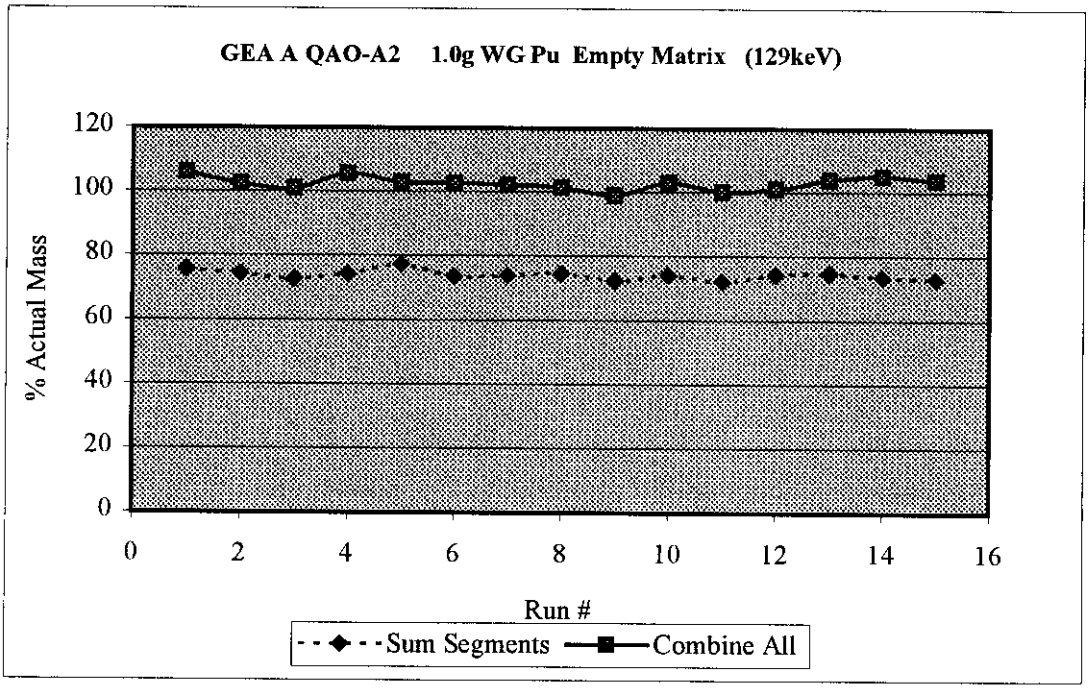
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	4.92E+03	7.82E-02	83.39	1.32E+03	2.10E-02	22.37
Run 2	6.32E+03	1.00E-01	107.12	6.32E+03	1.00E-01	107.12
Run 3	3.78E+03	6.01E-02	64.07	4.01E+03	6.38E-02	67.97
Run 4	5.25E+03	8.35E-02	88.98	5.25E+03	8.35E-02	88.98
Run 5	6.00E+03	9.54E-02	101.69	4.72E+03	7.50E-02	80.00
Run 6	5.08E+03	8.08E-02	86.10	5.08E+03	8.08E-02	86.10
Run 7	3.78E+03	6.01E-02	64.07	3.78E+03	6.01E-02	64.07
Run 8	4.97E+03	7.90E-02	84.24	1.09E+03	1.73E-02	18.47
Run 9	4.30E+03	6.84E-02	72.88	1.65E+03	2.62E-02	27.97
Run 10	5.07E+03	8.06E-02	85.93	2.93E+03	4.66E-02	49.66
Run 11	6.65E+03	1.06E-01	112.71	3.64E+03	5.79E-02	61.69
Run 12	3.33E+03	5.29E-02	56.44	3.33E+03	5.29E-02	56.44
Run 13	1.10E+04	1.75E-01	186.44	1.10E+04	1.75E-01	186.44
Run 14	5.30E+03	8.43E-02	89.83	5.30E+03	8.43E-02	89.83
Run 15	4.74E+03	7.54E-02	80.34	1.86E+03	2.96E-02	31.53
Average	**5.37E+03**	**8.53E-02**	**9.09E+01**	**4.09E+03**	**6.49E-02**	**6.92E+01**
	standard deviation = 2.88E-02			standard deviation = 3.96E-02		
Precision	% RSD = 33.76		***(Fail)***	% RSD = 60.93		***(Fail)***
Accuracy	% R = 90.95		***(Pass)***	% R = 69.24		***(Fail)***
Total Bias (%)	56.44 to 186.44			18.47 to 186.44		



GEA A QAO-A2 1.0g WG Pu in Empty Matrix

Pu-239A

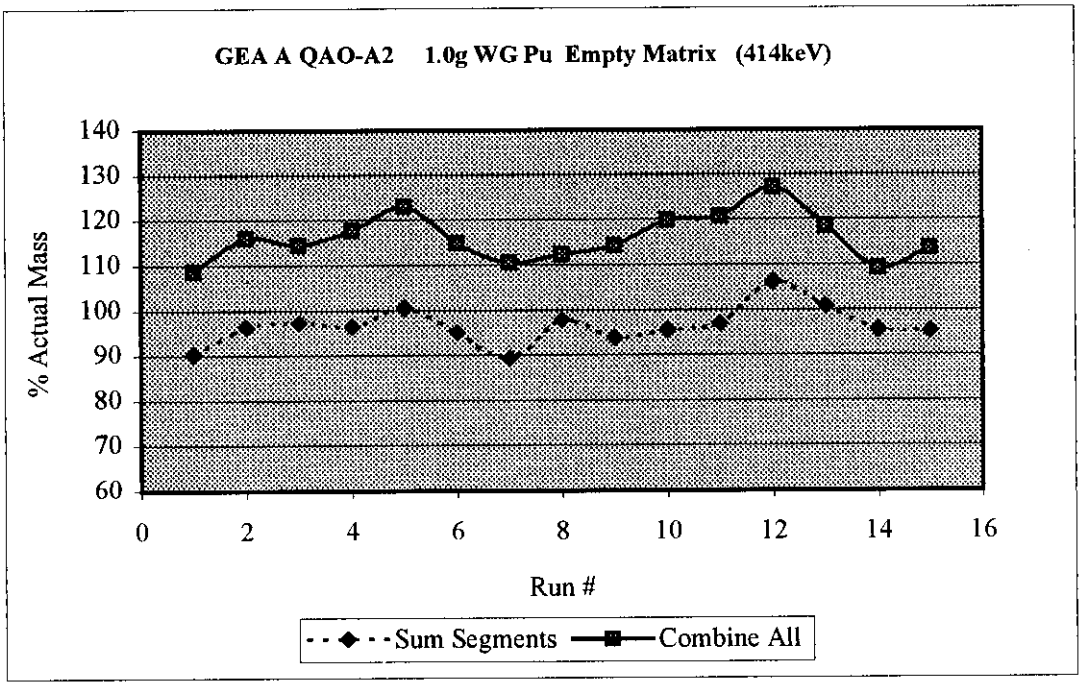
	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	4.47E+04	7.11E-01	75.76	6.26E+04	9.95E-01	106.10
Run 2	4.38E+04	6.96E-01	74.24	6.04E+04	9.60E-01	102.37
Run 3	4.29E+04	6.82E-01	72.71	5.96E+04	9.48E-01	101.02
Run 4	4.38E+04	6.96E-01	74.24	6.23E+04	9.90E-01	105.59
Run 5	4.56E+04	7.25E-01	77.29	6.08E+04	9.67E-01	103.05
Run 6	4.33E+04	6.88E-01	73.39	6.07E+04	9.65E-01	102.88
Run 7	4.36E+04	6.93E-01	73.90	6.03E+04	9.59E-01	102.20
Run 8	4.39E+04	6.98E-01	74.41	5.98E+04	9.51E-01	101.36
Run 9	4.27E+04	6.79E-01	72.37	5.84E+04	9.28E-01	98.98
Run 10	4.37E+04	6.95E-01	74.07	6.08E+04	9.67E-01	103.05
Run 11	4.25E+04	6.76E-01	72.03	5.91E+04	9.40E-01	100.17
Run 12	4.38E+04	6.96E-01	74.24	5.96E+04	9.48E-01	101.02
Run 13	4.41E+04	7.01E-01	74.75	6.14E+04	9.76E-01	104.07
Run 14	4.33E+04	6.88E-01	73.39	6.21E+04	9.87E-01	105.25
Run 15	4.30E+04	6.84E-01	72.88	6.12E+04	9.73E-01	103.73
Average	**4.36E+04**	**6.94E-01**	**7.40E+01**	**6.06E+04**	**9.64E-01**	**1.03E+02**
	standard deviation = 1.25E-02			standard deviation = 1.90E-02		
Precision	% RSD = 1.81		***(Pass)***	% RSD = 1.98		***(Pass)***
Accuracy	% R = 73.98		***(Pass)***	% R = 102.72		***(Pass)***
Total Bias (%)	72.03 to 77.29			98.98 to 106.10		



GEA A QAO-A2 1.0g WG Pu in Empty Matrix

Pu-239B

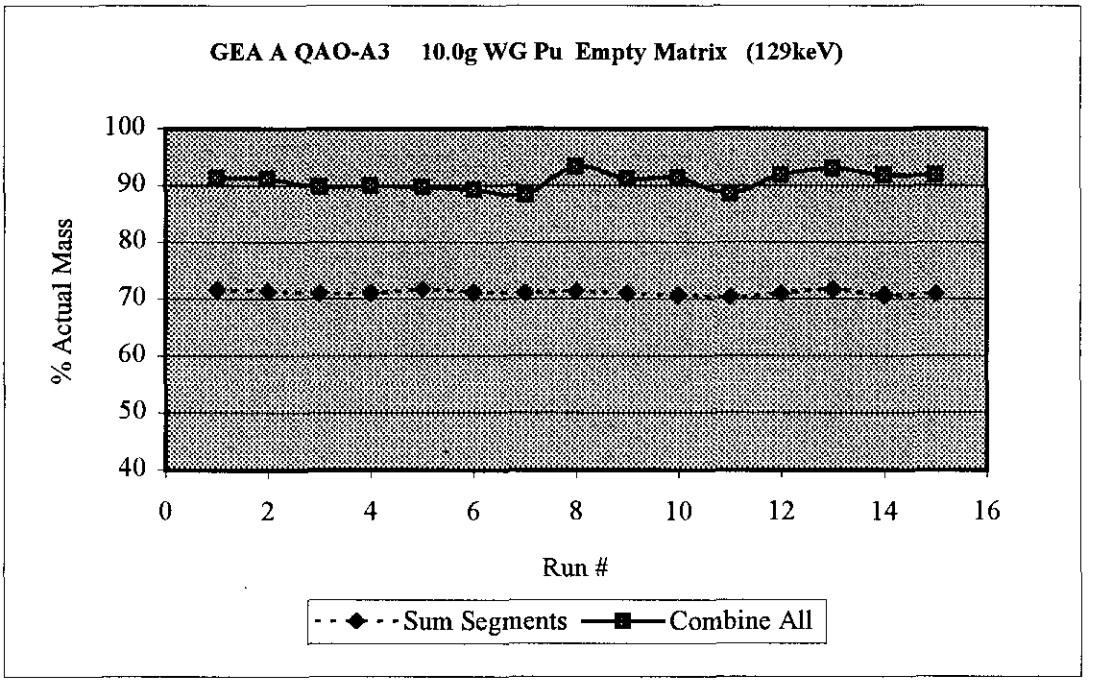
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	5.33E+04	8.47E-01	90.34	6.41E+04	1.02E+00	108.64
Run 2	5.68E+04	9.03E-01	96.27	6.85E+04	1.09E+00	116.10
Run 3	5.74E+04	9.13E-01	97.29	6.76E+04	1.07E+00	114.58
Run 4	5.69E+04	9.05E-01	96.44	6.95E+04	1.10E+00	117.80
Run 5	5.93E+04	9.43E-01	100.51	7.26E+04	1.15E+00	123.05
Run 6	5.60E+04	8.90E-01	94.91	6.78E+04	1.08E+00	114.91
Run 7	5.27E+04	8.38E-01	89.32	6.52E+04	1.04E+00	110.51
Run 8	5.77E+04	9.17E-01	97.80	6.63E+04	1.05E+00	112.37
Run 9	5.54E+04	8.81E-01	93.90	6.75E+04	1.07E+00	114.41
Run 10	5.64E+04	8.97E-01	95.59	7.07E+04	1.12E+00	119.83
Run 11	5.72E+04	9.09E-01	96.95	7.12E+04	1.13E+00	120.68
Run 12	6.26E+04	9.95E-01	106.10	7.50E+04	1.19E+00	127.12
Run 13	5.95E+04	9.46E-01	100.85	7.00E+04	1.11E+00	118.64
Run 14	5.64E+04	8.97E-01	95.59	6.45E+04	1.03E+00	109.32
Run 15	5.62E+04	8.93E-01	95.25	6.71E+04	1.07E+00	113.73
Average	**5.69E+04**	**9.05E-01**	**9.65E+01**	**6.85E+04**	**1.09E+00**	**1.16E+02**
	standard deviation =	3.82E-02		standard deviation =	4.84E-02	
Precision	% RSD =	4.22	***(Pass)***	% RSD =	4.44	***(Pass)***
Accuracy	% R =	96.47	***(Pass)***	% R =	116.11	***(Pass)***
Total Bias (%)	89.32	to 106.10		108.64	to 127.12	



GEA A QAO-A3 10.0g WG Pu in Empty Matrix

Pu-239A

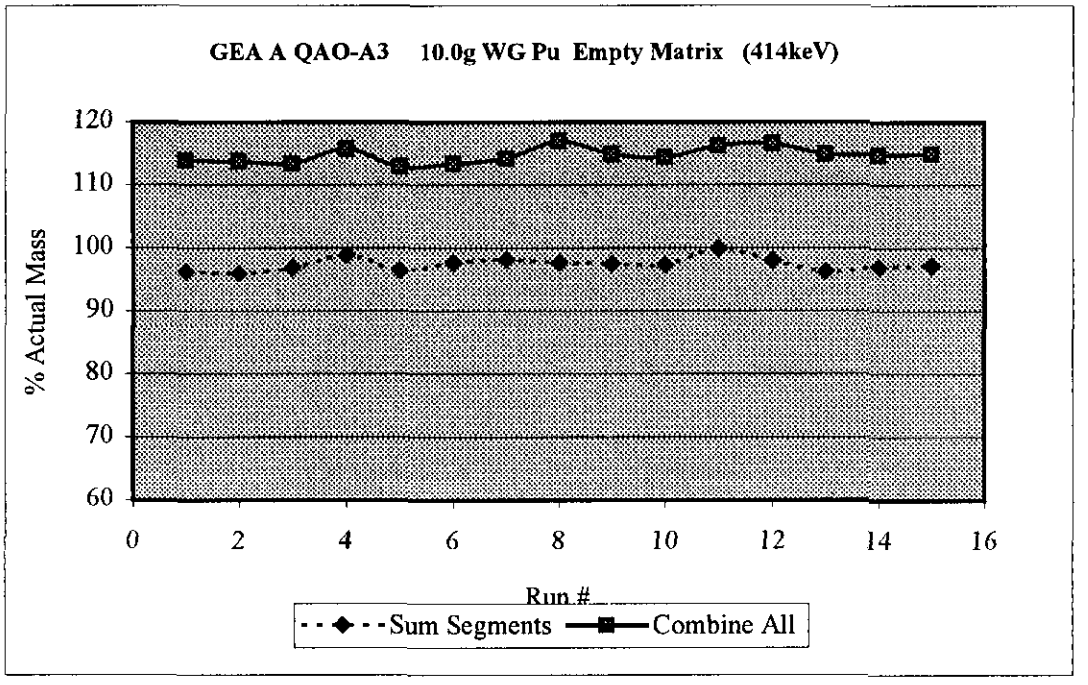
	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	4.22E+05	6.71E+00	71.53	5.39E+05	8.57E+00	91.36
Run 2	4.21E+05	6.69E+00	71.36	5.38E+05	8.55E+00	91.19
Run 3	4.19E+05	6.66E+00	71.02	5.30E+05	8.43E+00	89.83
Run 4	4.19E+05	6.66E+00	71.02	5.31E+05	8.44E+00	90.00
Run 5	4.23E+05	6.72E+00	71.69	5.30E+05	8.43E+00	89.83
Run 6	4.20E+05	6.68E+00	71.19	5.27E+05	8.38E+00	89.32
Run 7	4.19E+05	6.66E+00	71.02	5.22E+05	8.30E+00	88.47
Run 8	4.21E+05	6.69E+00	71.36	5.51E+05	8.76E+00	93.39
Run 9	4.19E+05	6.66E+00	71.02	5.38E+05	8.55E+00	91.19
Run 10	4.17E+05	6.63E+00	70.68	5.39E+05	8.57E+00	91.36
Run 11	4.15E+05	6.60E+00	70.34	5.23E+05	8.31E+00	88.64
Run 12	4.19E+05	6.66E+00	71.02	5.42E+05	8.62E+00	91.86
Run 13	4.23E+05	6.72E+00	71.69	5.49E+05	8.73E+00	93.05
Run 14	4.17E+05	6.63E+00	70.68	5.42E+05	8.62E+00	91.86
Run 15	4.19E+05	6.66E+00	71.02	5.42E+05	8.62E+00	91.86
Average	**4.20E+05**	**6.67E+00**	**7.11E+01**	**5.36E+05**	**8.52E+00**	**9.09E+01**
	standard deviation =	3.55E-02		standard deviation =	1.39E-01	
Precision	% RSD =	0.53	***(Pass)***	% RSD =	1.63	***(Pass)***
Accuracy	% R =	71.11	***(Pass)***	% R =	90.88	***(Pass)***
Total Bias (%)	70.34	to 71.69		88.47	to 93.39	



GEA A QAO-A3 10.0g WG Pu in Empty Matrix

Pu-239B

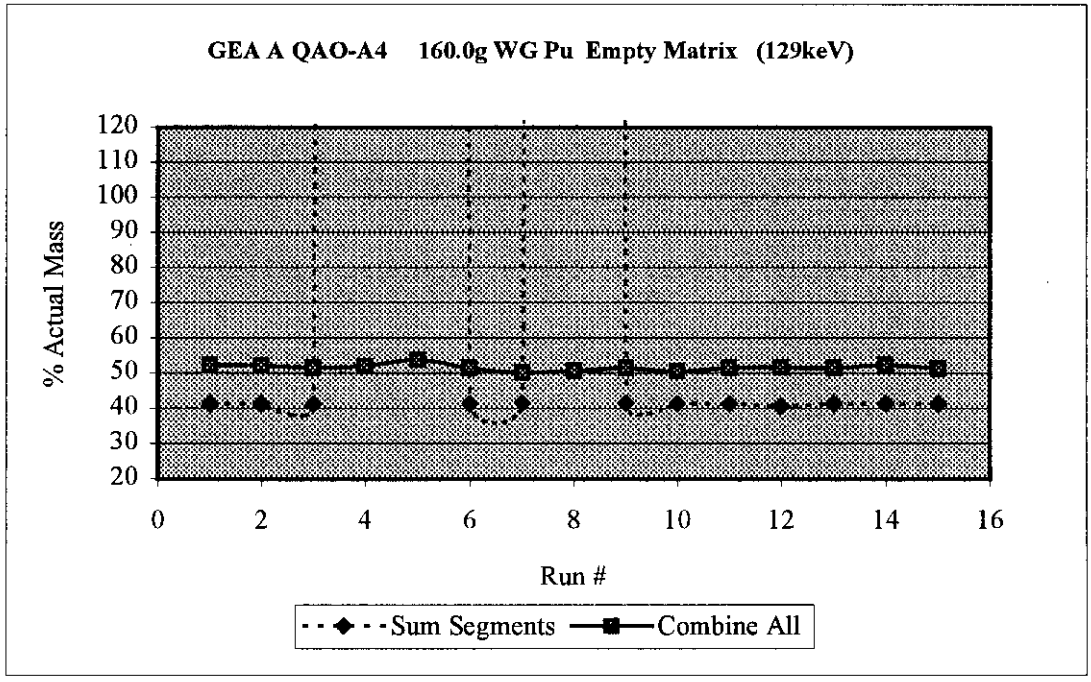
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	5.68E+05	9.03E+00	96.27	6.72E+05	1.07E+01	113.90
Run 2	5.66E+05	9.00E+00	95.93	6.71E+05	1.07E+01	113.73
Run 3	5.71E+05	9.08E+00	96.78	6.69E+05	1.06E+01	113.39
Run 4	5.83E+05	9.27E+00	98.81	6.83E+05	1.09E+01	115.76
Run 5	5.69E+05	9.05E+00	96.44	6.66E+05	1.06E+01	112.88
Run 6	5.76E+05	9.16E+00	97.63	6.69E+05	1.06E+01	113.39
Run 7	5.79E+05	9.21E+00	98.14	6.74E+05	1.07E+01	114.24
Run 8	5.76E+05	9.16E+00	97.63	6.90E+05	1.10E+01	116.95
Run 9	5.75E+05	9.14E+00	97.46	6.78E+05	1.08E+01	114.91
Run 10	5.74E+05	9.13E+00	97.29	6.75E+05	1.07E+01	114.41
Run 11	5.89E+05	9.36E+00	99.83	6.86E+05	1.09E+01	116.27
Run 12	5.78E+05	9.19E+00	97.97	6.88E+05	1.09E+01	116.61
Run 13	5.68E+05	9.03E+00	96.27	6.78E+05	1.08E+01	114.91
Run 14	5.72E+05	9.09E+00	96.95	6.77E+05	1.08E+01	114.75
Run 15	5.73E+05	9.11E+00	97.12	6.78E+05	1.08E+01	114.91
Average	**5.74E+05**	**9.13E+00**	**9.74E+01**	**6.77E+05**	**1.08E+01**	**1.15E+02**
	standard deviation =	9.76E-02		standard deviation =	1.15E-01	
Precision	% RSD =	1.07	***(Pass)***	% RSD =	1.07	***(Pass)***
Accuracy	% R =	97.37	***(Pass)***	% R =	114.73	***(Pass)***
Total Bias (%)	95.93 to	99.83		112.88 to	116.95	



GEA A QAO-A4 160.0g WG Pu in Empty Matrix -- Unattenuated

Pu-239A

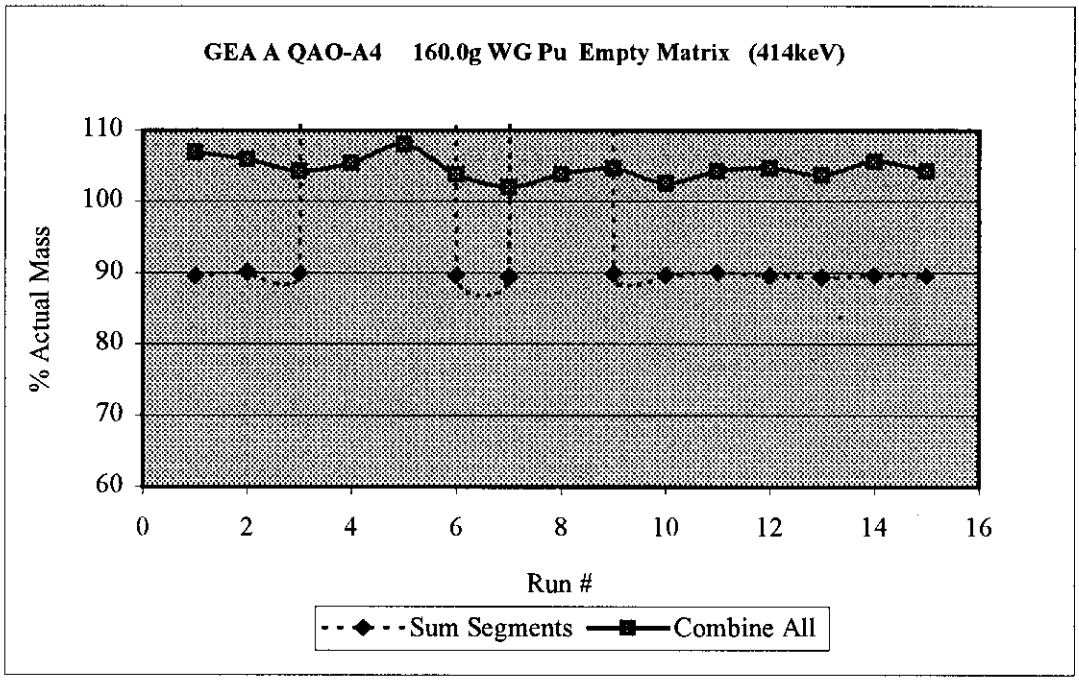
	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	3.90E+06	6.20E+01	41.31	4.94E+06	7.85E+01	52.33
Run 2	3.89E+06	6.18E+01	41.21	4.93E+06	7.84E+01	52.22
Run 3	3.88E+06	6.17E+01	41.10	4.85E+06	7.71E+01	51.38
Run 4	9.64E+08	1.53E+04	10211.83	4.91E+06	7.81E+01	52.01
Run 5	9.66E+08	1.54E+04	10233.02	5.08E+06	8.08E+01	53.81
Run 6	3.90E+06	6.20E+01	41.31	4.85E+06	7.71E+01	51.38
Run 7	3.91E+06	6.22E+01	41.42	4.74E+06	7.54E+01	50.21
Run 8	9.39E+08	1.49E+04	9947.00	4.79E+06	7.62E+01	50.74
Run 9	3.91E+06	6.22E+01	41.42	4.85E+06	7.71E+01	51.38
Run 10	3.90E+06	6.20E+01	41.31	4.78E+06	7.60E+01	50.64
Run 11	3.89E+06	6.18E+01	41.21	4.86E+06	7.73E+01	51.48
Run 12	3.82E+06	6.07E+01	40.47	4.88E+06	7.76E+01	51.69
Run 13	3.90E+06	6.20E+01	41.31	4.85E+06	7.71E+01	51.38
Run 14	3.90E+06	6.20E+01	41.31	4.94E+06	7.85E+01	52.33
Run 15	3.89E+06	6.18E+01	41.21	4.84E+06	7.69E+01	51.27
Average	**1.94E+08**	**3.09E+03**	**2.06E+03**	**4.87E+06**	**7.75E+01**	**5.16E+01**
	standard deviation = 6.27E+03			standard deviation = 1.30E+00		
Precision	% RSD = 202.90		*(Fail)*	% RSD = 1.67		*(Pass)*
Accuracy	% R = 2059.10		*(Fail)*	% R = 51.62		*(Fail)*
Total Bias (%)	40.47 to 10233.02			50.21 to 53.81		



GEA A QAO-A4 160.0g WG Pu in Empty Matrix -- Unattenuated

Pu-239B

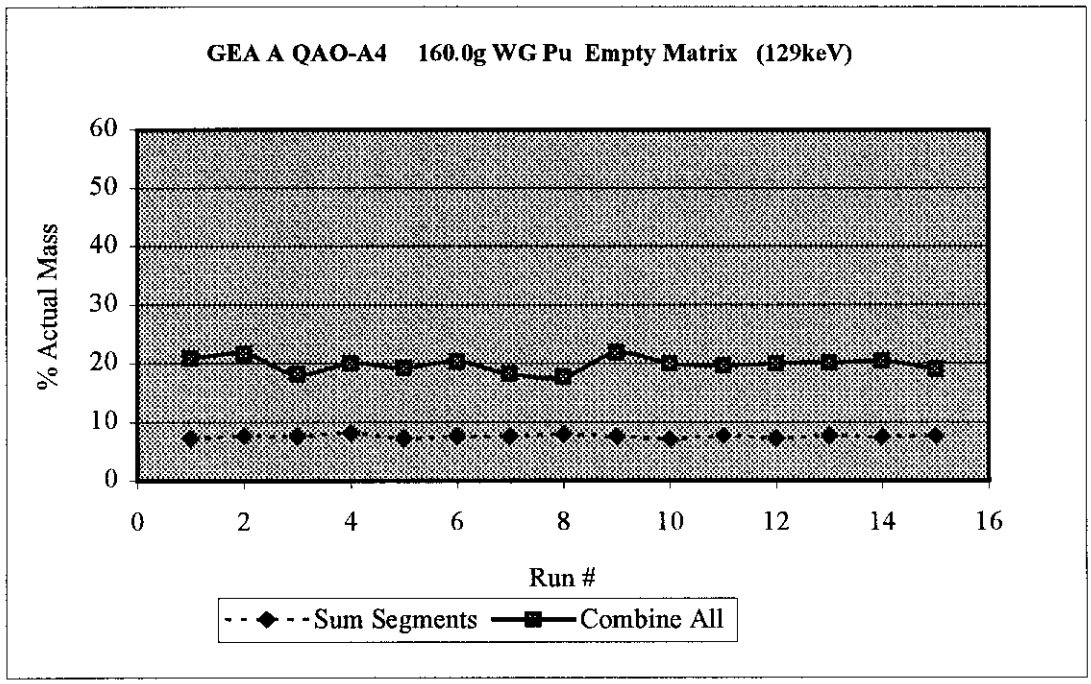
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	8.46E+06	1.34E+02	89.62	1.01E+07	1.61E+02	106.99
Run 2	8.51E+06	1.35E+02	90.15	1.00E+07	1.59E+02	105.93
Run 3	8.48E+06	1.35E+02	89.83	9.84E+06	1.56E+02	104.24
Run 4	2.10E+09	3.34E+04	22245.69	9.95E+06	1.58E+02	105.40
Run 5	2.10E+09	3.34E+04	22245.69	1.02E+07	1.62E+02	108.05
Run 6	8.46E+06	1.34E+02	89.62	9.80E+06	1.56E+02	103.81
Run 7	8.44E+06	1.34E+02	89.41	9.63E+06	1.53E+02	102.01
Run 8	2.09E+09	3.32E+04	22139.76	9.80E+06	1.56E+02	103.81
Run 9	8.48E+06	1.35E+02	89.83	9.88E+06	1.57E+02	104.66
Run 10	8.46E+06	1.34E+02	89.62	9.68E+06	1.54E+02	102.54
Run 11	8.50E+06	1.35E+02	90.04	9.84E+06	1.56E+02	104.24
Run 12	8.46E+06	1.34E+02	89.62	9.89E+06	1.57E+02	104.77
Run 13	8.43E+06	1.34E+02	89.30	9.79E+06	1.56E+02	103.71
Run 14	8.46E+06	1.34E+02	89.62	9.97E+06	1.59E+02	105.61
Run 15	8.45E+06	1.34E+02	89.51	9.84E+06	1.56E+02	104.24
Average	**4.26E+08**	**6.77E+03**	**4.51E+03**	**9.88E+06**	**1.57E+02**	**1.05E+02**
	standard deviation = 1.37E+04			standard deviation = 2.35E+00		
Precision	% RSD = 202.91		***(Fail)***	% RSD = 1.50		***(Pass)***
Accuracy	% R = 4513.82		***(Fail)***	% R = 104.67		***(Pass)***
Total Bias (%)	89.30 to 22245.69			102.01 to 108.05		



GEA A QAO-A4 160.0g WG Pu in Empty Matrix -- Attenuated

Pu-239A

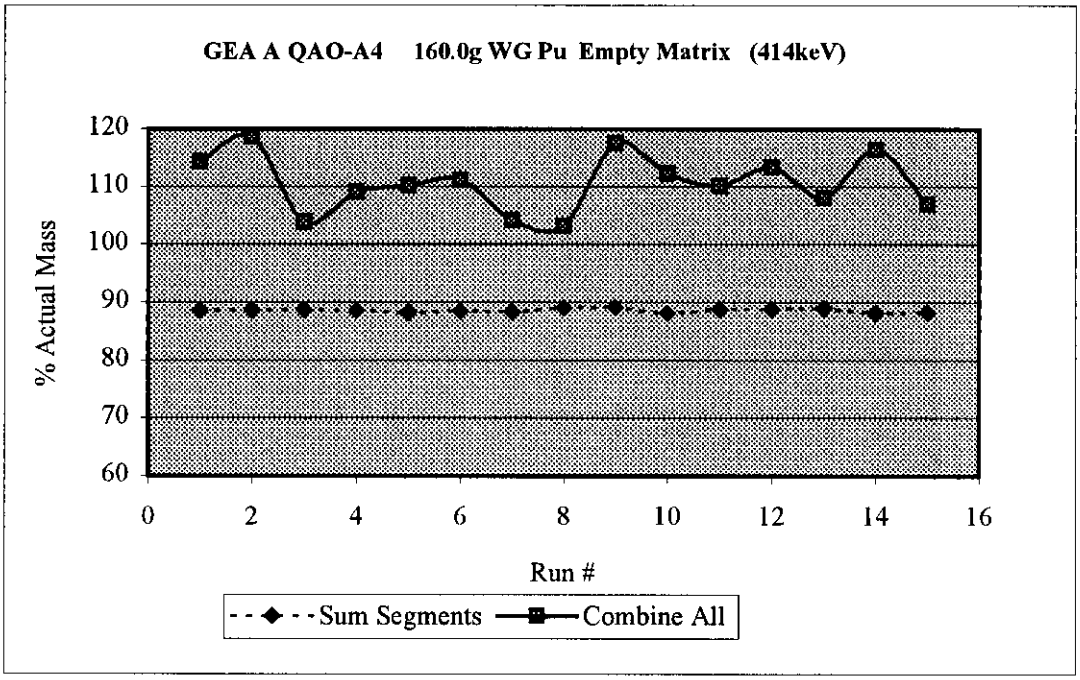
	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	6.77E+05	1.08E+01	7.17	1.97E+06	3.13E+01	20.87
Run 2	7.27E+05	1.16E+01	7.70	2.04E+06	3.24E+01	21.61
Run 3	7.08E+05	1.13E+01	7.50	1.71E+06	2.72E+01	18.11
Run 4	7.67E+05	1.22E+01	8.12	1.89E+06	3.00E+01	20.02
Run 5	6.86E+05	1.09E+01	7.27	1.82E+06	2.89E+01	19.28
Run 6	7.14E+05	1.14E+01	7.56	1.92E+06	3.05E+01	20.34
Run 7	7.12E+05	1.13E+01	7.54	1.72E+06	2.73E+01	18.22
Run 8	7.46E+05	1.19E+01	7.90	1.67E+06	2.66E+01	17.69
Run 9	7.10E+05	1.13E+01	7.52	2.06E+06	3.28E+01	21.82
Run 10	6.69E+05	1.06E+01	7.09	1.89E+06	3.00E+01	20.02
Run 11	7.24E+05	1.15E+01	7.67	1.86E+06	2.96E+01	19.70
Run 12	6.76E+05	1.07E+01	7.16	1.89E+06	3.00E+01	20.02
Run 13	7.22E+05	1.15E+01	7.65	1.90E+06	3.02E+01	20.13
Run 14	7.03E+05	1.12E+01	7.45	1.93E+06	3.07E+01	20.44
Run 15	7.26E+05	1.15E+01	7.69	1.80E+06	2.86E+01	19.07
Average	**7.11E+05**	**1.13E+01**	**7.53E+00**	**1.87E+06**	**2.98E+01**	**1.98E+01**
	standard deviation = 4.25E-01			standard deviation = 1.80E+00		
Precision	% RSD = 3.76		***(Pass)***	% RSD = 6.04		***(Fail)***
Accuracy	% R = 7.53		***(Fail)***	% R = 19.82		***(Fail)***
Total Bias (%)	7.09 to 8.12			17.69 to 21.82		



GEA A QAO-A4 160.0g WG Pu in Empty Matrix -- Attenuated

Pu-239B

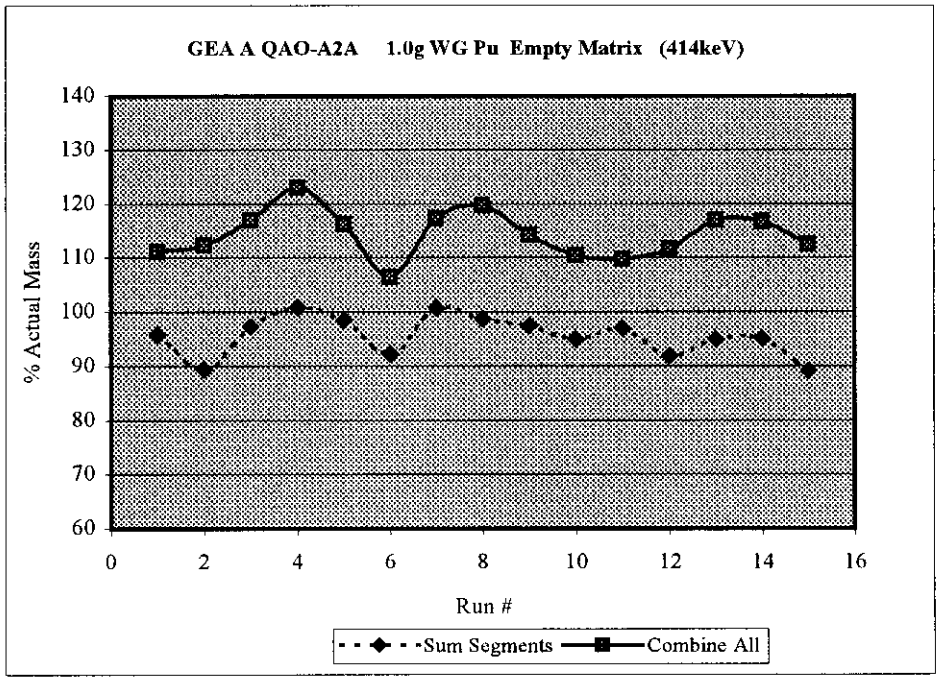
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	8.36E+06	1.33E+02	88.56	1.08E+07	1.72E+02	114.41
Run 2	8.37E+06	1.33E+02	88.66	1.12E+07	1.78E+02	118.64
Run 3	8.37E+06	1.33E+02	88.66	9.81E+06	1.56E+02	103.92
Run 4	8.36E+06	1.33E+02	88.56	1.03E+07	1.64E+02	109.11
Run 5	8.33E+06	1.32E+02	88.24	1.04E+07	1.65E+02	110.17
Run 6	8.35E+06	1.33E+02	88.45	1.05E+07	1.67E+02	111.23
Run 7	8.34E+06	1.33E+02	88.35	9.84E+06	1.56E+02	104.24
Run 8	8.40E+06	1.34E+02	88.98	9.75E+06	1.55E+02	103.28
Run 9	8.41E+06	1.34E+02	89.09	1.11E+07	1.76E+02	117.58
Run 10	8.32E+06	1.32E+02	88.14	1.06E+07	1.69E+02	112.29
Run 11	8.38E+06	1.33E+02	88.77	1.04E+07	1.65E+02	110.17
Run 12	8.38E+06	1.33E+02	88.77	1.07E+07	1.70E+02	113.35
Run 13	8.39E+06	1.33E+02	88.88	1.02E+07	1.62E+02	108.05
Run 14	8.32E+06	1.32E+02	88.14	1.10E+07	1.75E+02	116.53
Run 15	8.33E+06	1.32E+02	88.24	1.01E+07	1.61E+02	106.99
Average	**8.36E+06**	**1.33E+02**	**8.86E+01**	**1.04E+07**	**1.66E+02**	**1.11E+02**
	standard deviation = 4.56E-01			standard deviation = 7.34E+00		
Precision	% RSD = 0.34		***(Pass)***	% RSD = 4.42		***(Pass)***
Accuracy	% R = 88.57		***(Pass)***	% R = 110.66		***(Pass)***
Total Bias (%)	88.14 to 89.09			103.28 to 118.64		



GEA A QAO-A2A 1.0g WG Pu in Empty Matrix

Pu-239B

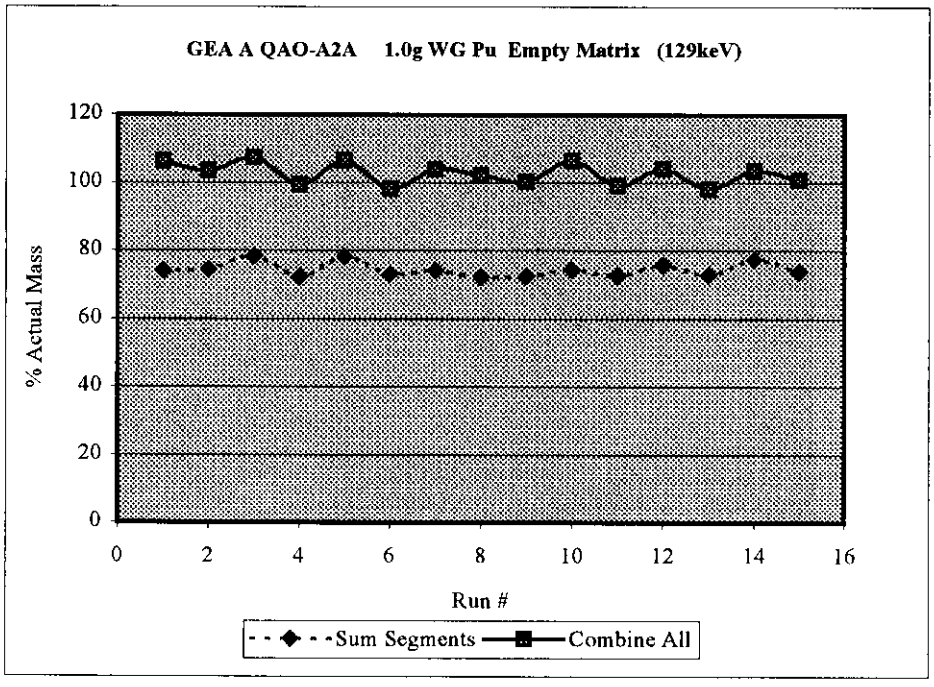
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	5.65E+04	8.98E-01	95.76	6.56E+04	1.04E+00	111.19
Run 2	5.27E+04	8.38E-01	89.32	6.63E+04	1.05E+00	112.37
Run 3	5.74E+04	9.13E-01	97.29	6.90E+04	1.10E+00	116.95
Run 4	5.95E+04	9.46E-01	100.85	7.26E+04	1.15E+00	123.05
Run 5	5.81E+04	9.24E-01	98.47	6.86E+04	1.09E+00	116.27
Run 6	5.44E+04	8.65E-01	92.20	6.28E+04	9.98E-01	106.44
Run 7	5.94E+04	9.44E-01	100.68	6.92E+04	1.10E+00	117.29
Run 8	5.82E+04	9.25E-01	98.64	7.06E+04	1.12E+00	119.66
Run 9	5.75E+04	9.14E-01	97.46	6.74E+04	1.07E+00	114.24
Run 10	5.60E+04	8.90E-01	94.91	6.52E+04	1.04E+00	110.51
Run 11	5.72E+04	9.09E-01	96.95	6.48E+04	1.03E+00	109.83
Run 12	5.42E+04	8.62E-01	91.86	6.59E+04	1.05E+00	111.69
Run 13	5.60E+04	8.90E-01	94.91	6.90E+04	1.10E+00	116.95
Run 14	5.61E+04	8.92E-01	95.08	6.89E+04	1.10E+00	116.78
Run 15	5.26E+04	8.36E-01	89.15	6.64E+04	1.06E+00	112.54
Average	**5.64E+04**	**8.96E-01**	**9.56E+01**	**6.75E+04**	**1.07E+00**	**1.14E+02**
	standard deviation = 3.43E-02			standard deviation = 4.02E-02		
Precision	% RSD = 3.82		***(Pass)***	% RSD = 3.75		***(Pass)***
Accuracy	% R = 95.57		***(Pass)***	% R = 114.38		***(Pass)***
Total Bias (	89.15 to 100.85			106.44 to 123.05		



GEA A QAO-A2A 1.0g WG Pu in Empty Matrix

Pu-239A

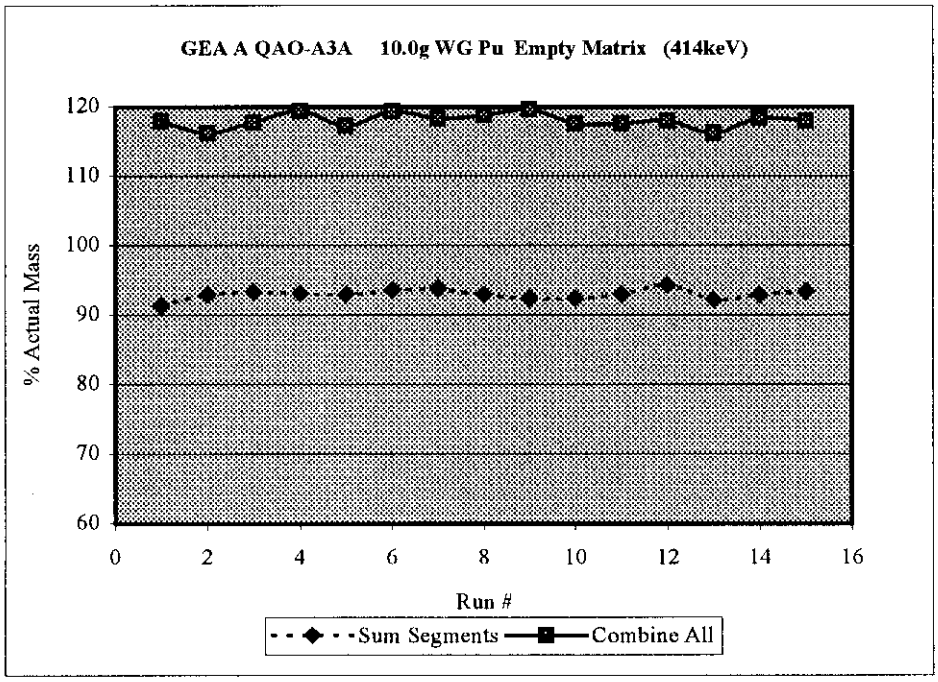
	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	4.37E+04	6.95E-01	74.07	6.27E+04	9.97E-01	106.27
Run 2	4.39E+04	6.98E-01	74.41	6.10E+04	9.70E-01	103.39
Run 3	4.62E+04	7.34E-01	78.30	6.34E+04	1.01E+00	107.46
Run 4	4.27E+04	6.79E-01	72.37	5.86E+04	9.32E-01	99.32
Run 5	4.61E+04	7.33E-01	78.14	6.28E+04	9.98E-01	106.44
Run 6	4.31E+04	6.85E-01	73.05	5.79E+04	9.21E-01	98.14
Run 7	4.38E+04	6.96E-01	74.24	6.13E+04	9.75E-01	103.90
Run 8	4.27E+04	6.79E-01	72.37	6.03E+04	9.59E-01	102.20
Run 9	4.28E+04	6.80E-01	72.54	5.92E+04	9.41E-01	100.34
Run 10	4.39E+04	6.98E-01	74.41	6.28E+04	9.98E-01	106.44
Run 11	4.29E+04	6.82E-01	72.71	5.85E+04	9.30E-01	99.15
Run 12	4.46E+04	7.09E-01	75.59	6.14E+04	9.76E-01	104.07
Run 13	4.30E+04	6.84E-01	72.88	5.79E+04	9.21E-01	98.14
Run 14	4.56E+04	7.25E-01	77.29	6.11E+04	9.71E-01	103.56
Run 15	4.35E+04	6.92E-01	73.73	5.95E+04	9.46E-01	100.85
Average	**4.39E+04**	**6.98E-01**	**7.44E+01**	**6.06E+04**	**9.63E-01**	**1.03E+02**
	standard deviation = 1.91E-02			standard deviation = 3.00E-02		
Precision	% RSD = 2.74		***(Pass)***	% RSD = 3.11		***(Pass)***
Accuracy	% R = 74.41		***(Pass)***	% R = 102.64		***(Pass)***
Total Bias (	72.37 to 78.30			98.14 to 107.46		



GEA A QAO-A3A 10.0g WG Pu in Empty Matrix

Pu-239B

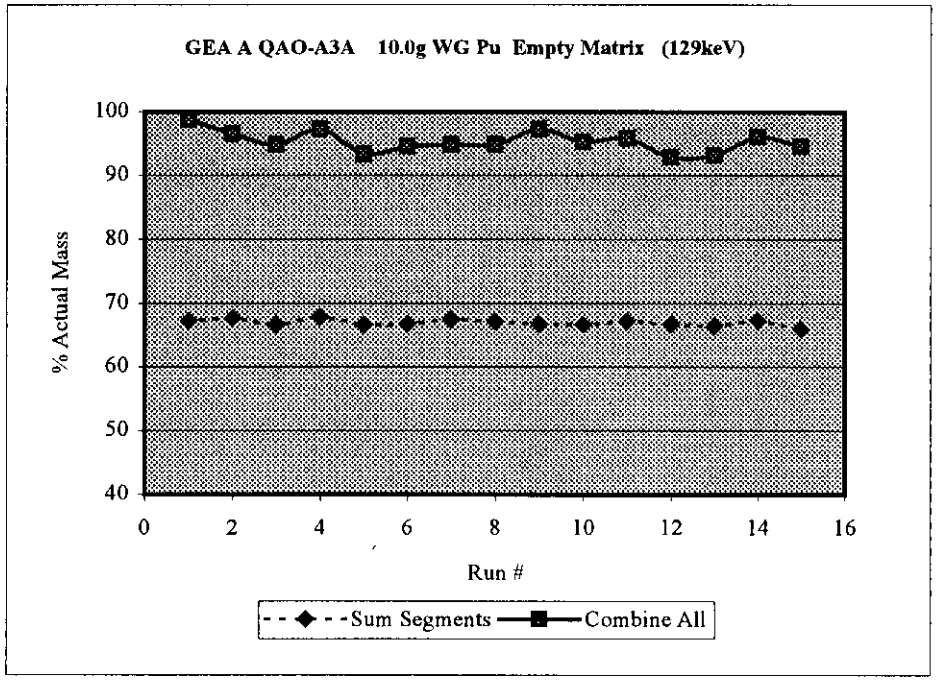
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	5.39E+05	8.57E+00	91.36	6.96E+05	1.11E+01	117.97
Run 2	5.48E+05	8.71E+00	92.88	6.86E+05	1.09E+01	116.27
Run 3	5.50E+05	8.74E+00	93.22	6.95E+05	1.10E+01	117.80
Run 4	5.49E+05	8.73E+00	93.05	7.05E+05	1.12E+01	119.49
Run 5	5.48E+05	8.71E+00	92.88	6.92E+05	1.10E+01	117.29
Run 6	5.52E+05	8.78E+00	93.56	7.04E+05	1.12E+01	119.32
Run 7	5.53E+05	8.79E+00	93.73	6.98E+05	1.11E+01	118.30
Run 8	5.48E+05	8.71E+00	92.88	7.01E+05	1.11E+01	118.81
Run 9	5.45E+05	8.66E+00	92.37	7.06E+05	1.12E+01	119.66
Run 10	5.45E+05	8.66E+00	92.37	6.94E+05	1.10E+01	117.63
Run 11	5.48E+05	8.71E+00	92.88	6.94E+05	1.10E+01	117.63
Run 12	5.56E+05	8.84E+00	94.24	6.96E+05	1.11E+01	117.97
Run 13	5.44E+05	8.65E+00	92.20	6.86E+05	1.09E+01	116.27
Run 14	5.48E+05	8.71E+00	92.88	6.98E+05	1.11E+01	118.30
Run 15	5.51E+05	8.76E+00	93.39	6.96E+05	1.11E+01	117.97
Average	**5.48E+05**	**8.72E+00**	**9.29E+01**	**6.96E+05**	**1.11E+01**	**1.18E+02**
	standard deviation = 6.48E-02			standard deviation = 9.50E-02		
Precision	% RSD = 0.74		***(Pass)***	% RSD = 0.86		***(Pass)***
Accuracy	% R = 92.93		***(Pass)***	% R = 118.04		***(Pass)***
Total Bias (	91.36 to 94.24			116.27 to 119.66		



GEA A QAO-A3A 10.0g WG Pu in Empty Matrix

Pu-239A

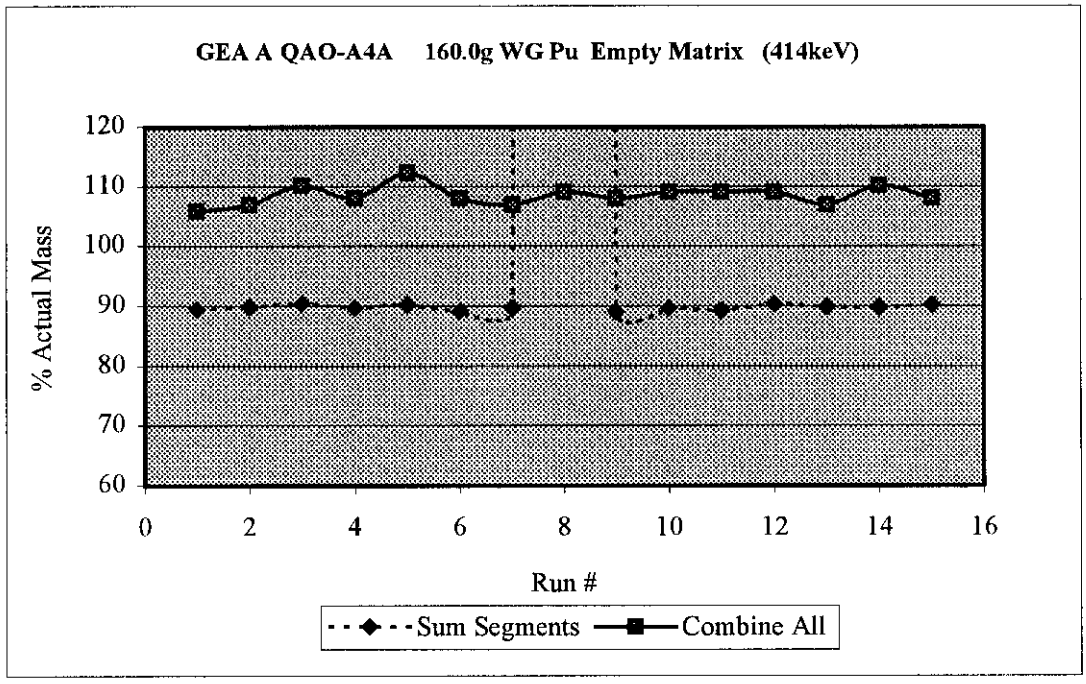
	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	3.97E+05	6.31E+00	67.29	5.83E+05	9.27E+00	98.81
Run 2	3.99E+05	6.34E+00	67.63	5.70E+05	9.06E+00	96.61
Run 3	3.93E+05	6.25E+00	66.61	5.60E+05	8.90E+00	94.91
Run 4	4.00E+05	6.36E+00	67.80	5.74E+05	9.13E+00	97.29
Run 5	3.93E+05	6.25E+00	66.61	5.51E+05	8.76E+00	93.39
Run 6	3.94E+05	6.26E+00	66.78	5.58E+05	8.87E+00	94.58
Run 7	3.98E+05	6.33E+00	67.46	5.60E+05	8.90E+00	94.91
Run 8	3.96E+05	6.30E+00	67.12	5.60E+05	8.90E+00	94.91
Run 9	3.94E+05	6.26E+00	66.78	5.74E+05	9.13E+00	97.29
Run 10	3.93E+05	6.25E+00	66.61	5.62E+05	8.93E+00	95.25
Run 11	3.96E+05	6.30E+00	67.12	5.66E+05	9.00E+00	95.93
Run 12	3.94E+05	6.26E+00	66.78	5.48E+05	8.71E+00	92.88
Run 13	3.92E+05	6.23E+00	66.44	5.50E+05	8.74E+00	93.22
Run 14	3.97E+05	6.31E+00	67.29	5.67E+05	9.01E+00	96.10
Run 15	3.89E+05	6.18E+00	65.93	5.58E+05	8.87E+00	94.58
Average	**3.95E+05**	**6.28E+00**	**6.69E+01**	**5.63E+05**	**8.95E+00**	**9.54E+01**
	standard deviation = 4.65E-02			standard deviation = 1.55E-01		
Precision	% RSD = 0.74		***(Pass)***	% RSD = 1.73		***(Pass)***
Accuracy	% R = 66.95		***(Fail)***	% R = 95.38		***(Pass)***
Total Bias (	65.93 to 67.80			92.88 to 98.81		



GEA A QAO-A4A 160.0g WG Pu in Empty Matrix -- Unattenuated

Pu-239B

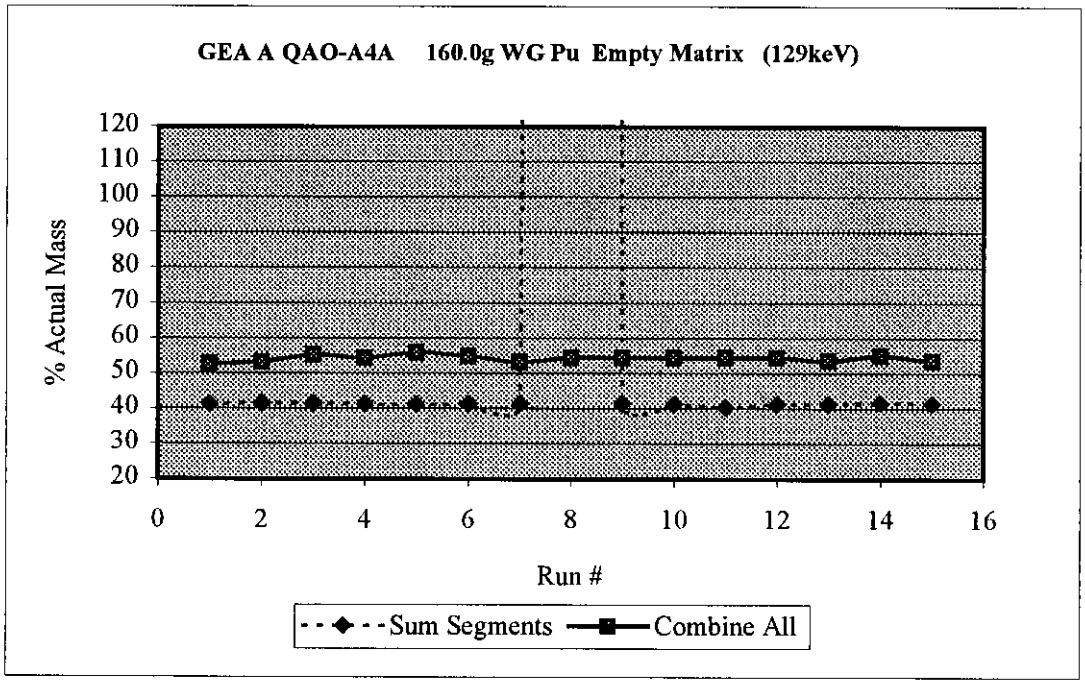
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	8.45E+06	1.34E+02	89.51	1.00E+07	1.59E+02	105.93
Run 2	8.49E+06	1.35E+02	89.94	1.01E+07	1.61E+02	106.99
Run 3	8.54E+06	1.36E+02	90.47	1.04E+07	1.65E+02	110.17
Run 4	8.47E+06	1.35E+02	89.72	1.02E+07	1.62E+02	108.05
Run 5	8.52E+06	1.35E+02	90.25	1.06E+07	1.69E+02	112.29
Run 6	8.42E+06	1.34E+02	89.19	1.02E+07	1.62E+02	108.05
Run 7	8.47E+06	1.35E+02	89.72	1.01E+07	1.61E+02	106.99
Run 8	2.08E+09	3.31E+04	22033.82	1.03E+07	1.64E+02	109.11
Run 9	8.41E+06	1.34E+02	89.09	1.02E+07	1.62E+02	108.05
Run 10	8.47E+06	1.35E+02	89.72	1.03E+07	1.64E+02	109.11
Run 11	8.43E+06	1.34E+02	89.30	1.03E+07	1.64E+02	109.11
Run 12	8.53E+06	1.36E+02	90.36	1.03E+07	1.64E+02	109.11
Run 13	8.49E+06	1.35E+02	89.94	1.01E+07	1.61E+02	106.99
Run 14	8.48E+06	1.35E+02	89.83	1.04E+07	1.65E+02	110.17
Run 15	8.52E+06	1.35E+02	90.25	1.02E+07	1.62E+02	108.05
Average	**1.47E+08**	**2.33E+03**	**1.55E+03**	**1.02E+07**	**1.63E+02**	**1.09E+02**
	standard deviation = 8.50E+03			standard deviation = 2.39E+00		
Precision	% RSD = 364.90		***(Fail)***	% RSD = 1.47		***(Pass)***
Accuracy	% R = 1552.74		***(Fail)***	% R = 108.54		***(Pass)***
Total Bias (%)	89.09 to 22033.82			105.93 to 112.29		



GEA A QAO-A4A 160.0g WG Pu in Empty Matrix -- Unattenuated

Pu-239A

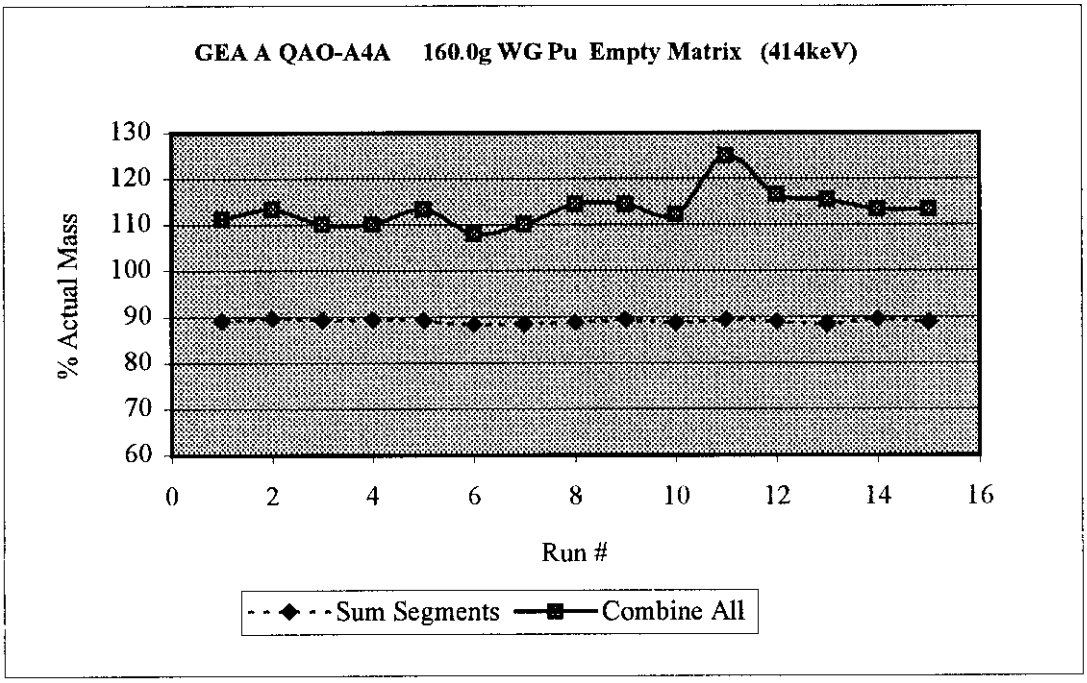
	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	3.90E+06	6.20E+01	41.31	4.97E+06	7.90E+01	52.65
Run 2	3.91E+06	6.22E+01	41.42	5.03E+06	8.00E+01	53.28
Run 3	3.91E+06	6.22E+01	41.42	5.21E+06	8.28E+01	55.19
Run 4	3.90E+06	6.20E+01	41.31	5.12E+06	8.14E+01	54.24
Run 5	3.88E+06	6.17E+01	41.10	5.28E+06	8.39E+01	55.93
Run 6	3.90E+06	6.20E+01	41.31	5.17E+06	8.22E+01	54.77
Run 7	3.90E+06	6.20E+01	41.31	5.03E+06	8.00E+01	53.28
Run 8	9.58E+08	1.52E+04	10148.27	5.14E+06	8.17E+01	54.45
Run 9	3.91E+06	6.22E+01	41.42	5.15E+06	8.19E+01	54.55
Run 10	3.89E+06	6.18E+01	41.21	5.14E+06	8.17E+01	54.45
Run 11	3.81E+06	6.06E+01	40.36	5.15E+06	8.19E+01	54.55
Run 12	3.90E+06	6.20E+01	41.31	5.14E+06	8.17E+01	54.45
Run 13	3.89E+06	6.18E+01	41.21	5.05E+06	8.03E+01	53.50
Run 14	3.92E+06	6.23E+01	41.53	5.19E+06	8.25E+01	54.98
Run 15	3.91E+06	6.22E+01	41.42	5.05E+06	8.03E+01	53.50
Average	**6.75E+07**	**1.07E+03**	**7.15E+02**	**5.12E+06**	**8.14E+01**	**5.43E+01**
	standard deviation = 3.92E+03			standard deviation = 1.29E+00		
Precision	% RSD = 364.95		***(Fail)***	% RSD = 1.59		***(Pass)***
Accuracy	% R = 715.06		***(Fail)***	% R = 54.25		***(Fail)***
Total Bias (%)	40.36 to 10148.27			52.65 to 55.93		



GEA A QAO-A4A 160.0g WG Pu in Empty Matrix - Attenuated

Pu-239B

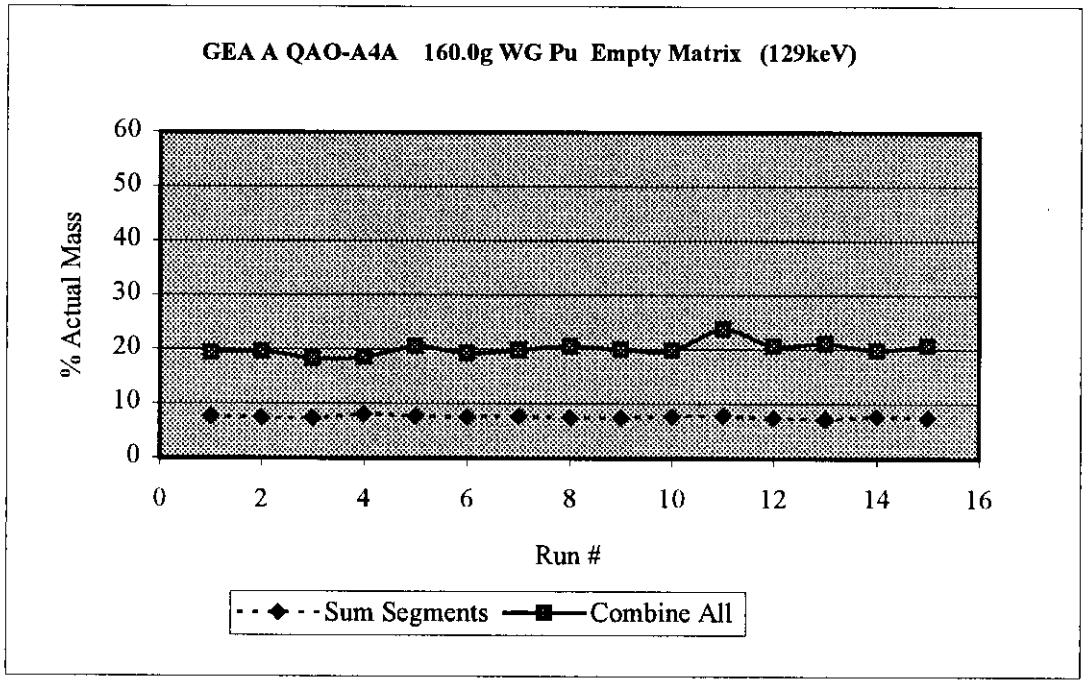
	Summed Segments 414keV			Combine All Results 414keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	8.41E+06	1.34E+02	89.09	1.05E+07	1.67E+02	111.23
Run 2	8.46E+06	1.34E+02	89.62	1.07E+07	1.70E+02	113.35
Run 3	8.43E+06	1.34E+02	89.30	1.04E+07	1.65E+02	110.17
Run 4	8.44E+06	1.34E+02	89.41	1.04E+07	1.65E+02	110.17
Run 5	8.43E+06	1.34E+02	89.30	1.07E+07	1.70E+02	113.35
Run 6	8.33E+06	1.32E+02	88.24	1.02E+07	1.62E+02	108.05
Run 7	8.34E+06	1.33E+02	88.35	1.04E+07	1.65E+02	110.17
Run 8	8.38E+06	1.33E+02	88.77	1.08E+07	1.72E+02	114.41
Run 9	8.44E+06	1.34E+02	89.41	1.08E+07	1.72E+02	114.41
Run 10	8.37E+06	1.33E+02	88.66	1.06E+07	1.69E+02	112.29
Run 11	8.44E+06	1.34E+02	89.41	1.18E+07	1.88E+02	125.00
Run 12	8.40E+06	1.34E+02	88.98	1.10E+07	1.75E+02	116.53
Run 13	8.34E+06	1.33E+02	88.35	1.09E+07	1.73E+02	115.47
Run 14	8.45E+06	1.34E+02	89.51	1.07E+07	1.70E+02	113.35
Run 15	8.39E+06	1.33E+02	88.88	1.07E+07	1.70E+02	113.35
Average	**8.40E+06**	**1.34E+02**	**8.90E+01**	**1.07E+07**	**1.70E+02**	**1.13E+02**
	standard deviation =	6.87E-01		standard deviation =	5.90E+00	
Precision	% RSD =	0.51	***(Pass)***	% RSD =	3.47	***(Pass)***
Accuracy	% R =	89.02	***(Pass)***	% R =	113.42	***(Pass)***
Total Bias (%)	88.24 to	89.62		108.05 to	125.00	



GEA A QAO-A4A 160.0g WG Pu in Empty Matrix - Attenuated

Pu-239A

	Summed Segments 129keV			Combine All Results 129keV		
	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass	Detected Activity (uCi)	Detected Mass (g)	% Actual Mass
Run 1	7.21E+05	1.15E+01	7.64	1.83E+06	2.91E+01	19.39
Run 2	6.99E+05	1.11E+01	7.40	1.85E+06	2.94E+01	19.60
Run 3	6.88E+05	1.09E+01	7.29	1.73E+06	2.75E+01	18.33
Run 4	7.52E+05	1.20E+01	7.97	1.76E+06	2.80E+01	18.64
Run 5	7.17E+05	1.14E+01	7.60	1.94E+06	3.08E+01	20.55
Run 6	7.12E+05	1.13E+01	7.54	1.82E+06	2.89E+01	19.28
Run 7	7.23E+05	1.15E+01	7.66	1.88E+06	2.99E+01	19.92
Run 8	7.04E+05	1.12E+01	7.46	1.94E+06	3.08E+01	20.55
Run 9	6.95E+05	1.10E+01	7.36	1.89E+06	3.00E+01	20.02
Run 10	7.23E+05	1.15E+01	7.66	1.88E+06	2.99E+01	19.92
Run 11	7.38E+05	1.17E+01	7.82	2.24E+06	3.56E+01	23.73
Run 12	7.04E+05	1.12E+01	7.46	1.95E+06	3.10E+01	20.66
Run 13	6.81E+05	1.08E+01	7.21	2.00E+06	3.18E+01	21.19
Run 14	7.27E+05	1.16E+01	7.70	1.88E+06	2.99E+01	19.92
Run 15	6.98E+05	1.11E+01	7.39	1.97E+06	3.13E+01	20.87
Average	**7.12E+05**	**1.13E+01**	**7.54E+00**	**1.90E+06**	**3.03E+01**	**2.02E+01**
	standard deviation = 3.05E-01			standard deviation = 1.90E+00		
Precision	% RSD = 2.70		***(Pass)***	% RSD = 6.27		***(Fail)***
Accuracy	% R = 7.54		***(Fail)***	% R = 20.17		***(Fail)***
Total Bias (%)	7.21 to 7.97			18.33 to 23.73		



Los Alamos National Laboratory
Certificate of Content and Traceability

PuO_2-Diatomaceous Earth Standard WRAP100MGPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	0.11064 grams	± 0.00005 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	0.09710 grams	± 0.00011 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	0.110 mg*	± 0.001 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	6.635 mCi** 2.455E+08 Bq	± 0.017 mCi [g] ± 6E+05 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Robert S. Marshall, Project Manager
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

Los Alamos National Laboratory
Certificate of Content and Traceability

PuO_2-Diatomaceous Earth Standard WRAP-1 500MGPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	0.57920 grams	± 0.00008 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	0.50831 grams	± 0.00051 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	0.574 mg*	± 0.004 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	34.73 mCi** 1.285E+09 Bq	± 0.09 mCi [g] ± 3E+06 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Sandra Mucklenburg, acting
Robert S. Marshall, Project Manager
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

Los Alamos National Laboratory
Certificate of Content and Traceability

PuO_2-Diatomaceous Earth Standard WRAP-2 500MGPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	0.58708 grams	± 0.00006 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	0.51522 grams	± 0.00051 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	0.582 mg*	± 0.004 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	35.21 mCi** 1.303E+09 Bq	± 0.09 mCi [g] ± 3E+06 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Robert S. Marshall, Project Manager
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

Los Alamos National Laboratory
Certificate of Content and Traceability

PuO_2-Diatomaceous Earth Standard WRAP-1 5.0GPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	5.74627 grams	± 0.00020 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	5.04298 grams	± 0.00474 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	5.69 mg*	± 0.04 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	344.6 mCi**	± 0.9 mCi [g]
	1.275E+10 Bq	± 3E+07 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Sandra Mucklow acting
Robert S. Marshall, Project Manager
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

Los Alamos National Laboratory
Certificate of Content and Traceability

PuO_2-Diatomaceous Earth Standard WRAP-2 5.0GPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	5.71060 grams	± 0.00021 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	5.01168 grams	± 0.00472 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	5.66 mg*	± 0.04 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	342.5 mCi** 1.267E+10 Bq	± 0.9 mCi [g] ± 3E+07 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill U. McKerley, Group Leader
CMR Analytical Chemistry

Robert S. Marshall, Project Manager, acting
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

Los Alamos National Laboratory
Certificate of Content and Traceability

PuO_2-Diatomaceous Earth Standard WRAP-3 5.0GPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	5.69429 grams	± 0.00031 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	4.99736 grams	± 0.00476 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	5.64 mg*	± 0.04 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	341.5 mCi** 1.263E+10 Bq	± 0.9 mCi [g] ± 3E+07 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Robert S. Marshall, Project Manager
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

Los Alamos National Laboratory

Certificate of Content and Traceability

PuO_2-Diatomaceous Earth Standard WRAP10GPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	11.40156 grams	± 0.00049 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	10.00612 grams	± 0.00945 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	11.30 mg*	± 0.09 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	683.7 mCi** 2.530E+10 Bq	± 1.8 mCi [g] ± 7E+07 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Robert S. Marshall, Project Manager, acting
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

Los Alamos National Laboratory
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PuO_2-Diatomaceous Earth Standard WRAP20GPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	22.79925 grams	± 0.00062 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	20.00884 grams	± 0.01875 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	22.59 mg*	± 0.17 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	1367 mCi** 5.059E+10 Bq	± 4 mCi [g] ± 1E+08 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

B.R.J. McKerley, Group Leader
CMR Analytical Chemistry

Robert S. Marshall, Project Manager, acting
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

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PuO_2-Diatomaceous Earth Standard WRAP30GPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	34.19337 grams	± 0.00101 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	30.00842 grams	± 0.02815 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	33.88 mg*	± 0.26 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	2051 mCi** 7.587E+10 Bq	± 5 mCi [g] ± 2E+08 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Sandra Mullenburg acting
Robert S. Marshall, Project Manager
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

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PuO_2-Diatomaceous Earth Standard WRAP40GPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	45.58093 grams	± 0.00111 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	40.00226 grams	± 0.03740 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	45.16 mg*	± 0.35 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	2733 mCi** 1.011E+11 Bq	± 7 mCi [g] ± 3E+08 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Robert S. Marshall, Project Manager, acting
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

Los Alamos National Laboratory
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PuO_2-Diatomaceous Earth Standard WRAP50GPU

This NDA standard contains high purity plutonium dioxide dispersed in diatomaceous earth. Quantitative information and uncertainties on the nuclear content of this WRM are listed below. Complete information regarding the Pu and Am content, Pu isotopic ratios, chemical composition, elemental impurities, containment, and fabrication procedures are retained in files by the Los Alamos National Laboratory CMR Analytical Chemistry Group.

NUCLEAR MATERIAL CONTENT

The nuclear material content and total alpha activity for this standard are listed below. Also listed are overall uncertainty estimates at 95% confidence intervals (CI) for each component.

Component	Quantity or Value	95 % CI
PuO_2 in standard	56.99360 grams	± 0.00112 grams [a]
Pu Assay	87.761 % of PuO_2*	± 0.081 % [b]
Pu in standard	50.01813 grams	± 0.04664 grams [c]
^{241}Am Assay	1128.9 µg/g PuO_2*	± 0.3 µg/g [d]
^{241}Am in standard	56.47 mg*	± 0.43 mg [e]
Isotopic Weight Fraction*		
^{238}Pu	0.00014	± 0.000005 [f]
^{239}Pu	0.93809	± 0.000015 [f]
^{240}Pu	0.05939	± 0.000007 [f]
^{241}Pu	0.00185	± 0.000009 [f]
^{242}Pu	0.00054	± 0.000003 [f]
Total Alpha Activity in standard	3418 mCi** 1.265E+11 Bq	± 9 mCi [g] ± 3E+08 Bq [g]

*Decay corrected value on 1/21/99 ** Effective 1/21/99

Bill J. McKerley, Group Leader
CMR Analytical Chemistry

Robert S. Marshall, Project Manager
NDA WRM Production

MEASUREMENT METHOD AND TRACEABILITY

The nuclear contents of this standard were characterized and quantified using the following methods with traceability to the National Institute of Standards and Technology (NIST) or New Brunswick Laboratory (NBL) standards.

Measurement	Measurement Method	Reference Material
Weighing	5 place analytical balance	NIST traceable weights
Pu Assay	Controlled Potential Coulometry	NBL CRM # 126
Am Assay	Isotope Dilution Mass Spectrometry	NBL CRM # 128
Pu Isotopic	Total Evaporation Mass Spectrometry	NBL CRM # 128
Alpha Activity	Calculated from Pu and Am mass, and isotope alpha specific activities listed below.	Pu $t_{1/2}$ as stated for NIST SRM946 Am $t_{1/2}$ as stated for NIST SRM4322B

The stated Alpha Activity was calculated using the following isotope half lives (in years): ^{238}Pu: 87.74; ^{239}Pu: 24,119; ^{240}Pu: 6,560; ^{241}Pu: 14.34; ^{242}Pu: 387,000; and ^{241}Am: 432.2.

NOTES

Random and systematic error terms were combined and reported as 95% confidence intervals. Error terms include estimates of the following:

(a) Balance precision, buoyancy, standard weight bias, and transfer loss.
(b) Long and short term precision, control check bias, weighing precision and bias.
(c) Above weighing and assay terms, and transfer loss.
(d) Long and short term precision, and bias.
(e) Above weighing terms, Am assay terms, and transfer loss.
(f) Long and short term precision, and bias.
(g) Based on propagated uncertainties on the Pu mass, ^{241}Am mass and Pu isotopic uncertainties listed above. No half-life uncertainty components are included and it is recommended that all facilities participating in the NDA PDP program use the half-lives listed above to preclude facility-to-facility error terms introduced by using different half life values.

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