INL/EXT-11-22507

Calibration of the Accuscan II In Vivo System for I-131 Thyroid Counting

O. R. Perry

July 2011

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Health Physics Dosimetry Laboratory
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http://www.inl.gov

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Health Physics Dosimetry Laboratory

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Approved by:

Orval R. Perry — Date: 7/21/2011

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Lawrence L. Burke
Health Physics Dosimetry Laboratory Manager — Date: 7/21/2011

ABSTRACT

This report describes the March 2011 calibration of the Accuscan II HpGe In Vivo system for I-131 thyroid counting. The source used for the calibration was an Analytics mixed gamma source # 82834-121 distributed in an epoxy matrix in a Wheaton Liquid Scintillation Vial with energies from 88.0 keV to 1836.1 keV. The center of the detectors was position 64" from the vault floor. This position places the approximate center line of the detectors at the center line of the source in the thyroid tube. The calibration was performed using an RMC II phantom (Appendix J). Validation testing was performed using a Ba-133 source and an ANSI N44.3 Phantom (Appendix I). This report includes an overview introduction and records for the energy/FWHM and efficiency calibrations including verification counting. The Accuscan II system was successfully calibrated for counting the thyroid for I-131 and verified in accordance with ANSI/HPS N13.30-1996 criteria.

CONTENTS

FIGURES

No table of figures entries found.

TABLES

ACRONYMS

ANSI	American National Standard Institute
ASF	Analysis Sequence File
BE	Broad Energy
CFA	Central Facility Area
CPS	Counts per second
FWHM	Full With at Half Maximum
HpGe	High Purity Germanium –also HPGe
HPL	Health Physics Laboratory
HPS	Health Physics Society
INL	Idaho National Laboratory
MDA	Minimum Detectable Activity
NIST	National Institute of Standards and Testing
PC	Personal Computer
RMC	Radiation Management Corporation
WBC	Whole Body Counting

Calibration of the Accuscan II In Vivo System for I-131 Thyroid Counting

1. INTRODUCTION

This document describes the March 2011 calibration of the Accuscan II in vivo system for thyroid counting of I-131. The new calibration files were stored on the system disk and made available for thyroid counting after all verification counts were completed. This is the initial calibration of the Accuscan II for personnel thyroid counting for I-131.

The energy/FWHM-Low Tail calibration was performed on February 28, 2011. An Analytics mixed gamma source #82835-121 was use together with an RMC II phantom to establish a thyroid counting geometry. This source (#82835-121) is NIST traceable and is presented in Appendix A. The mixed gamma source has a reference date of July 1, 2010, with the current activity presented in Appendix B. The RMC II phantom was used for the efficiency calibration. The source vial was positioned in the phantom thyroid tube and counted 60 minutes for the efficiency calibration. The energy calibration (Appendix C) was conducted with the source positioned on the rearwall of the counter at approximately 46” from the counter floor. The center line of the Accuscan II detectors were positioned at the center line of the source 61.25” from the counter floor (64.0” from the vault floor) for the efficiency count.

An efficiency calibration was performed subsequent to the energy/FWHM calibration (Appendix D). To calibrate this counting geometry, a mathematical function relating efficiency versus photopeak energy was created. The mathematical efficiency function generated on March 1, 2011 is expressed as a duel fit with no crossover. The efficiency is determined empirically by measuring known standards and using least squares fitting techniques. The efficiency function is stored as a calibration file, which is used to analyze spectra, collected under the same counting conditions.

Replicate performance (verification) counts (using the new calibration files) were performed to confirm that the accuracy and precision of the calibration satisfied ANSI/HPS N13.30-1996[1] performance criteria and are presented in Appendix E.

In addition to the performance tests, a set of 5 validation counts were performed using a NIST traceable I-133 source manufactured by DOE. The validation counts Relative Bias and Relative Precision were tested to ANSI/HPS N13.30-1996[1] criteria. The results are presented in Appendix H.

2. COUNTING SYSTEM DESCRIPTION

The Accuscan II system contains two broad energy BE type HpGe detectors used for both low and high energy counting. This would include Whole Body, High Energy Lung, Thyroid, and Low Energy Lung (although at this time the system is not calibrated for energies <26 keV). The Canberra Apex-InVivo software system, supported by Genie 2000 Spectroscopy software, operates on a Dell Optiplex 780 PC. The counter system is located in a 9’4” high × 8’71/2” wide × 11’5” deep counting vault constructed of concrete and masonry blocks. The counting system is standup with the detectors scanning from head to foot for whole body counting. For Lung and Thyroid counting the detectors are stationary at fixed counting positions. Personnel are positioned in a counting shield constructed of 4” of low background steel and face the detectors which are “shadow shielded” with both lead and copper. The counting vault is located on the INL site at HPL-1618. The detectors are cooled to −185°C by an electrically refrigerated cryostat system.

3. CALIBRATION SOURCES AND PHANTOMS

A NIST traceable Analytics mixed gamma source #82835-121 was used. The certification for this source is described in Appendix A. The source is uniformly distributed in an epoxy matrix in Wheaton Liquid Scintillation Vial (~22 ml).

The source activity was decayed to the efficiency calibration date of March 1, 2011 by the Apex software. The Apex software also decayed the source for verification testing and presented the results in gammas per second. The phantom has been verified against the ANSI N44.3[2] thyroid phantom, Realistic torso phantom and Bottle Manikin Absorber model and is described in Appendix J.

An ANSI N44.3[2] phantom was used with a 30.0 ml vial containing 101 nCi of Ba-133 to provide Validation testing subsequent to the calibration. The phantom is described in Appendix I.

4. DETECTOR AND LYNX DIGITAL AMPLIFIER TESTING

A Pole Zero was performed in accordance with MCP-3336[3], "Accuscan II Calibration, Proficiency Testing, and Reporting," for both detectors. The pole zero residual value for detector 1 was 2421 and 2421 after the adjustment. The pole zero residual value for detector 2 was 2678 and 2677 after the adjustment. The Co-60/Cs-137 check source was positioned on the Canberra Calibration Table top 5 1/2" from the counter rearwall and 14 3/4" from the counter left wall. The center line of the detectors was raised 38 3/4" from the concrete vault floor. This places the center line of the detectors in line with the check source. To perform a pole zero on the amplifiers the count rate must be within 200 to 2000 cps.

5. ENERGY/FWHM CALIBRATION

An energy/FWHM calibration was performed February 28, 2011. The mixed gamma source 82835-121 was placed on the counter backwall and the detectors were placed in a scanning mode of operation. The count was for 60 minutes and energy, FWHM and Low Tail equations developed. The results and graphs of the energy, FWHM and Low Tail calibrations are documented in Appendix C.

6. EFFICIENCY CALIBRATION

An efficiency calibration was conducted March 1, 2011 in accordance with MCP-3336[3] and the Canberra Apex-InVivo User's Manual[4] and documented in Appendix D. Appendix D contains the worksheets, listings, and plots for these new efficiency calibration files. The efficiency calibration count was performed using the energy calibration count described in Section 5.0. Spectral data was transferred to a disk file at the completion of the count, using "Efficiency Calibration 3/1/2011 11:30 AM" as the ID number. The mixed gamma source 82835-121 was positioned in the RMC II thyroid tube and the center line of the detector housing was position at 64" from the vault floor. The detectors remained in this position for the calibration count. The efficiency count was for 60 minutes.

7. CALIBRATION COUNT REANALYSIS

Subsequent to the energy and efficiency calibrations the calibration count (performed on 3/1/2011 10:22 AM) was analyzed using the new calibrations. The results indicated a relative bias between −0.03 and 0.02. This result is well within the bias criteria of Reference 1. The results also indicated an excellent calibration. The summary result and supporting documentation is attached as Appendix E.

8. PERFORMANCE (VERIFICATION) TESTING

The efficiency calibration used certificate 82835-121 New. A set of five replicate verification test of the radionuclides in certificate 82835-121 were performed March 1, 2011 with the center line of the detectors positioned 64" from the vault floor and the source located in the RMC II phantom thyroid tube. These counts were analyzed using the new efficiency calibration file and the nuclide library file MixGamm.NLB. Relative bias and relative precision, as defined in ANSI/HPS N13.30-1996[1] were calculated for these counts. Analysis results and calculated bias values for these verification counts are summarized in Appendix F. The bias ranged from −6.2% to 0.23%. The relative precision for these verification counts ranged from 9.61% to 1.11%. These results are well within the ANSI/HPS N13.30-1996[1] criteria (–0.25 to +0.50 for the relative bias and less than or equal to 0.4 for the relative precision).

9. MDA CALCULATIONS

MDA testing was conducted on March 1, 2011. The RMC-II phantom (with no sources installed) was counted three times with the Apex-In Vivo Analysis Sequence File (ASF) counting file (ROUNPPGE.ASF) containing the Detection Limit-Curie MDA Step. The Curie MDA equation of $(4.65*S_b + 3)/KT$ was installed in the step. The MDA summary and supporting documentation are attached as Appendix G.

10. VALIDATION TESTING

At the completion of calibration and verification testing, a second set of tests were conducted using a different source. These tests were termed Validation Tests. The source was Ba-133 with energy lines similar to I-131. The tests were conducted using the ANSI N44.3[2] phantom and a 30 ml containing 101 nCi of Ba-133. The front of the ANSI N44.3[1] phantom was placed 611/4" inches from the counter floor, 6 9/16" from the counter rearwall and 23 7/8" from the counter right wall. The center line of the detector housing was position at 64" from the vault floor (the counter floor is approximately 2 3/4" from the vault floor). The results of the Ba-133 tests are attached as Appendix H. The summary notes a Relative Bias of 0.4% and a Relative Precision of 9.3%.

11. SUMMARY AND CONCLUSION

Final review of all calibration and verification count results confirmed that the high energy thyroid calibration created on March 1, 2011 for the Accuscan II counter is satisfactory for I-131 counting where the detectors are positioned in-accordance-with TEV-1273[5], "Basis for Positioning of the In Vivo Accuscan II Detectors," (center of the individual's throat). A summary of current calibration files for this counter is shown in Table 1.

The THYROIDLIB (I-131/I-133).NLB nuclide library file is the default for thyroid counting for I-131. Non-systematic and systematic errors for the in vivo system are described and quantified in TEV-1275[6], "INL In Vivo System Counting Uncertainty."

The overall percent (%) counting uncertainty using the Accuscan II for I-131 counting is:

$$\text{Total \% Uncertainty (Accuscan II) for I} - 131 = \sqrt{(\%\ \text{counting uncertainty})^2 + (5.44)^2 + (18.0)^2}$$

Table 1. Calibration summary table.

Facility: Idaho National Laboratory, Building HPDL CFA-1618

Counting System: Accuscan II Thyroid Stationary Position

Counter Arrangement: Accuscan II for I-131

Detector	Energy Calibration Date/Time
Accuscan II BE Detectors	02/28/2011 9:51

Efficiency Calibration:

Detector	Efficiency Calibration Time
Accuscan II BE Detectors	03/01/2011 11:30

12. REFERENCES

1. American National Standard, American National Standards Institute/Health Physics Society ANSI/HPS N13.30-1996, “Performance Criteria for Radiobioassay,” 1996
2. American National Standard ANSI N44.3-1973, “Thyroid Radioiodine Uptake Measurements Using a Neck Phantom,” August 1973
3. Idaho National Laboratory, Management Control Procedure MCP-3336, “Accuscan II Calibration, Proficiency Testing, and Reporting,” Health Physics Dosimetry Laboratory, Revision 0, March 2011
4. Canberra Industries Inc., 70655586, V.1, “Apex-InVivo Productivity Software User’s Manual
5. Idaho National Laboratory, Basis Document TEV-1273, “Basis for Positioning of the In Vivo Accuscan II Detectors,” 2011
6. Idaho National Laboratory, Basis Document TEV-1275, “INL In Vivo System Counting Uncertainty,” 2011

Appendix A

Source Certificate

Appendix A
Source Certificate

Eckert & Ziegler
Analytics

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

CERTIFICATE OF CALIBRATION
Standard Radionuclide Source

82835-121
Solid in Wheaton Liquid Scintillation Vial

Customer: Canberra Industries, Inc.
P.O. No.: 4022022, Item 00010 (2256)
Reference Date: 01-Jul-2010 12:00 PM EST **Grams of Master Source:** 0.029369

This standard radionuclide source was prepared using aliquots measured gravimetrically from master radionuclide solutions. Calibration and purity were checked using a germanium gamma spectrometer system. At the time of calibration no interfering gamma-ray emitting impurities were detected. The gamma-ray emission rates for the most intense gamma-ray lines are given. Eckert & Ziegler Analytics (EZA) maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Revision 1, February, 1979, and compliance with ANSI N42.22-1995, "Traceability of Radioactive Sources to NIST." EZA is accredited by the Health Physics Society (HPS) for the production of NIST-traceable sources, and this source was produced in accordance with the HPS accreditation requirements. Customers may report any concerns with the accreditation program to the HPS Secretariat, 1313 Dolley Madison Blvd., Ste. 402, McLean, VA 22101. Density of solid matrix 1.15 g/cc.

Nuclide	Gamma-Ray Energy (keV)	Half-Life, Days	Master Source* γps/gram	This Source γps	Uncertainty, % Type u_A	u_B	U	Calibration Method
Cd-109	88.0	4.626E+02	1.663E+05	4.884E+03	0.4	2.3	4.7	HPGe
Co-57	122.1	2.718E+02	8.706E+04	2.557E+03	0.5	2.0	4.1	HPGe
Ce-139	165.9	1.376E+02	1.236E+05	3.630E+03	0.4	1.9	3.9	HPGe
Hg-203	279.2	4.661E+01	2.704E+05	7.941E+03	0.3	1.9	3.8	HPGe
Sn-113	391.7	1.151E+02	1.722E+05	5.057E+03	0.4	1.9	3.9	HPGe
Cs-137	661.7	1.098E+04	1.149E+05	3.374E+03	0.6	1.9	4.0	HPGe
Y-88	898.0	1.066E+02	4.213E+05	1.237E+04	0.3	1.9	3.8	HPGe
Co-60	1173.2	1.925E+03	2.119E+05	6.223E+03	0.8	1.9	4.1	HPGe
Co-60	1332.5	1.925E+03	2.120E+05	6.226E+03	0.6	1.9	4.0	HPGe
Y-88	1836.1	1.066E+02	4.460E+05	1.310E+04	0.6	1.9	4.0	HPGe

* Master Source refers to Analytics' 8-isotope mixture which is calibrated quarterly.

Calibration Methods: 4π LS - 4 pi Liquid Scintillation Counting, HPGe - High Purity Germanium Gamma-Ray Spectrometer, IC - Ionization Chamber. **Uncertainty:** U - Relative expanded uncertainty, k = 2. See NIST Technical Note 1297, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results."

(Certificate continued on reverse side)

Corporate Office
24937 Avenue Tibbitts Valencia, California 91355

Laboratory
1380 Seaboard Industrial Blvd Atlanta, Georgia, 30318

Comments:
Approximate volume 22 mL.
This standard will expire one year after the reference date.

Source Prepared by: _____
W. Mao, Radiochemist

QA Approved: _____ Date: 3/19/10
J. D. McCorvey, QA Manager Alternate

DOE Source Certificate Ba-133 BEA Thyroid 002

Certified Reference Material

Certificate of Traceability

U.S. Department of Energy
Radiological and Environmental Sciences Laboratory

Standard Identification: Ba-133 BEA Thyroid 002

Radionuclide	Activity
Ba-133	(2.21 ±0.02) E2 nCi

This Certified Reference Material (CRM) contains a known quantity of radionuclides in a stable and homogeneous matrix. This material is intended for the calibration of instruments and for the verification of the accuracy and precision of analytical radiochemistry measurements. The activities listed for each radionuclide are traceable to NIST through an unbroken chain of comparisons, all having stated uncertainties (k=1) calculated according to ISO and NIST Guidelines.

This material was prepared by the Radiological and Environmental Sciences Laboratory (RESL). RESL maintains direct traceability to NIST through successful participation in the NIST/RESL Radiological Traceability Program and is accredited to ISO 17043 as a Performance Testing Provider and ISO 17025 as a Chemical Testing Laboratory by The American Association for Laboratory Accreditation.

David S. Sill
Senior Technical Manager - Chemistry

April 1, 1999
Reference Date

Supplemental Information

Ba-133 BEA Thyroid 002

Final weight of vial with sticker and tape: 38.928 grams

Weight of solution in vial: 20.408 +/- 0.002 grams

Solution in vial: Solidified with 0.395 grams of WaterWorks Crystal SP400.

Half life: 10.574 years

Appendix B

Source Decay

Appendix B
Source Decay

Analytics 82835-121 Mixed Gamma Source Decay

Ba-133 BEA Thyroid 002

Reference Date	4/1/1999
Current Date	3/1/2011
Elapsed Time	4352.00

Radionuclide	Energy (keV)	Reference Activity (nCi)	Yield %	T1/2 Days	G/nCi	Reference GPS	Current Activity (nCi)
Ba-133	81	221	33	3862	37	2.70E+03	1.01E+02
	276.397	221	6.9	3862	37	5.64E+02	1.01E+02
	302.839	221	17.8	3862	37	1.46E+03	1.01E+02
	356	221	60	3862	37	4.91E+03	1.01E+02
	383.85	221	8.7	3862	37	7.11E+02	1.01E+02

DOE Manufactured Source # Ba-133 BEA Thyroid 002 Decay

Ba-133 BEA Thyroid 002

Reference Date	4/1/1999
Current Date	3/1/2011
Elapse Time	4352.00

Identy	Energy (keV)	Reference Activity (nCi)	Yield %	T1/2 Days	G/nCi	Reference GPS	Current Activity (nCi)
Ba-133	81	221	33	3862	37	2.70E+03	1.01E+02
	276.397	221	6.9	3862	37	5.64E+02	1.01E+02
	302.839	221	17.8	3862	37	1.46E+03	1.01E+02
	356	221	60	3862	37	4.91E+03	1.01E+02
	383.85	221	8.7	3862	37	7.11E+02	1.01E+02

Appendix C

Energy/FWHM and Low Tail Calibration Documentation

Appendix C

Energy/FWHM and Low Tail Calibration Worksheet

Created 3/8/2011 1:59:08 PM
Idaho Falls Id.
Battelle Energy Alliance LLC

Energy Calibration

Calibration Information

Calibration Title	Energy Calibration 2/28/2011 9:46 AM
Calibration Date	2/28/2011 9:46:21 AM
Performed By	David Georgeson
Count Used	Calibration Count 2/28/2011 8:33 AM
Is Default	No

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle

Detector Group Information

Detector Group Name	Left
Calibration Source	MG 82835 - New
Analysis Sequence File	
Nuclide Library	MIXGAMMA.NLB
Peak Search Library	MIXGAMMA.NLB

Energy Calibration Coefficients

Energy = - 0.183621 + 0.462054 * ch + 6.99337e-09 * ch^2

FWHM = 0.897159 + 0.0293202 * E^1/2

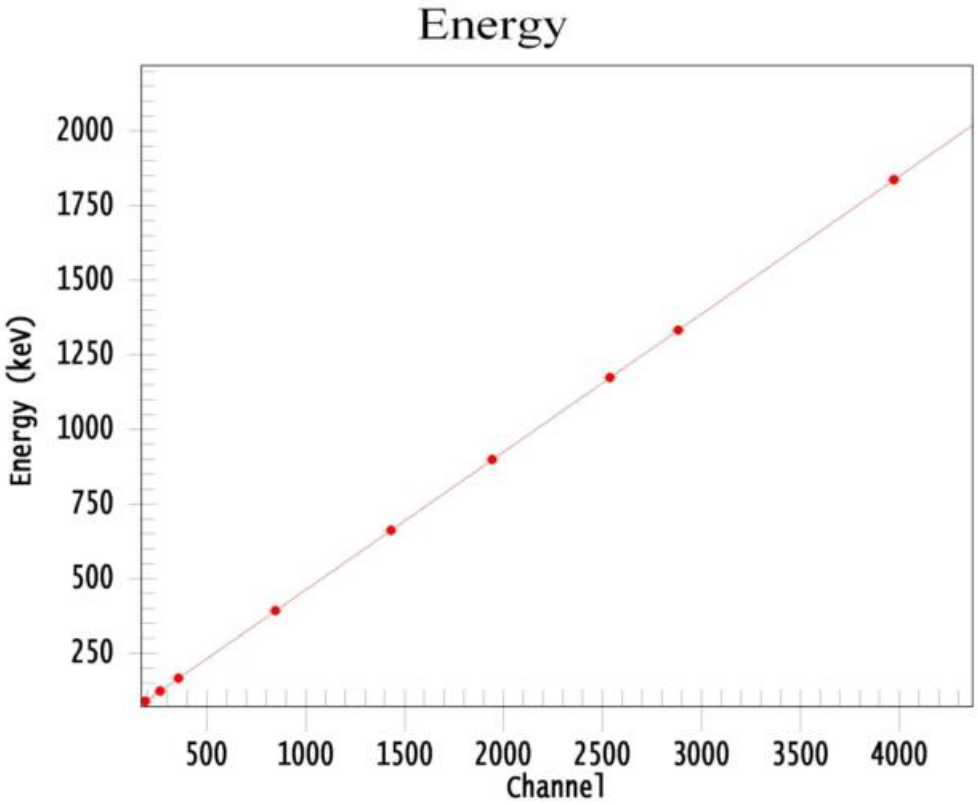
LOW TAIL = 1.22265 + 0.00459415 * E

Energy Calibration Results Table

Centroid Channel	Centroid Error	Energy (keV)
190.98	0.04	88.03
264.57	0.04	122.06
359.19	0.07	165.90
848.11	0.06	391.70
1432.42	0.07	661.65
1943.81	0.07	898.00
2539.45	0.05	1173.20
2884.08	0.05	1332.50
3973.97	0.10	1836.10

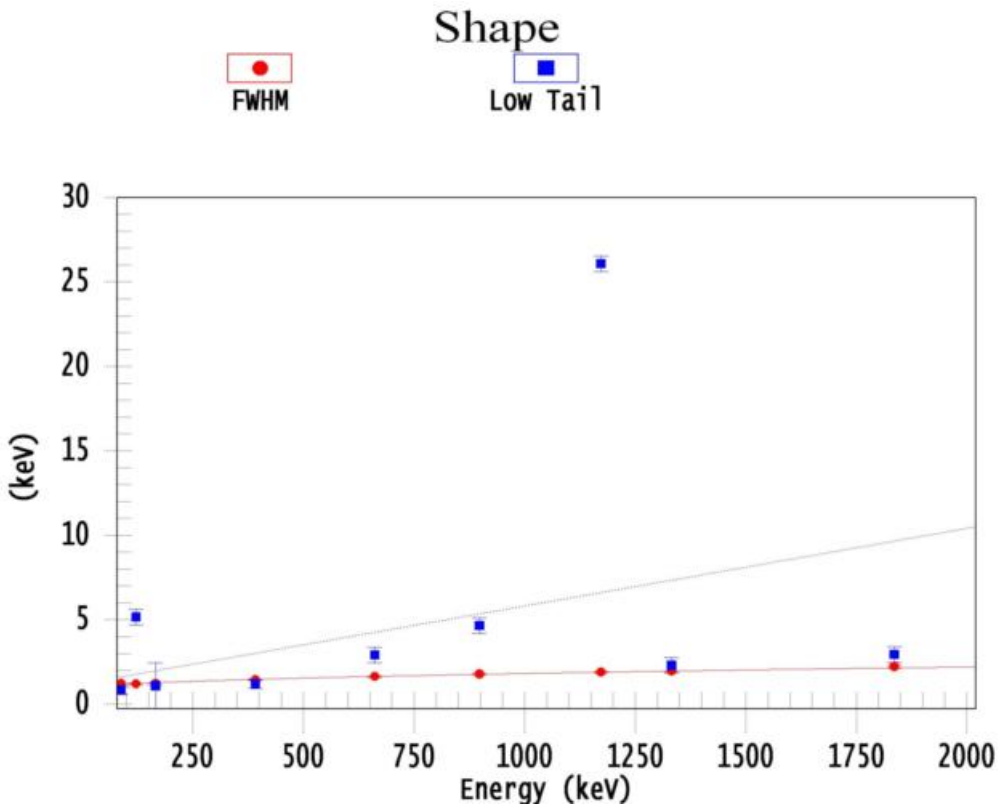
Approved by: _____

Date: _____



Energy Calibration Results Table

Energy (keV)	FWHM Channels	FWHM Error	TAIL Channels	TAIL Error
88.03	2.66	0.10	1.82	0.54
122.06	2.61	0.10	11.17	1.00
165.90	2.62	0.16	2.36	2.96
391.70	3.14	0.11	2.58	0.54
661.65	3.54	0.13	6.29	1.00
898.00	3.87	0.14	10.09	1.00
1173.20	4.12	0.10	56.43	1.00
1332.50	4.22	0.09	4.97	1.00
1836.10	4.82	0.18	6.39	1.00


Shape
FWHM
Low Tail
30
25
20
15
10
5
0
(keV)
250
500
750
1000
1250
1500
1750
2000
Energy (keV)

Energy Calibration

Calibration Information

Calibration Title	Energy Calibration 2/28/2011 9:48 AM
Calibration Date	2/28/2011 9:48:44 AM
Performed By	David Georgeson
Count Used	Calibration Count 2/28/2011 8:33 AM
Is Default	No

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle

Detector Group Information

Detector Group Name	Right
Calibration Source	MG 82835 - New
Analysis Sequence File	
Nuclide Library	MIXGAMMA.NLB
Peak Search Library	MIXGAMMA.NLB

Energy Calibration Coefficients

Energy = - 0.283268 + 0.46196 * ch + 1.37122e-08 * ch^2

FWHM = 0.576968 + 0.0303325 * E^1/2

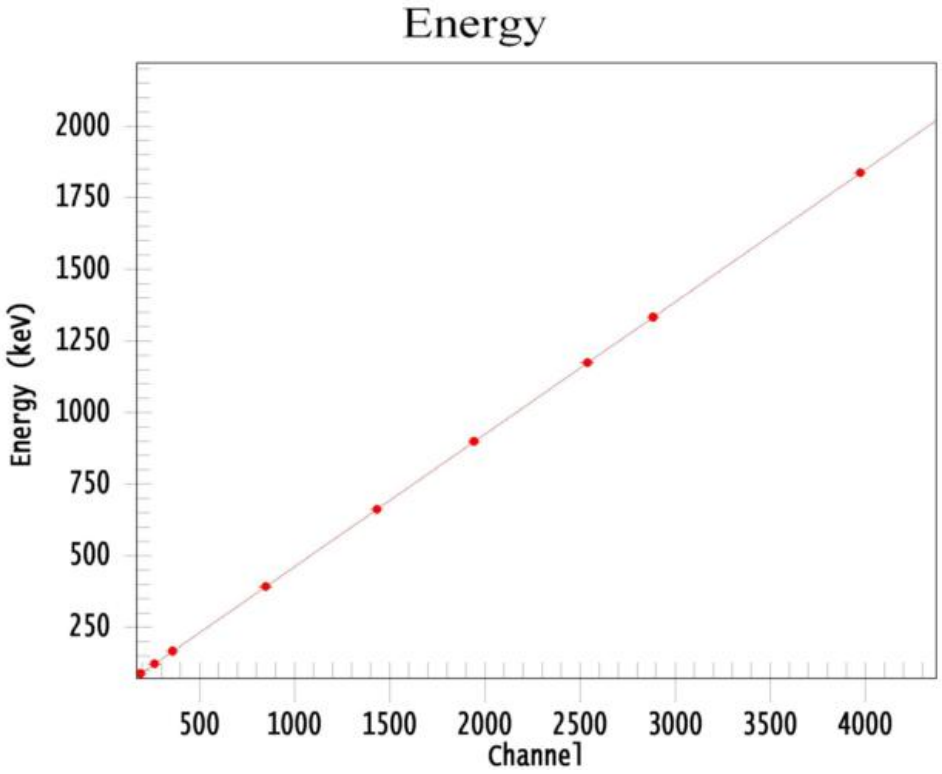
LOW TAIL = 0.4527 + 0.000733058 * E

Energy Calibration Results Table

Centroid Channel	Centroid Error	Energy (keV)
191.21	0.02	88.03
264.79	0.02	122.06
359.61	0.04	165.90
848.45	0.04	391.70
1432.87	0.04	661.65
1944.47	0.07	898.00
2540.03	0.05	1173.20
2884.79	0.05	1332.50
3974.74	0.08	1836.10

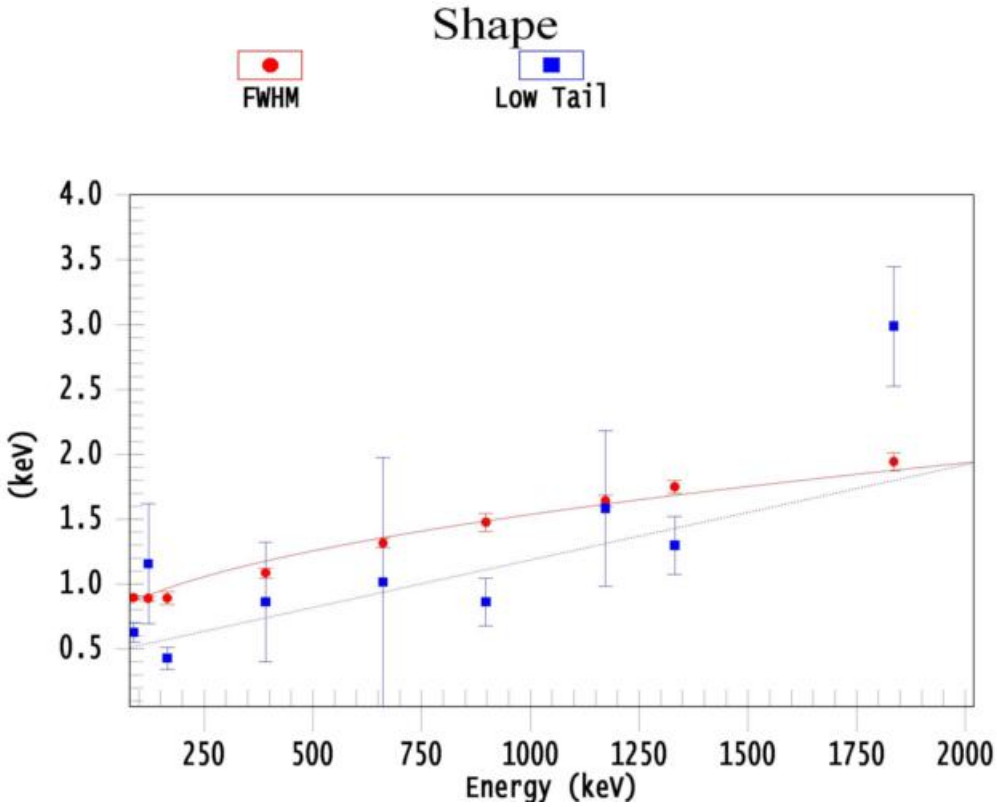
Approved by: _____

Date: _____



Energy Calibration Results Table

Energy (keV)	FWHM Channels	FWHM Error	TAIL Channels	TAIL Error
88.03	1.94	0.03	1.36	0.16
122.06	1.92	0.05	2.50	1.00
165.90	1.93	0.11	0.93	0.19
391.70	2.35	0.08	1.87	1.00
661.65	2.85	0.08	2.20	2.08
898.00	3.19	0.15	1.87	0.40
1173.20	3.55	0.10	3.42	1.30
1332.50	3.78	0.10	2.81	0.48
1836.10	4.20	0.15	6.46	1.00


Shape
FWHM
Low Tail
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
(keV)
250
500
750
1000
1250
1500
1750
2000
Energy (keV)

Energy Calibration

Calibration Information

Calibration Title	Energy Calibration 2/28/2011 9:51 AM
Calibration Date	2/28/2011 9:51:12 AM
Performed By	David Georgeson
Count Used	Calibration Count 2/28/2011 8:33 AM
Is Default	No

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle

Detector Group Information

Detector Group Name	Summed
Calibration Source	MG 82835 - New
Analysis Sequence File	
Nuclide Library	MIXGAMMA.NLB
Peak Search Library	MIXGAMMA.NLB

Energy Calibration Coefficients

Energy = - 0.17689 + 0.462044 * ch + 9.5002e-09 * ch^2

FWHM = 0.765694 + 0.0309232 * E^1/2

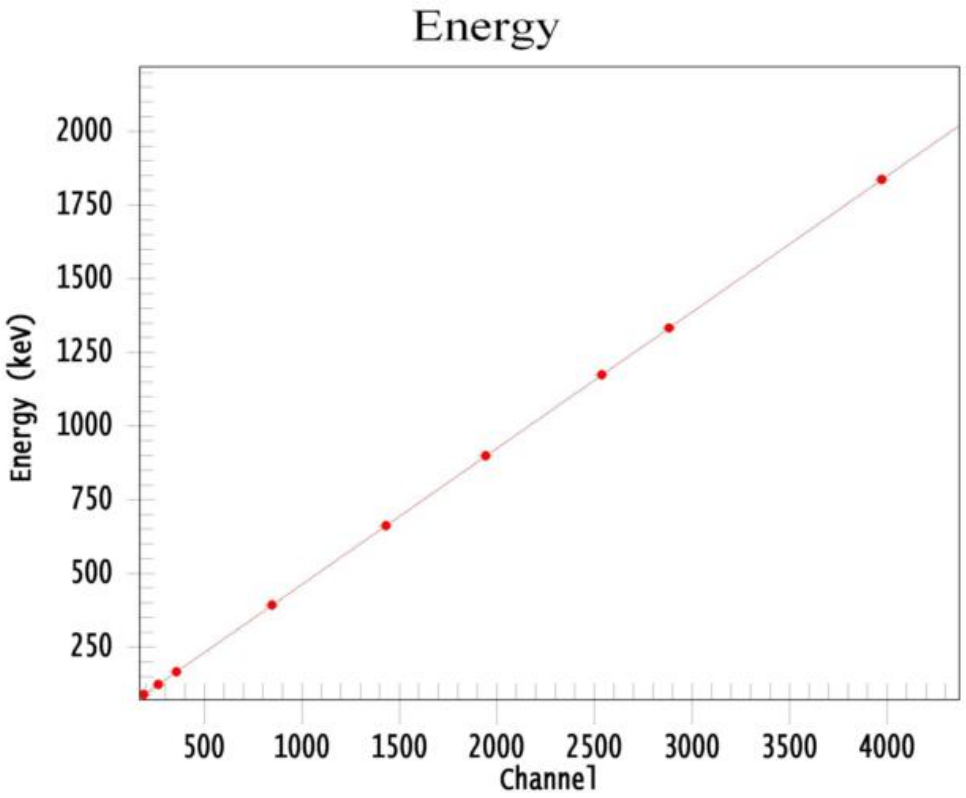
LOW TAIL = 0.951539 + 0.00111546 * E

Energy Calibration Results Table

Centroid Channel	Centroid Error	Energy (keV)
190.97	0.03	88.03
264.56	0.02	122.06
359.25	0.05	165.90
848.08	0.05	391.70
1432.40	0.03	661.65
1943.83	0.03	898.00
2539.41	0.04	1173.20
2884.10	0.04	1332.50
3973.96	0.06	1836.10

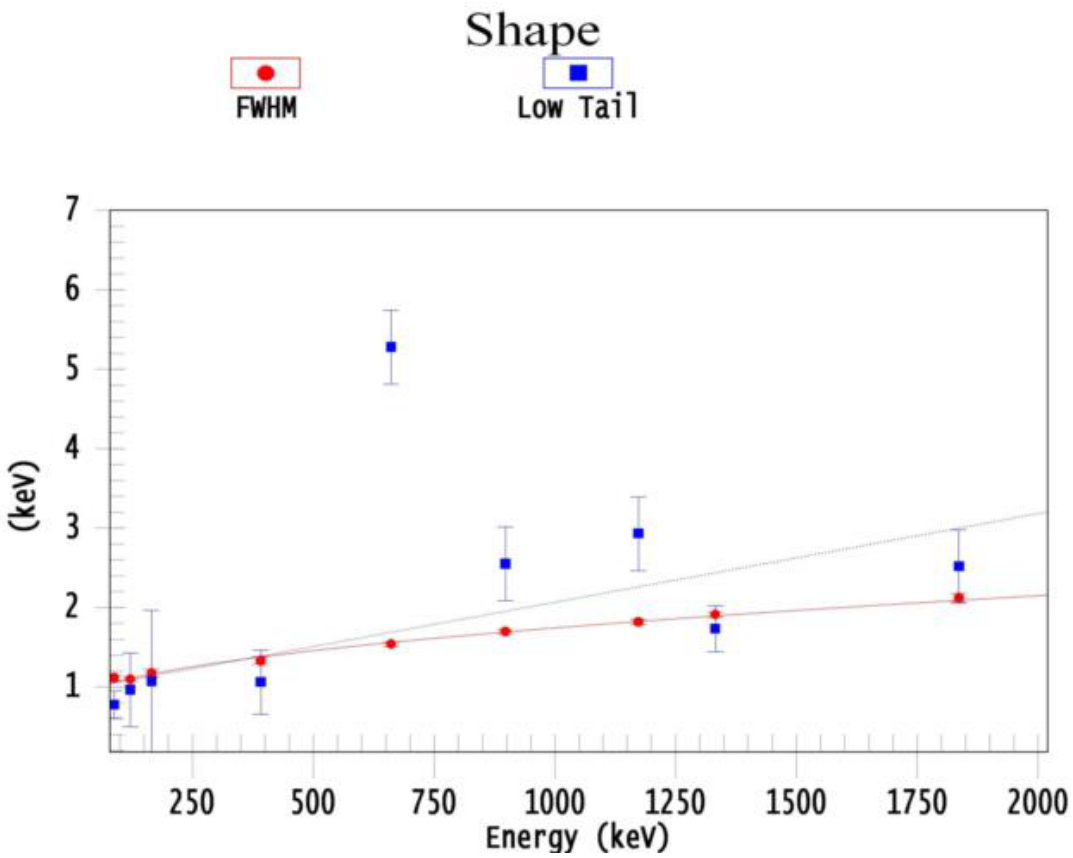
Approved by: _____

Date: _____



Energy Calibration Results Table

Energy (keV)	FWHM Channels	FWHM Error	TAIL Channels	TAIL Error
88.03	2.41	0.08	1.68	0.37
122.06	2.37	0.05	2.09	1.00
165.90	2.53	0.11	2.32	1.93
391.70	2.88	0.10	2.30	0.87
661.65	3.33	0.06	11.42	1.00
898.00	3.68	0.06	5.52	1.00
1173.20	3.93	0.07	6.34	1.00
1332.50	4.14	0.07	3.75	0.62
1836.10	4.59	0.12	5.44	1.00


Shape
FWHM
Low Tail
7
6
5
4
3
2
1
(keV)
250
500
750
1000
1250
1500
1750
2000
Energy (keV)

Appendix D

Efficiency Calibration Documentation

Appendix D
Efficiency Calibration

Created 3/8/2011 2:04:41 PM

Idaho Falls Id.

Battelle Energy Alliance LLC

Efficiency Calibration

Calibration Information

Calibration Title	Efficiency Calibration 3/1/2011 11:30 AM
Calibration Date	3/1/2011 11:28:20 AM
Performed By	David Georgeson
Count Used	Calibration Count 3/1/2011 10:22 AM
Approved	3/1/2011 6:03:55 PM by David Georgeson
Is Default	Yes
Is Multi Curve	No

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle
Counter Configuration	Thyroid - High Energy

Detector Group Information

Detector Group Name	Summed
Calibration Source	MG 82835 - New
Analysis Sequence File	CALWBCGE.ASF
Nuclide Library	MIXGAMMA.NLB
Peak Search Library	MIXGAMMA.NLB

Approved by: _____

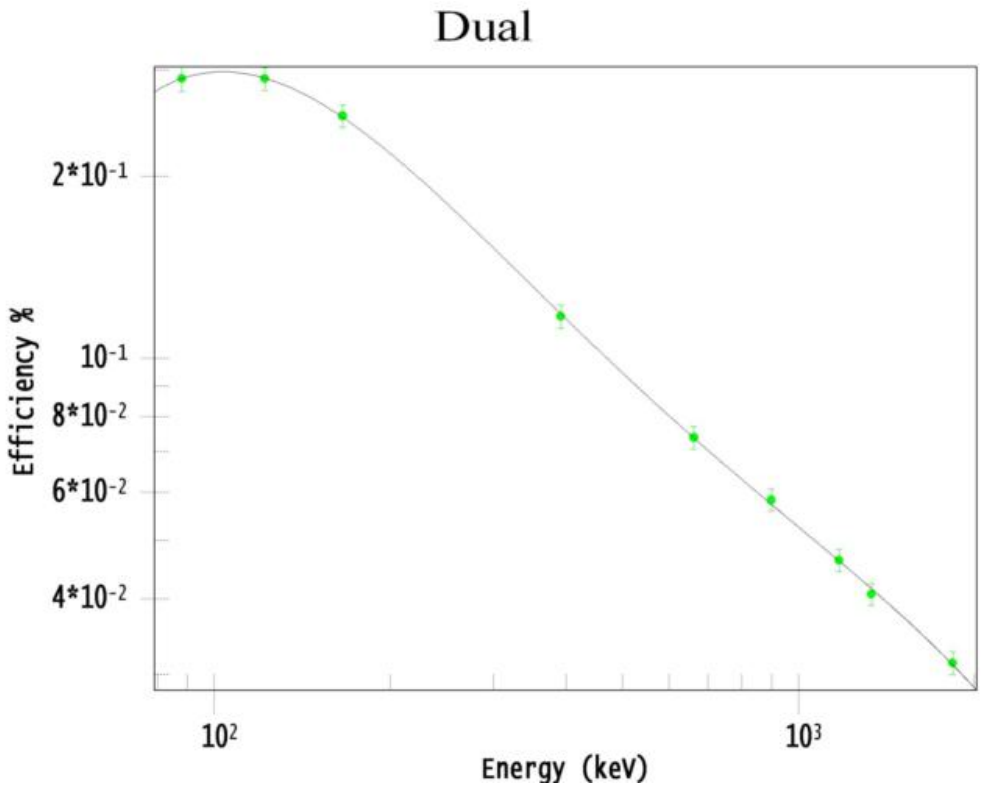
Date: _____

Efficiency Triplets

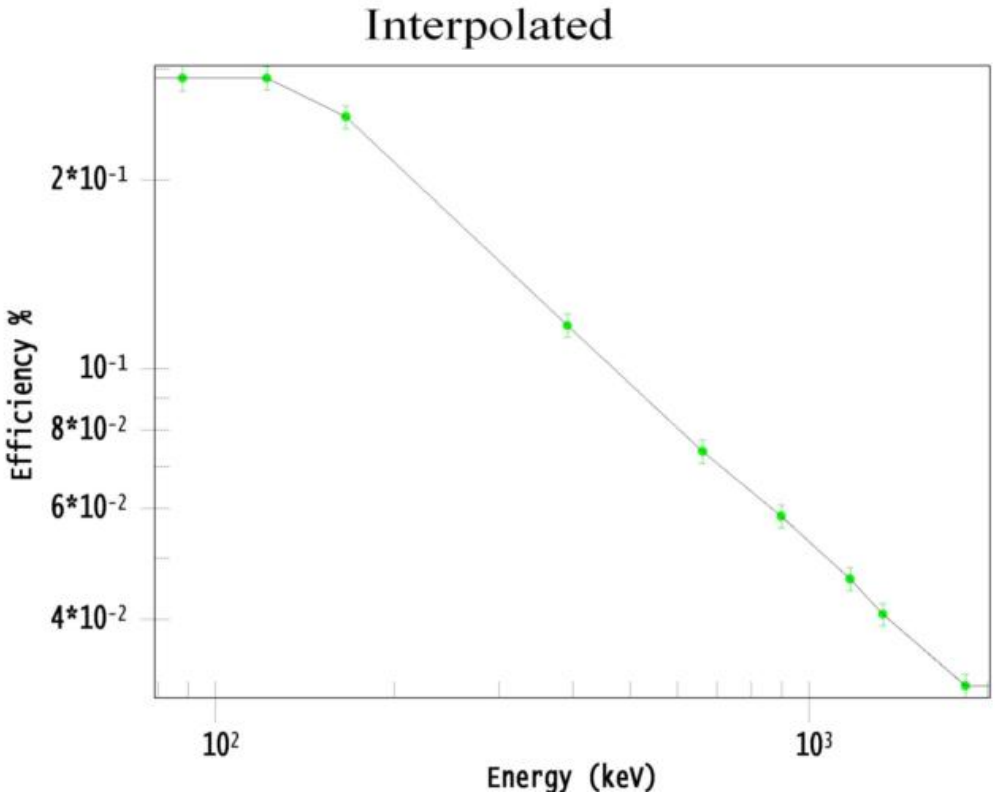
Energy (keV)	Efficiency	Error	Dual	Difference	Empirical	Difference	Linear	Difference
8.803E+001	2.904E-003	1.382E-004	2.906E-003	-0.06 %	2.906E-003	-0.06 %	2.904E-003	0.00 %
1.221E+002	2.905E-003	1.265E-004	2.910E-003	-0.18 %	2.910E-003	-0.18 %	2.905E-003	-0.01 %
1.659E+002	2.520E-003	1.071E-004	2.506E-003	0.55 %	2.506E-003	0.55 %	2.518E-003	0.05 %
3.917E+002	1.173E-003	5.096E-005	1.185E-003	-1.02 %	1.185E-003	-1.02 %	1.176E-003	-0.29 %
6.617E+002	7.392E-004	3.096E-005	7.384E-004	0.11 %	7.384E-004	0.11 %	7.398E-004	-0.08 %
8.980E+002	5.828E-004	2.414E-005	5.732E-004	1.65 %	5.732E-004	1.65 %	5.751E-004	1.31 %
1.173E+003	4.631E-004	1.965E-005	4.618E-004	0.29 %	4.618E-004	0.29 %	4.620E-004	0.25 %
1.333E+003	4.069E-004	1.691E-005	4.156E-004	-2.13 %	4.156E-004	-2.13 %	4.150E-004	-1.99 %
1.836E+003	3.131E-004	1.378E-005	3.108E-004	0.74 %	3.108E-004	0.75 %	3.106E-004	0.79 %

Dual

$\ln(\text{eff}) = -93.7358 + 58.2486 * \ln(E) - 14.1094 * (\ln(E))^2 + 1.48573 * (\ln(E))^3 - 0.0582572 * (\ln(E))^4$
where E = Energy in keV

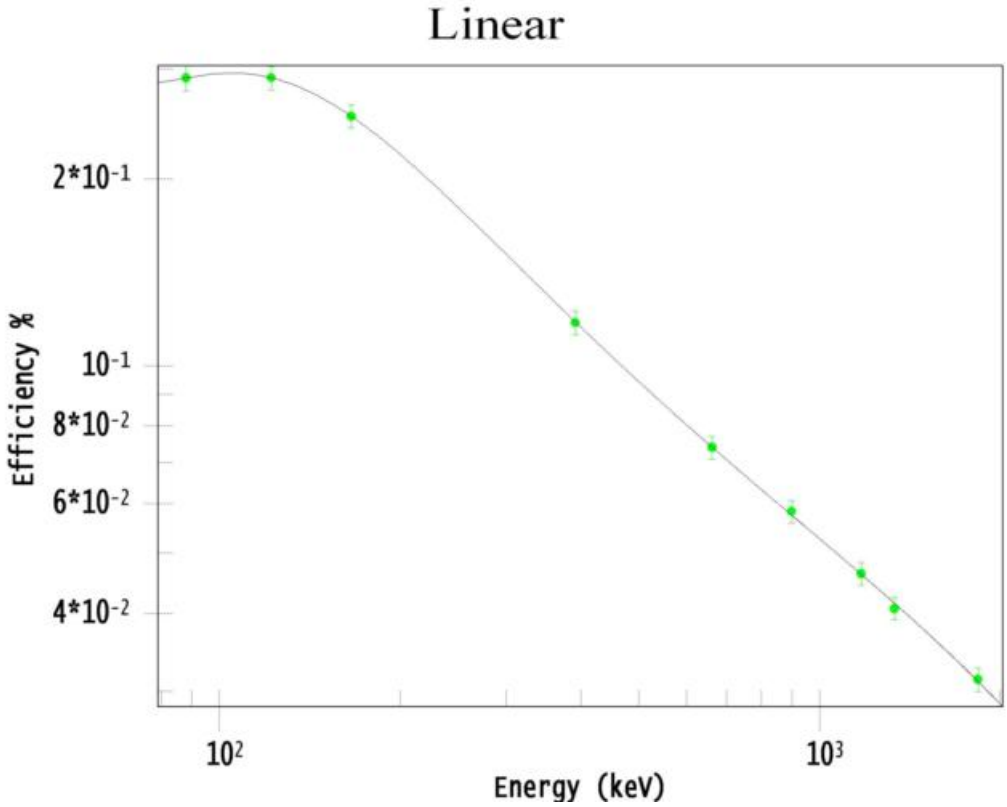


Interpolated



Linear

log(eff) = - 0.000168042 * E - 3.31638 + 226.173 / E - 20681.5 / E^2 + 609650 / E^3
where E = Energy in keV

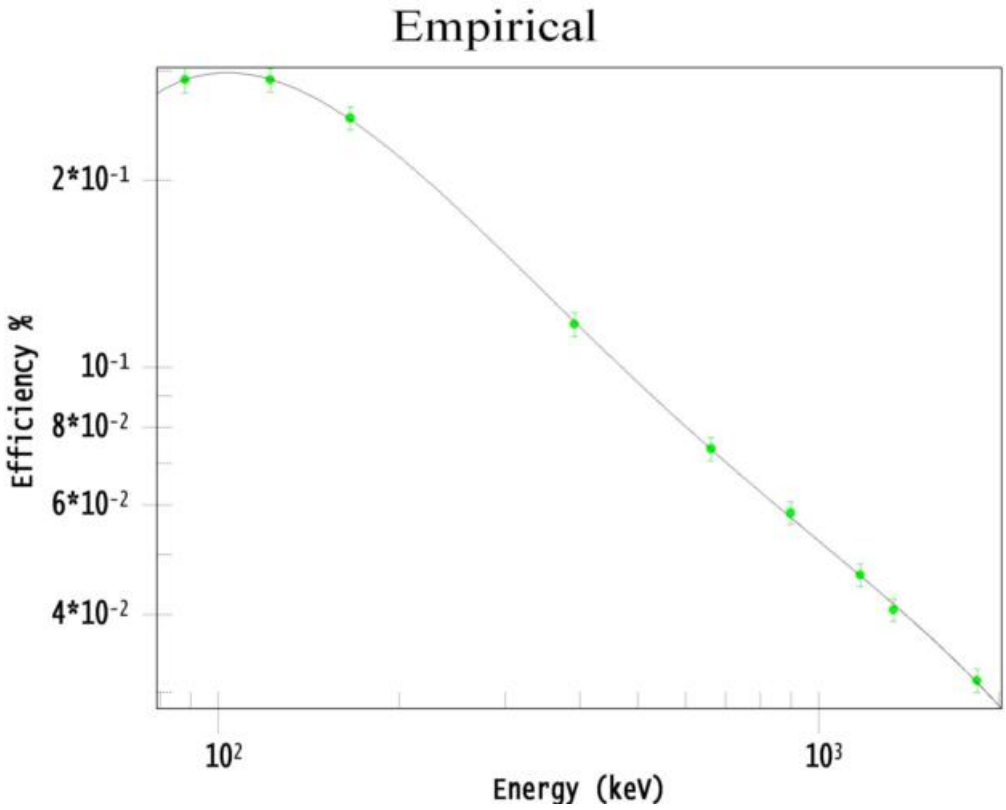


Empirical

ln(eff) = - 7.51996 + 0.806661 * x + 0.0144832 * x^2 + 0.114963 * x^3 - 0.0582572 * x^4

where x = ln(962.065 / E)

where E = Energy in keV



Appendix E

I-131 Calibration Count Reanalysis

Appendix E
I-131 Calibration Count Reanalysis

Summary

Reanalysis of the Calibration Count
Arrangement/Geometry: Thyroid (I-131)
Analysis Library: Mixgamma.NLB
Energy Calibration Time: 2/28/2011 9:51 AM
Efficiency Calibration Time: 3/1/2011 11:30 AM
Count Type/Live Time: 3615.51 seconds
Count Start Times: 3/1/2011 10:22

Nuclide Energy (keV)	Energy keV	Expected Activity (nCi)	Count Results (nCi)	Relative Bias
Cd-109	88	2550	2475.1	-0.03
Co-57	122.05	43.4	43.3	0
Ce-139	165.9	36.5	37.1	0.02
Sn-113	391.7	48.7	49.4	0.01
Cs-137	661.7	106	105.5	0
Y-88	898	73.7	75	0.02
Co-60	1173.2	154	154.7	0
Co-60	1332.5	154	150.8	-0.02
Y-88	1836.1	73.8	73.8	0

Created 4/27/2011 10:33:25 AM
Idaho Falls Id.

Battelle Energy Alliance LLC

Analysis Report - Calibration Count 3/1/2011 10:22 AM

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Total Body Scan

COUNT INFORMATION

Count Operation	Calibration Count
Comment	
Intake Date	
Acquisition Started	3/1/2011 10:22:39 AM
Acquisition Time	3615.51
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Left	132.06	1 - 4096	3600.0	No		8f821c231022.cnf
Right	132.45	1 - 4096	3600.0	No		e3e18f6a1022.cnf
Summed	0.00	1 - 4096	3600.0	Yes	4/27/2011 10:33:11 AM	4ef35ac61022.cnf
MCS Full Range		-	0.0	No		a26432401022.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

User: David Georgeson Database: InVivo Server: 127.0.0.1

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	4/27/2011 10:33:11 AM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	MIXGAMMA.NLB
Tentative NID Library	MIXGAMMA.NLB
Peak Search Library	MIXGAMMA.NLB
Analysis Limits (channels)	40 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis						Nuclide Information			
	No	Peak Centroid	Energy (keV)	Net Peak Area	Continuum Counts	Nuclide Name	Activity (nCi)	Error (1SD)	Yield (%)
M	1	48.29	22.14	1.76E+005	2.00E+004	Unknown	2.621671E+004		100.00
m	2	54.43	24.97	6.39E+004	1.47E+004	Unknown	4.473923E+003		100.00
M	3	66.11	30.37	1.05E+003	6.08E+003	Unknown	2.664437E+001		100.00
m	4	72.28	33.22	5.64E+003	8.63E+003	Unknown	9.672281E+001		100.00
m	5	82.58	37.98	1.63E+003	5.88E+003	Unknown	1.697554E+001		100.00
	6	191.04	88.09	3.56E+004	1.02E+004	Cd-109	2.475096E+003	5.54 %	3.72
	7	264.54	122.05	1.44E+004	8.05E+003	Co-57	4.334325E+001	3.51 %	85.51
	8	295.61	136.41	1.77E+003	7.24E+003	Unknown	4.744322E+000		100.00
	9	359.31	165.84	9.95E+003	5.77E+003	Ce-139	3.710574E+001	3.94 %	80.35
	10	604.73	279.24	1.37E+003	2.20E+003	Hg-203	8.157141E+000	9.58 %	77.30
	11	848.00	391.64	5.06E+003	1.30E+003	Sn-113	4.937763E+001	4.33 %	64.90
	12	1432.24	661.60	8.83E+003	9.69E+002	Cs-137	1.055257E+002	2.90 %	85.12
	13	1762.15	814.05	1.44E+002	3.89E+002	Unknown	1.739637E+000		100.00
	14	1943.66	897.92	5.35E+003	8.78E+002	Y-88	7.495531E+001	3.00 %	93.40
	15	2539.19	1173.10	9.52E+003	4.27E+002	Co-60	1.547462E+002	2.75 %	100.00
M	16	2868.26	1325.17	6.93E+001	1.58E+002	Unknown	1.246400E+000		100.00
m	17	2883.79	1332.34	8.35E+003	1.44E+002	Co-60	1.508071E+002	2.72 %	100.00
	18	3161.30	1460.58	3.08E+002	1.53E+002	Unknown	6.017912E+000		100.00
	19	3818.99	1764.50	4.59E+001	2.11E+001	Unknown	1.067497E+000		100.00
	20	3973.50	1835.91	3.04E+003	3.32E+001	Y-88	7.383502E+001	4.64 %	99.38

For unknown peaks we assume yield to be 100% and no decay correction is performed.

M = First peak in a multiplet region

m = Other peak in a multiplet region

F = Fitted singlet

Appendix F

Accuscan II I-131 Calibration Verification

Appendix F
Accuscan-II I-131 Calibration Verification

Created 3/8/2011 2:09:01 PM
Idaho Falls Id.
Battelle Energy Alliance LLC

Efficiency Verification

Calibration Information

Calibration Title	Efficiency Calibration 3/1/2011 11:30 AM
Calibration Date	3/1/2011 11:28:20 AM
Operator Name	David Georgeson
Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Source Distribution	Thyroid

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle
Counter Configuration Name	Thyroid - High Energy

Count List

Num	Date	Name
1	3/1/2011 11:41:25 AM	Verification Count 3/1/2011 11:41 AM (1/5)
2	3/1/2011 11:48:06 AM	Verification Count 3/1/2011 11:41 AM (2/5)
3	3/1/2011 11:54:20 AM	Verification Count 3/1/2011 11:41 AM (3/5)
4	3/1/2011 12:01:58 PM	Verification Count 3/1/2011 11:41 AM (4/5)
5	3/1/2011 12:08:15 PM	Verification Count 3/1/2011 11:41 AM (5/5)

Source Certificate MG 82835 - New

Nuclide	Energy	Certificate Activity (g/s)	Half Life	Count 1	Count 2	Count 3	Count 4	Count 5	Relative Bias (%)	Relative Precision (%)
CD-109	88.03	4884.00	464.00 d	3322.10 3397.29	3450.72 3397.27	3330.06 3397.24	3483.12 3397.22	3419.82 3397.19	0.12 %	1.90 %
CO-57	122.06	2557.00	270.90 d	1308.81 1373.15	1368.99 1373.13	1447.93 1373.12	1387.54 1373.10	1359.18 1373.09	0.10 %	3.28 %
CE-139	165.90	3630.00	137.70 d	1053.91 1068.33	1160.81 1068.31	999.98 1068.28	987.58 1068.25	1148.99 1068.23	0.18 %	6.81 %
SN-113	391.70	5057.00	115.10 d	990.11 1170.55	1198.00 1170.52	1091.89 1170.49	1281.13 1170.45	1277.94 1170.42	-0.23 %	9.61 %
CS-137	661.65	3374.00	30.17 y	3351.64 3322.82	3289.15 3322.82	3453.45 3322.82	3347.12 3322.82	3211.30 3322.82	0.23 %	2.40 %
Y-88	898.00	12370.00	106.60 d	2516.48 2547.96	2503.64 2547.89	2549.98 2547.82	2582.82 2547.73	2553.19 2547.66	-0.26 %	1.11 %
CO-60	1173.20	6223.00	5.27 y	5643.89 5701.62	5604.75 5701.61	5976.46 5701.60	5580.61 5701.59	5525.97 5701.58	-0.62 %	2.80 %
CO-60	1332.50	6226.00	5.27 y	5565.62 5704.37	5872.55 5704.36	5932.51 5704.35	5451.91 5704.34	5212.87 5704.33	-1.70 %	4.69 %
Y-88	1836.10	13100.00	106.60 d	2423.88 2698.33	2552.20 2698.25	2676.92 2698.17	2560.22 2698.08	2441.83 2698.00	-6.20 %	3.40 %
								|xbar| =	1.07 %	4.00 %

For each count, the number on the top is the observed activity and the number on the bottom is the expected activity.

References:

Draft American National Standard, Performance Criteria for Radiobioassay, ANSI N13.30

Certificate of Calibration, Standard Radionuclide Source, Analytics

Appendix G

MDA Determination

Appendix G
MDA Determination

MDA COUNT DATA

MDA SUMMARY CALCULATIONS FROM COUNT DATA

MDA CALCULATION For I-131 and I-133

ACCUSCAN II COUNTER

MDA Calculations

Arrangement Geometry: Thyroid (I-131)
Analysis Library: THYROIDLIB.NLB
Energy Calibration Time: 2/28/2011 9:51 AM
Efficiency Calibration Time: 3/1/2011 11:30 AM
Count Type/Live Time: 300 Seconds
Count Start Times:

1. 3/1/11 1:26 AM
2. 3/1/11 2:15 AM
3. 3/1/11 2:28 AM

MDA = (4.65Sb + 3)/KT

Where:
Sb = Standard deviation of the blank phantom counts = SQRT (gross rate (CPS) x routine counting time)
K = Efficiency X Abundance X 37 Bq/nCi
T = Routine counting time in seconds = 300 seconds

Nuclide	#1 Count (MDA) (nCi)	#2 Count (MDA) (nCi)	#3 Count (MDA) (nCi)	Average (nCi)
I-131	1.99E+00	2.25E+00	1.78E+00	2.02E+00
I-133	2.51E+00	2.22E+00	2.37E+00	2.30E+00

Analysis Report - Thyroid MDA [00-00-00-00]

SOURCE INFORMATION

Primary ID	00-00-00-00
Last Name	MDA
First Name	Thyroid
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Total Body Scan

COUNT INFORMATION

Count Operation	Individual 5 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/1/2011 1:26:53 PM
Acquisition Time	300.48
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Left	14.11	1 - 4096	300.0	No		3db72af71326.cnf
Right	14.47	1 - 4096	300.0	No		cdbfa94d1326.cnf
Summed	28.22	1 - 4096	300.0	Yes	3/2/2011 7:05:25 AM	14d40b890705.cnf
MCS Full Range		-	0.0	No		c7e83db31326.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/2/2011 7:05:25 AM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	THYROIDLIB.NLB
Tentative NID Library	THYROIDLIB.NLB
Peak Search Library	THYROIDLIB.NLB
Analysis Limits (channels)	100 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis						Nuclide Information			
	No	Peak Centroid	Energy (keV)	Net Peak Area	Continuum Counts	Nuclide Name	Activity (nCi)	Error (1SD)	Yield (%)
	1	3160.99	1460.44	2.32E+001	5.79E+000	Unknown	5.441771E+000		100.00

For unknown peaks we assume yield to be 100% and no decay correction is performed.

M = First peak in a multiplet region

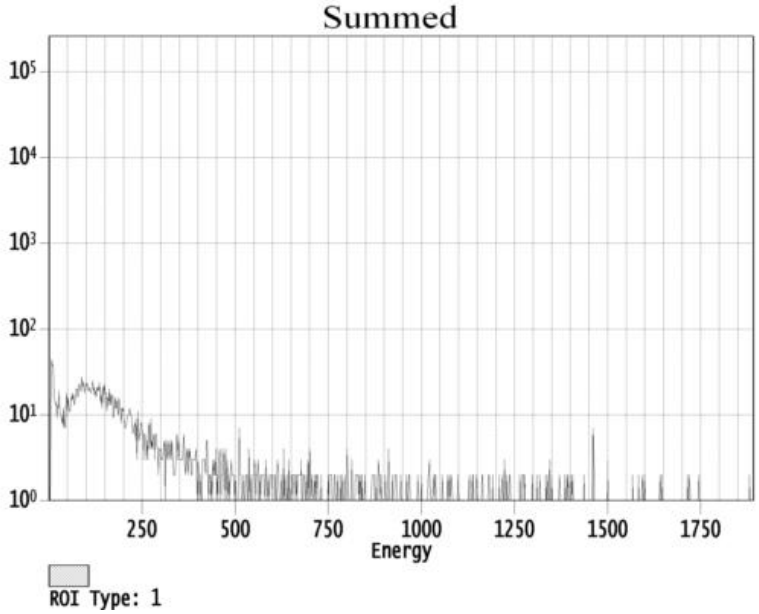
m = Other peak in a multiplet region

F = Fitted singlet

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

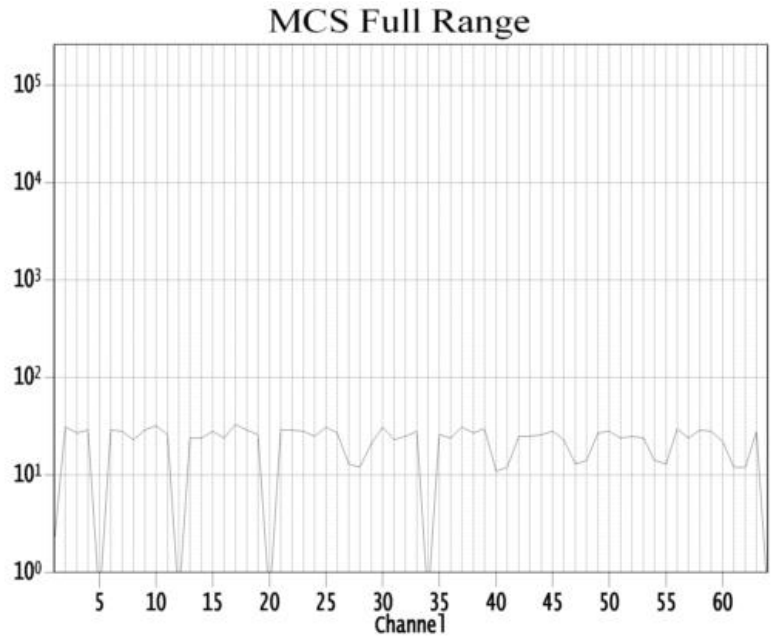
	Nuclide Name	Energy (keV)	Yield (%)	Line MDA (nCi)	Nuclide MDA (nCi)	Activity (nCi)
	I-131	80.18	2.62	7.5848E+001	1.9879E+000	-3.1623E+001
		284.30	6.05	2.7962E+001		6.4998E+000
		364.48	81.20	1.9879E+000		5.3451E-001
		636.97	7.26	2.3409E+001		-2.7112E+000
		722.89	1.80	8.9856E+001		-4.0179E+001
	I-133	529.87	86.30	2.5143E+000	2.5143E+000	-7.2751E-002
		875.33	4.47	1.0332E+001		0.0000E+000

* = Energy Line found in the spectrum



MCS GROUPS

MCS Full Range



Analysis Report - Thyroid MDA [00-00-00-00]

SOURCE INFORMATION

Primary ID	00-00-00-00
Last Name	MDA
First Name	Thyroid
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Total Body Scan

COUNT INFORMATION

Count Operation	Individual 5 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/1/2011 2:15:38 PM
Acquisition Time	300.56
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Right	14.55	1 - 4096	300.0	No		25b90b9c1415.cnf
Left	14.02	1 - 4096	300.0	No		92d427c21415.cnf
Summed	28.26	1 - 4096	300.0	Yes	3/1/2011 7:22:09 PM	71f647831922.cnf
MCS Full Range		-	0.0	No		f0b9f7d51415.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

User: David Georgeson Database: InVivo Server: 127.0.0.1

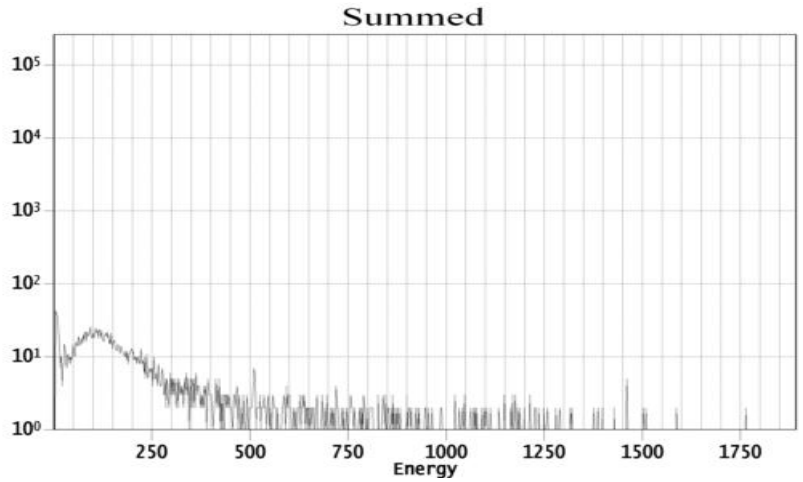
DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/1/2011 7:22:09 PM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	THYROIDLIB.NLB
Tentative NID Library	THYROIDLIB.NLB
Peak Search Library	THYROIDLIB.NLB
Analysis Limits (channels)	100 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

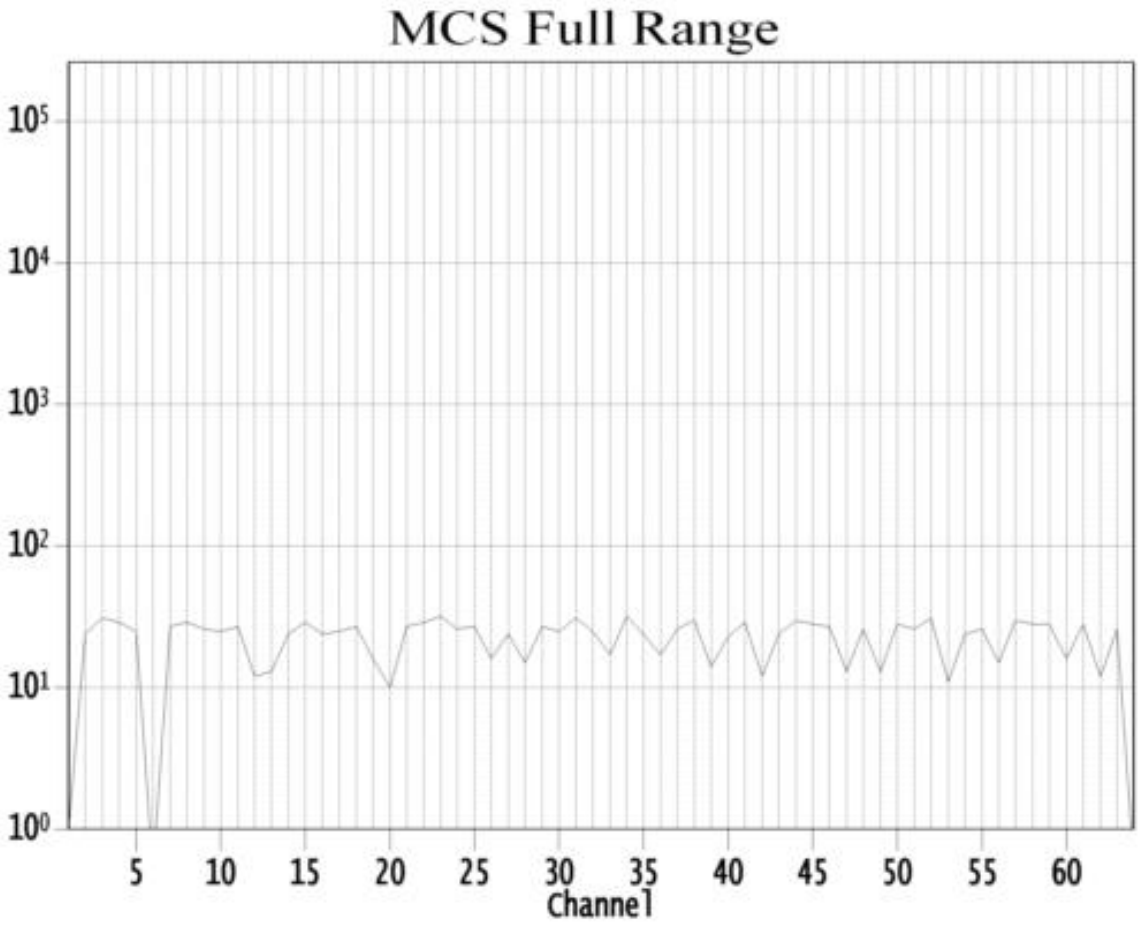
NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide Name	Energy (keV)	Yield (%)	Line MDA (nCi)	Nuclide MDA (nCi)	Activity (nCi)
	I-131	80.18	2.62	7.9846E+001	2.2549E+000	2.0801E+001
		284.30	6.05	2.4802E+001		5.8570E+000
		364.48	81.20	2.2549E+000		4.3733E-001
		636.97	7.26	3.8709E+001		1.3339E+001
		722.89	1.80	1.4902E+002		1.8785E+001
	I-133	529.87	86.30	2.2242E+000	2.2242E+000	2.9100E-001
		875.33	4.47	6.0973E+001		2.7551E+000

* = Energy Line found in the spectrum



MCS GROUPS


MCS Full Range
10^5
10^4
10^3
10^2
10^1
10^0
5
10
15
20
25
30
35
40
45
50
55
60
Channel

Created 3/8/2011 2:19:34 PM
Idaho Falls Id.

Battelle Energy Alliance LLC

Analysis Report - Thyroid MDA [00-00-00-00]

SOURCE INFORMATION

Primary ID	00-00-00-00
Last Name	MDA
First Name	Thyroid
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Fixed-Thyroid

COUNT INFORMATION

Count Operation	Individual 5 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/1/2011 2:28:38 PM
Acquisition Time	300.54
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Right	14.60	1 - 4096	300.0	No		a86dce7b1428.cnf
Left	14.47	1 - 4096	300.0	No		ab5a9e031428.cnf
Summed	29.01	1 - 4096	300.0	Yes	3/1/2011 2:28:26 PM	0adaf96e1428.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

User: David Georgeson Database: InVivo Server: 127.0.0.1

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/1/2011 2:28:26 PM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	THYROIDLIB.NLB
Tentative NID Library	THYROIDLIB.NLB
Peak Search Library	THYROIDLIB.NLB
Analysis Limits (channels)	100 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis						Nuclide Information			
	No	**Peak Centroid**	**Energy (keV)**	**Net Peak Area**	**Continuum Counts**	**Nuclide Name**	**Activity (nCi)**	**Error (1SD)**	**Yield (%)**
	1	**3161.52**	**1460.68**	**4.28E+001**	**3.24E+000**	**Unknown**	**1.002861E+001**		**100.00**

For unknown peaks we assume yield to be 100% and no decay correction is performed.

M = First peak in a multiplet region

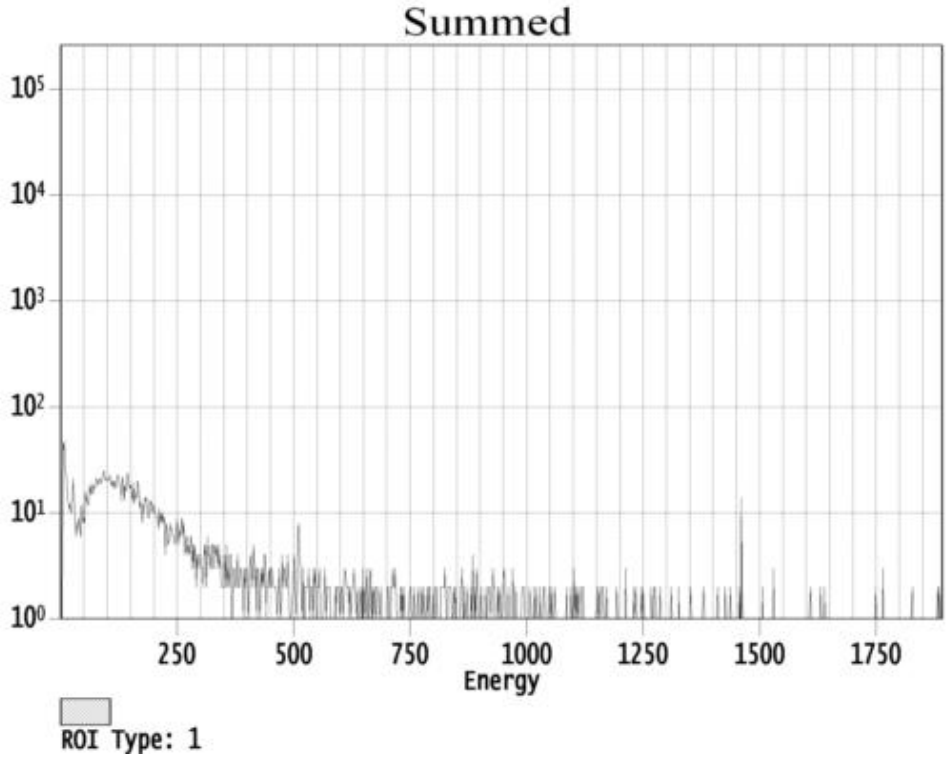
m = Other peak in a multiplet region

F = Fitted singlet

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide Name	Energy (keV)	Yield (%)	Line MDA (nCi)	Nuclide MDA (nCi)	Activity (nCi)
	I-131	80.18	2.62	7.5848E+001	1.7842E+000	-1.2218E+001
		284.30	6.05	2.7962E+001		1.8571E+000
		364.48	81.20	1.7842E+000		-1.1370E+000
		636.97	7.26	3.1084E+001		6.9136E+000
		722.89	1.80	1.0512E+002		-1.0958E+001
	I-133	529.87	86.30	2.3744E+000	2.3744E+000	-2.8269E-001
		875.33	4.47	4.9558E+001		-1.7220E+000

* = Energy Line found in the spectrum


Summed
10^5
10^4
10^3
10^2
10^1
10^0
250
500
750
1000
1250
1500
1750
Energy
ROI Type: 1

Appendix H

Calibration Validation Using BA-133

Appendix H
Calibration Verification

SUMMARY

Calibration Validation Counts
Accuscan II Calibration Validation for I-131 Thyroid

Arrangement/Geometry: Thyroid
Analysis Library: BA133Lib.NLB
Energy Calibration Date: 2/28/2011 9:51 Am
Efficiency Calibration Date: 3/1/2011 11:30 AM
Count Live Time: 300 Seconds
Count Start Times:
Count # 1 - 03/01/2011 3:15 PM
Count # 2 - 03/01/2011 3:31 PM
Count # 3 - 03/01/2011 3:39 PM
Count # 4 - 03/01/2011 3:50 PM
Count # 5 - 03/01/2011 4:01 PM

Nuclide/ Energy (keV)	Expected Activity (nCi)	Observed Activity (nCi)					Relative Bias	Relative Precision
		#1	#2	#3	#4	#5		
Ba-133/88	101.0000	109.500	110.700	107.400	104.700	115.800	0.085	0.041
Ba-133/276.4	101.0000	68.000	97.500	124.000	102.600	108.700	-0.008	0.203
Ba-133/302.8	101.0000	107.200	106.000	93.100	104.300	90.600	-0.008	0.077
Ba-133/356	101.0000	105.700	103.200	99.700	106.600	100.000	0.020	0.031
Ba-133/383.9	101.0000	86.500	89.100	98.500	84.000	111.400	-0.070	0.111
						Average	0.004	0.093

Created 3/8/2011 2:37:08 PM
Idaho Falls Id.

Battelle Energy Alliance LLC

Analysis Report - Thyroid MDA [00-00-00-00]

SOURCE INFORMATION

Primary ID	00-00-00-00
Last Name	MDA
First Name	Thyroid
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Fixed-Thyroid

COUNT INFORMATION

Count Operation	Individual 5 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/1/2011 3:15:37 PM
Acquisition Time	300.68
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Left	35.62	1 - 4096	300.0	No		95947e571515.cnf
Right	36.40	1 - 4096	300.0	No		10ad64151515.cnf
Summed	72.00	1 - 4096	300.0	Yes	3/1/2011 3:15:28 PM	26889c0a1515.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/1/2011 3:15:28 PM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	BA133Lib.nlb
Tentative NID Library	BA133Lib.nlb
Peak Search Library	BA133Lib.nlb
Analysis Limits (channels)	100 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis						Nuclide Information			
	No	Peak Centroid	Energy (keV)	Net Peak Area	Continuum Counts	Nuclide Name	Activity (nCi)	Error (1SD)	Yield (%)
	1	175.69	81.00	1.12E+003	3.24E+002	BA-133	1.094923E+002	10.42 %	33.00
	2	598.17	276.21	8.58E+001	7.22E+001	BA-133	6.800234E+001	27.83 %	6.90
	3	655.74	302.81	3.20E+002	3.68E+001	BA-133	1.072249E+002	9.73 %	17.80
	4	770.86	356.00	9.13E+002	1.78E+001	BA-133	1.057195E+002	5.22 %	60.00
	5	830.93	383.75	1.01E+002	2.80E+001	BA-133	8.654021E+001	20.04 %	8.70

For unknown peaks we assume yield to be 100% and no decay correction is performed.

M = First peak in a multiplet region

m = Other peak in a multiplet region

F = Fitted singlet

NUCLIDE RESULTS FOR Accuscan II <Summed>

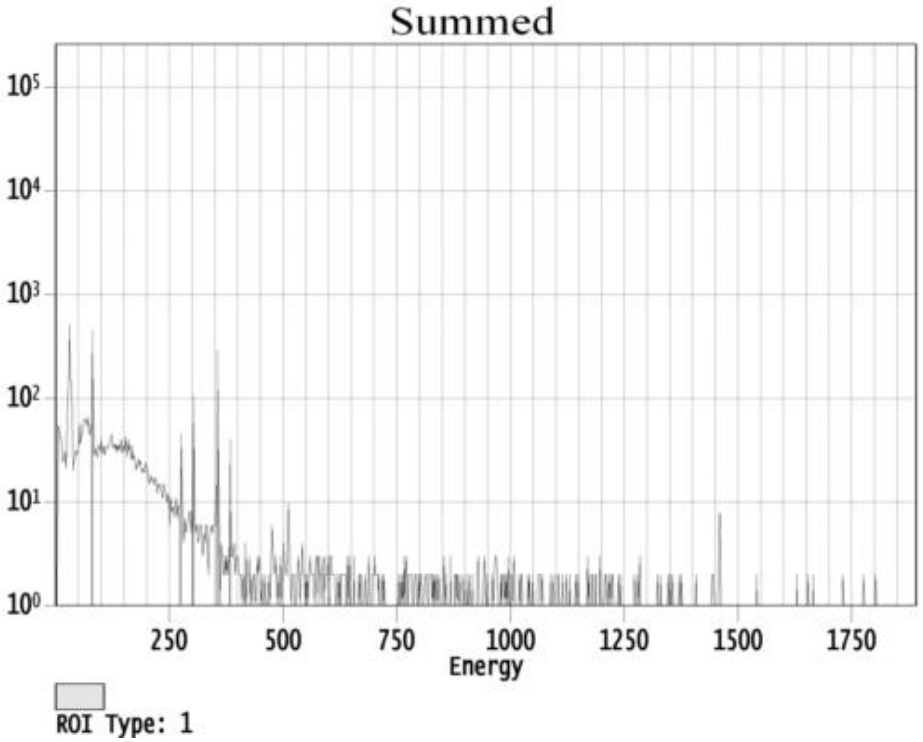
	Nuclide Name	Id Confidence	Wt Mean Activity (nCi)	Error (1SD)	Action Level 1	Action Level 2	MDA (nCi)
	BA-133	1.000	1.034609E+002	4.09 %	Not Performed	Not Performed	0.000E+000

? = Nuclide is part of an undetermined solution

X = Nuclide rejected by the interference analysis

@ = Nuclide contains energy lines not used in Weighted Mean Activity

! = Nuclide was corrected for parent/daughter


Summed
10^5
10^4
10^3
10^2
10^1
10^0
250
500
750
1000
1250
1500
1750
Energy
ROI Type: 1

Created 3/8/2011 2:38:49 PM
Idaho Falls Id.

Battelle Energy Alliance LLC

Analysis Report - Thyroid MDA [00-00-00-00]

SOURCE INFORMATION

Primary ID	00-00-00-00
Last Name	MDA
First Name	Thyroid
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Fixed-Thyroid

COUNT INFORMATION

Count Operation	Individual 5 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/1/2011 3:31:44 PM
Acquisition Time	300.69
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Right	36.33	1 - 4096	300.0	No		af7af3b01529.cnf
Left	35.08	1 - 4096	300.0	No		c0cad3241529.cnf
Summed	70.32	1 - 4096	300.0	Yes	3/1/2011 3:29:34 PM	c02f89251529.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

User: David Georgeson Database: InVivo Server: 127.0.0.1

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/1/2011 3:29:34 PM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	BA133Lib.nlb
Tentative NID Library	BA133Lib.nlb
Peak Search Library	BA133Lib.nlb
Analysis Limits (channels)	100 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis						Nuclide Information			
	No	Peak Centroid	Energy (keV)	Net Peak Area	Continuum Counts	Nuclide Name	Activity (nCi)	Error (1SD)	Yield (%)
	1	175.69	81.00	1.14E+003	3.37E+002	BA-133	1.106520E+002	10.41 %	33.00
	2	598.15	276.20	1.23E+002	7.80E+001	BA-133	9.747955E+001	22.09 %	6.90
	3	655.84	302.85	3.17E+002	3.54E+001	BA-133	1.060093E+002	9.69 %	17.80
	4	770.83	355.99	8.92E+002	1.93E+001	BA-133	1.032156E+002	5.27 %	60.00
	5	831.10	383.83	1.04E+002	3.61E+001	BA-133	8.905715E+001	21.25 %	8.70

For unknown peaks we assume yield to be 100% and no decay correction is performed.

M = First peak in a multiplet region

m = Other peak in a multiplet region

F = Fitted singlet

NUCLIDE RESULTS FOR Accuscan II <Summed>

Nuclide Name	Id Confidence	Wt Mean Activity (nCi)	Error (1SD)	Action Level 1	Action Level 2	MDA (nCi)
BA-133	1.000	1.037660E+002	4.08 %	Not Performed	Not Performed	6.812E+000

? = Nuclide is part of an undetermined solution

X = Nuclide rejected by the interference analysis

@ = Nuclide contains energy lines not used in Weighted Mean Activity

! = Nuclide was corrected for parent/daughter

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

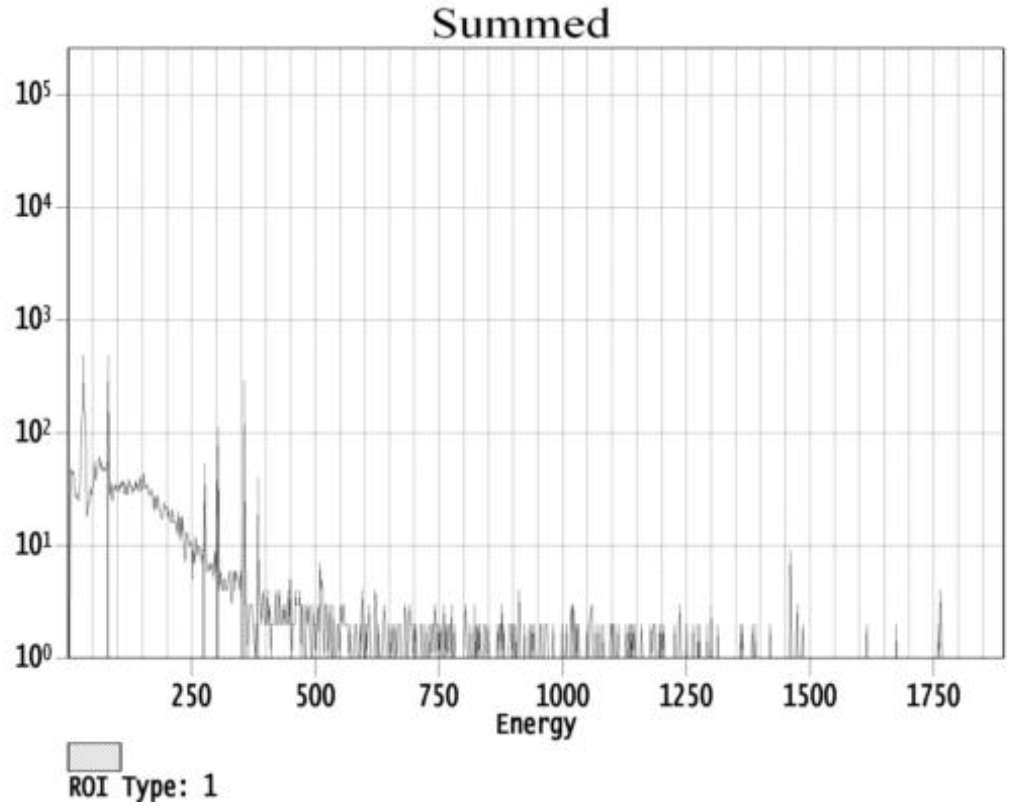
	Nuclide Name	Energy (keV)		Yield (%)	Line MDA (nCi)	Nuclide MDA (nCi)	Activity (nCi)
+	BA-133	79.62		2.55	2.1764E+002	6.8117E+000	-5.3859E+002
+		81.00	*	33.00	2.0561E+001		1.1065E+002
+		276.40	*	6.90	8.8522E+001		9.7480E+001

+		302.84 *	17.80	2.5405E+001		1.0601E+002
+		356.00 *	60.00	6.8117E+000		1.0322E+002
+		383.85 *	8.70	6.6193E+001		8.9057E+001

+ = Nuclide Identified during the nuclide identification

* = Energy Line found in the spectrum

User: David Georgeson Database: InVivo Server: 127.0.0.1


Summed
10^5
10^4
10^3
10^2
10^1
10^0
250
500
750
1000
1250
1500
1750
Energy
ROI Type: 1

Analysis Report - Thyroid MDA [00-00-00-00]

SOURCE INFORMATION

Primary ID	00-00-00-00
Last Name	MDA
First Name	Thyroid
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Fixed-Thyroid

COUNT INFORMATION

Count Operation	Individual 5 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/1/2011 3:39:02 PM
Acquisition Time	300.65
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Left	35.36	1 - 4096	300.0	No		f7c9bcac1538.cnf
Right	36.20	1 - 4096	300.0	No		236ea0a31538.cnf
Summed	70.97	1 - 4096	300.0	Yes	3/1/2011 3:38:52 PM	d7b636dd1538.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/1/2011 3:38:52 PM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	BA133Lib.nlb
Tentative NID Library	BA133Lib.nlb
Peak Search Library	BA133Lib.nlb
Analysis Limits (channels)	100 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis						Nuclide Information			
	No	Peak Centroid	Energy (keV)	Net Peak Area	Continuum Counts	Nuclide Name	Activity (nCi)	Error (1SD)	Yield (%)
	1	175.75	81.03	1.10E+003	3.67E+002	BA-133	1.074034E+002	10.54 %	33.00
	2	598.86	276.52	1.56E+002	4.87E+001	BA-133	1.240082E+002	15.48 %	6.90
	3	655.69	302.79	2.78E+002	8.40E+001	BA-133	9.307291E+001	12.25 %	17.80
	4	770.83	355.98	8.61E+002	1.77E+001	BA-133	9.969924E+001	5.30 %	60.00
	5	831.07	383.82	1.15E+002	1.81E+001	BA-133	9.853306E+001	17.40 %	8.70
	6	3161.59	1460.71	2.70E+001	0.00E+000	Unknown	6.332285E+000		100.00

For unknown peaks we assume yield to be 100% and no decay correction is performed.

M = First peak in a multiplet region

m = Other peak in a multiplet region

F = Fitted singlet

NUCLIDE RESULTS FOR Accuscan II <Summed>

	Nuclide Name	Id Confidence	Wt Mean Activity (nCi)	Error (1SD)	Action Level 1	Action Level 2	MDA (nCi)
	BA-133	1.000	1.009381E+002	4.13 %	Not Performed	Not Performed	6.307E+000

? = Nuclide is part of an undetermined solution

X = Nuclide rejected by the interference analysis

@ = Nuclide contains energy lines not used in Weighted Mean Activity

! = Nuclide was corrected for parent/daughter

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

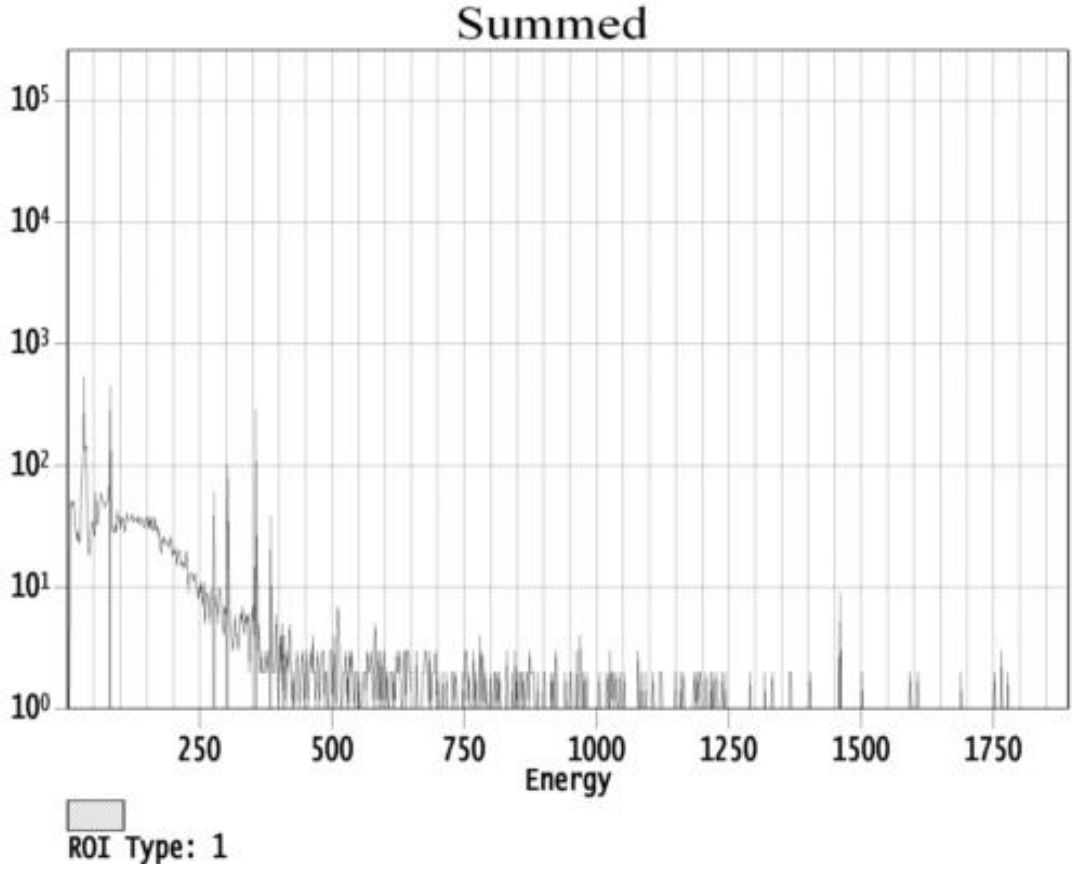
	Nuclide Name	Energy (keV)	Yield (%)	Line MDA (nCi)	Nuclide MDA (nCi)	Activity (nCi)
+	BA-133	79.62	2.55	2.2473E+002	6.3065E+000	-4.7549E+002

+		81.00 *	33.00	2.1511E+001		1.0740E+002
+		276.40 *	6.90	6.8185E+001		1.2401E+002
+		302.84 *	17.80	3.8841E+001		9.3073E+001
+		356.00 *	60.00	6.3065E+000		9.9699E+001
+		383.85 *	8.70	4.7515E+001		9.8533E+001

+ = Nuclide Identified during the nuclide identification

* = Energy Line found in the spectrum

User: David Georgeson Database: InVivo Server: 127.0.0.1


Summed
10^5
10^4
10^3
10^2
10^1
10^0
250
500
750
1000
1250
1500
1750
Energy
ROI Type: 1

Analysis Report - Thyroid MDA [00-00-00-00]

SOURCE INFORMATION

Primary ID	00-00-00-00
Last Name	MDA
First Name	Thyroid
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Fixed-Thyroid

COUNT INFORMATION

Count Operation	Individual 5 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/1/2011 3:50:19 PM
Acquisition Time	300.69
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Left	35.79	1 - 4096	300.0	No		a32bddc01550.cnf
Right	37.21	1 - 4096	300.0	No		212565471550.cnf
Summed	72.43	1 - 4096	300.0	Yes	3/1/2011 3:50:09 PM	cfbaaa261550.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

User: David Georgeson Database: InVivo Server: 127.0.0.1

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/1/2011 3:50:09 PM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	BA133Lib.nlb
Tentative NID Library	BA133Lib.nlb
Peak Search Library	BA133Lib.nlb
Analysis Limits (channels)	100 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis						Nuclide Information			
	No	Peak Centroid	Energy (keV)	Net Peak Area	Continuum Counts	Nuclide Name	Activity (nCi)	Error (1SD)	Yield (%)
	1	175.85	81.07	1.07E+003	3.92E+002	BA-133	1.047016E+002	10.64 %	33.00
	2	598.81	276.50	1.29E+002	7.07E+001	BA-133	1.026000E+002	20.43 %	6.90
	3	655.75	302.81	3.12E+002	4.24E+001	BA-133	1.043456E+002	10.03 %	17.80
	4	770.77	355.96	9.21E+002	6.32E+000	BA-133	1.065655E+002	5.12 %	60.00
	5	830.95	383.76	9.80E+001	2.20E+001	BA-133	8.399797E+001	19.26 %	8.70
	6	3161.02	1460.45	3.30E+001	0.00E+000	Unknown	7.738334E+000		100.00

For unknown peaks we assume yield to be 100% and no decay correction is performed.

M = First peak in a multiplet region

m = Other peak in a multiplet region

F = Fitted singlet

NUCLIDE RESULTS FOR Accuscan II <Summed>

	Nuclide Name	Id Confidence	Wt Mean Activity (nCi)	Error (1SD)	Action Level 1	Action Level 2	MDA (nCi)
	BA-133	1.000	1.042718E+002	4.02 %	Not Performed	Not Performed	4.009E+000

? = Nuclide is part of an undetermined solution

X = Nuclide rejected by the interference analysis

@ = Nuclide contains energy lines not used in Weighted Mean Activity

! = Nuclide was corrected for parent/daughter

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

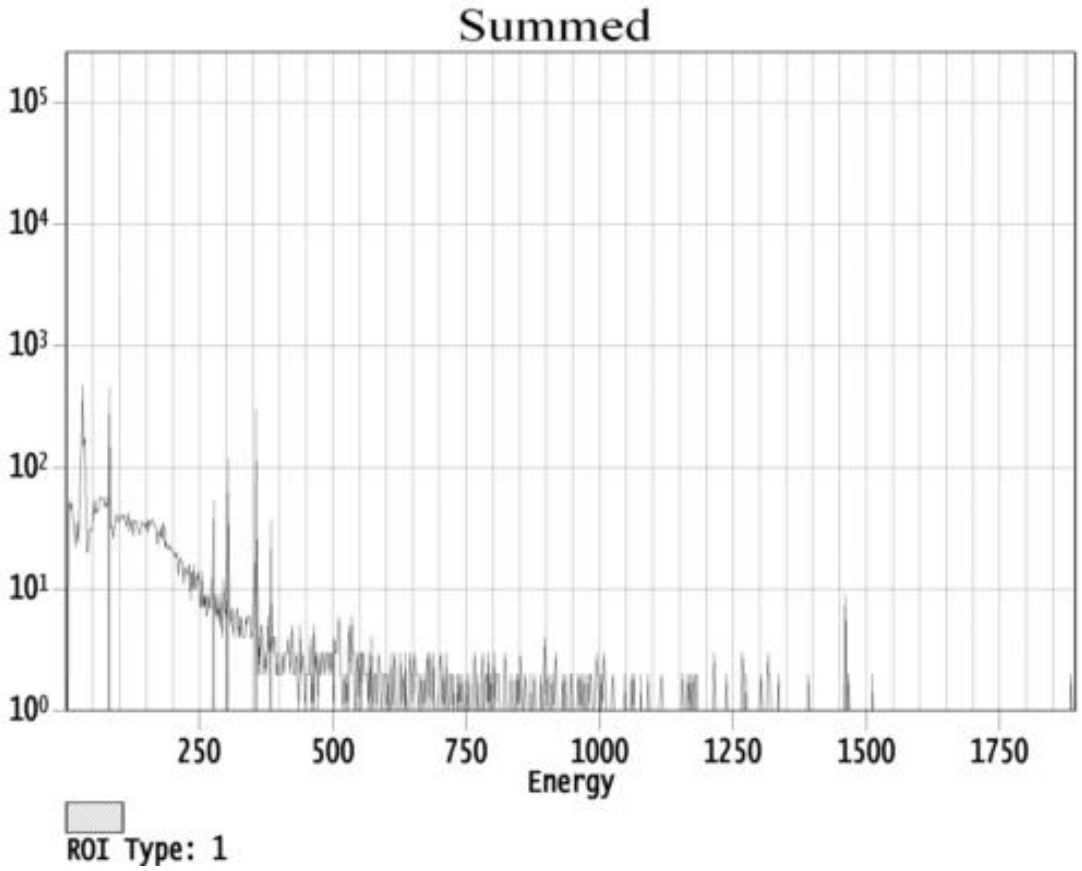
	Nuclide Name	Energy (keV)	Yield (%)	Line MDA (nCi)	Nuclide MDA (nCi)	Activity (nCi)
+	BA-133	79.62	2.55	2.1599E+002	4.0090E+000	-5.4904E+002

+		81.00 *	33.00	2.2194E+001		1.0470E+002
+		276.40 *	6.90	8.4301E+001		1.0260E+002
+		302.84 *	17.80	2.7955E+001		1.0435E+002
+		356.00 *	60.00	4.0090E+000		1.0657E+002
+		383.85 *	8.70	5.0339E+001		8.3998E+001

+ = Nuclide Identified during the nuclide identification

* = Energy Line found in the spectrum

User: David Georgeson Database: InVivo Server: 127.0.0.1


Summed
10^5
10^4
10^3
10^2
10^1
10^0
250
500
750
1000
1250
1500
1750
Energy
ROI Type: 1

Created 3/8/2011 2:40:31 PM
Idaho Falls Id.

Battelle Energy Alliance LLC

Analysis Report - Thyroid MDA [00-00-00-00]

SOURCE INFORMATION

Primary ID	00-00-00-00
Last Name	MDA
First Name	Thyroid
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Fixed-Thyroid

COUNT INFORMATION

Count Operation	Individual 5 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/1/2011 4:01:08 PM
Acquisition Time	300.72
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate Range	Live Time	Analyzed	Analyzed Date	File Name
Right	36.76	1 - 4096	300.0	No		811d388e1600.cnf
Left	35.37	1 - 4096	300.0	No		73f3a1271600.cnf
Summed	71.65	1 - 4096	300.0	Yes	3/1/2011 4:00:59 PM	7bf27d921600.cnf

Primary Review by: _____ **Secondary Review by:** _____

Date: _____ **Date:** _____

User: David Georgeson Database: InVivo Server: 127.0.0.1

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/1/2011 4:00:59 PM
Energy Calibration	Energy Calibration 2/28/2011 9:51 AM
Efficiency Calibration	Efficiency Calibration 3/1/2011 11:30 AM (Dual)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	ROUNPPGE.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	BA133Lib.nlb
Tentative NID Library	BA133Lib.nlb
Peak Search Library	BA133Lib.nlb
Analysis Limits (channels)	100 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis						Nuclide Information			
	No	Peak Centroid	Energy (keV)	Net Peak Area	Continuum Counts	Nuclide Name	Activity (nCi)	Error (1SD)	Yield (%)
	1	175.69	81.00	1.19E+003	2.99E+002	BA-133	1.158216E+002	10.25 %	33.00
	2	598.45	276.34	1.37E+002	6.10E+001	BA-133	1.086705E+002	18.21 %	6.90
	3	655.86	302.86	2.71E+002	5.23E+001	BA-133	9.064557E+001	11.13 %	17.80
	4	770.80	355.97	8.64E+002	5.20E+001	BA-133	1.000113E+002	5.62 %	60.00
	5	831.05	383.81	1.30E+002	1.00E+001	BA-133	1.114385E+002	15.26 %	8.70

For unknown peaks we assume yield to be 100% and no decay correction is performed.

M = First peak in a multiplet region

m = Other peak in a multiplet region

F = Fitted singlet

NUCLIDE RESULTS FOR Accuscan II <Summed>

	Nuclide Name	Id Confidence	Wt Mean Activity (nCi)	Error (1SD)	Action Level 1	Action Level 2	MDA (nCi)
	BA-133	1.000	1.015110E+002	4.22 %	Not Performed	Not Performed	1.098E+001

? = Nuclide is part of an undetermined solution

X = Nuclide rejected by the interference analysis

@ = Nuclide contains energy lines not used in Weighted Mean Activity

! = Nuclide was corrected for parent/daughter

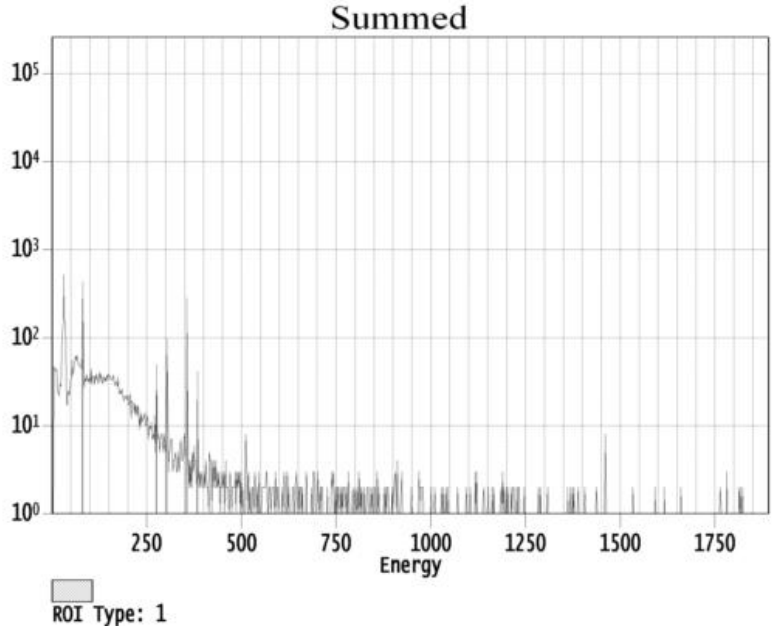
NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide Name	Energy (keV)		Yield (%)	Line MDA (nCi)	Nuclide MDA (nCi)	Activity (nCi)
+	BA-133	79.62		2.55	2.2929E+002	1.0980E+001	-3.7062E+002
+		81.00	*	33.00	1.9397E+001		1.1582E+002

+		276.40	* 6.90	7.6185E+001		1.0867E+002
+		302.84	* 17.80	3.0578E+001		9.0646E+001
+		356.00	* 60.00	1.0980E+001		1.0001E+002
+		383.85	* 8.70	3.3868E+001		1.1144E+002

+ = Nuclide Identified during the nuclide identification

* = Energy Line found in the spectrum


Summed
10^5
10^4
10^3
10^2
10^1
10^0
250
500
750
1000
1250
1500
1750
Energy
ROI Type: 1

Appendix I

ANSI N44.3 Phantom

Appendix I
ANSI N44.3 Phantom

Abstract

American National Standard Thyroid Radioiodine Uptake Measurements Using a Neck Phantom

Secretariat

Bureau of Radiological Health of the U.S. Public Health Service

Approved August 24, 1973

American National Standards Institute, Inc.

This standard establishes a neck phantom and uniform procedure to be used for thyroid radioiodide uptake measurements. A reference activity, the method for its preparation and use, and performance parameters for the detection system to be employed in the uptake measurement are specified. A formula for calculating percentage uptake is given as well as a uniform method for making background activity corrections of the counts derived from the patient and from the phantom. Using this phantom and specified methodology, the requirement for uniform and valid test results is met. Additionally, the use of this standard will provide a basis for direct intercomparison of the results obtained by various laboratories and clinics.

Foreword

(This Foreword is not part of American National Standard Thyroid Radioiodine Uptake Measurements Using a Neck Phantom, N44.3-1973.)

The task group who prepared this standard considered that a standard for a thyroid radioiodine phantom is needed because the only existing "standard" is a recommendation of a panel of consultants convened by the International Atomic Energy Agency (IAEA) in 1960. When making recommendations on a thyroid uptake phantom, other national and international organizations either include or draw heavily on the IAEA recommendation. In the United States, however, the phantom in widespread use is based on work carried out at the Oak Ridge Institute of Nuclear Studies (ORINS) in 1959. The IAEA and ORINS phantoms are physically different. The use of capsules containing radioiodine as recommended by ORINS, though considered by the IAEA consultants, was not recommended.

The task group considered that standardization of a neck phantom would be incomplete without specification of the manner in which it was to be used, and thus this standard is for the thyroid ^{131}I uptake measurement, as well as the use of the neck phantom. The task group also noted that the use of radioisotopes of iodine other than ^{131}I, the use of nonIodine radionuclides, such as ^{99m}Tc, and the need for consideration of pediatric thyroid uptake measurements should also be considered. However, reports are just becoming available on the measurement of thyroid uptake in children and on the construction of appropriate phantoms for use in these measurements. The task group felt that presently available data were insufficient as a base for a standard covering these situations.

This standard was developed by a task group under the direction of Subcommittee N44-3 on Nuclear Medicine, Henry N. Wagner, Jr, Chairman (The Johns Hopkins Medical Institutions). James P. Cooper and Samuel C. Ingraham, III, Secretaries (Bureau of Radiological Health of the U.S. Public Health Service, Food and Drug Administration). The task group had the following members:

Peter Paraskevoulakis, Chairman
(Puerto Rico Nuclear Center)
Richard C. Riley, Secretary
(University of Kansas Medical Center)

H. Glaser
(Nuclear Associates, Inc)
Robert Goldman
(University of Texas)
C. Craig Hanik
(Duke University Medical Center)
John D. Hidalgo
(Tulane University)
Gerald J. Hine
(Veterans Administration)

William J. Mackenzie
(University Hospitals of Cleveland)
Robert A. Phillips
(Salt Lake's Hospital Center)
Theodore Villafaña
(George Washington U. Medical Center)
Henry N. Wellman
(Indiana University Medical Center)

American National Standard
Thyroid Radioiodine Uptake Measurements Using a Neck Phantom

1. Scope

This standard establishes the reference activity (source) and the neck phantom to be used for the thyroid radioiodine (^{131}I) uptake measurement, the measuring equipment to be used, and those procedural aspects of the use of the neck phantom in the measurements that are required to obtain valid test results. No clinical value judgments were made in preparing this standard.

2. Definitions

activity. The number of nuclear transformations occurring per unit time.

"B" filter. A lead shield that is placed against the neck of phantom to totally obscure the view of the thyroid gland or reference standard from the detector. The dimensions of the "B" filter are 10.2 X 10.2 X 1.3 cm (4 X 4 X 1/2 in).

"B" filter technique. A technique utilizing a "B" filter for correction of background and extrathyroidal activity.

background (radiation). Ionizing radiation recorded from sources other than that of primary concern.

reference activity. The activity used in the neck phantom to simulate total uptake by the thyroid gland of the activity administered to the patient.

NOTE: It can be in liquid or capsule form, as described in 3.1.

thyroid uptake. The thyroid uptake (TU), expressed as a percentage; that is,

$$TU = \frac{P - P_B}{S - S_B} \times 100 \times K$$

where

P = counts per unit time from the patient
P_B = counts per unit time from the patient with the "B" filter in place
S = counts per unit time from the reference activity in the neck phantom
S_B = counts per unit time from the reference activity in the neck phantom with the "B" filter in place
K = ratio of reference activity to the activity administered to the patient

3. Reference Activity and Neck Phantom

3.1 Reference Activity

3.1.1 The reference activity shall have the same activity of radioiodine as is administered to the patient or have a known relationship to it based on measurements.

3.1.2 If a liquid reference activity is used, its volume shall be 30 ml.

3.1.3 If a capsule reference activity is used, it shall be either: (1) dissolved in water to make a liquid reference activity as described in 3.1.2, or (2) placed in the capsule holder (see 3.2.4) for insertion into the neck phantom.

3.1.4 The vessel for the liquid reference activity shall be a polyethlene bottle 3 cm (1.2 in) in diameter with such height that it will accept 30 ml of fluid.

3.2 Neck Phantom

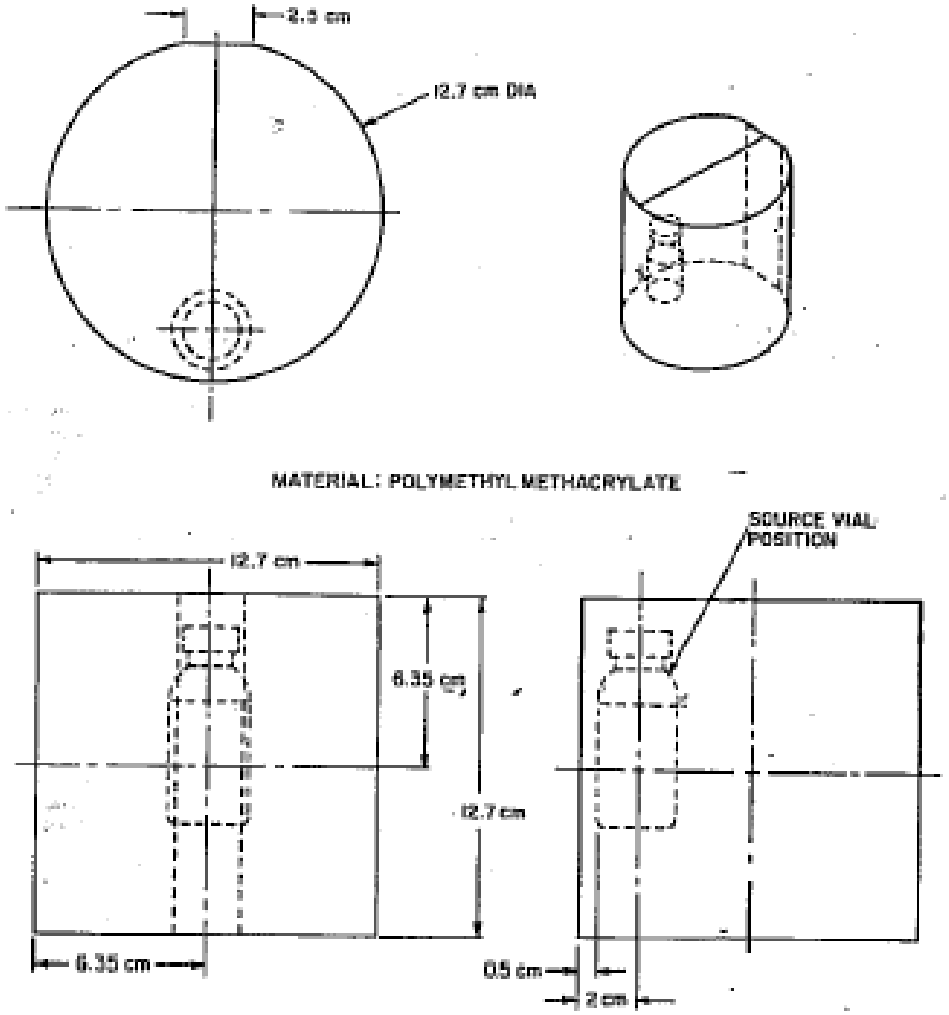
3.2.1 The neck phantom, illustrated in Fig. 1, shall be a right cylinder 12.7 cm (5 in) in diameter and 12.7 cm (5 in) in height and shall be made of polymethyl methacrylate.[1] It shall have a cylindrical cavity to accept the reference activity described in 3.1.

3.2.2 The radial distance from the surface of the phantom to the surface of the cavity shall be 0.5 cm (0.2 in). The central axis of the cavity shall be 2.0 cm (0.8 in) from the surface of the phantom (see Fig. 1).

3.2.3 There shall be a flat surface on the phantom located 180° from the cavity (see Fig. 1). It shall have a width of 2.5 cm (1 in).

3.2.4 A means shall be provided to hold the center of the capsule reference activity at the geometrical center of the liquid reference activity site within the neck phantom. This should be accomplished by means of a polymethyl methacrylate holder of the dimensions

[1] For example, Lucite or Plexiglas.



NOTE: For illustration of neck phantom details only. Method of source vial insertion not shown.

Fig. 1
Neck Phantom for Thyroid Uptake

of the reference activity vessel and containing a central hole of appropriate diameter and depth.

3.2.5 The phantom shall contain marked centering lines on its surface that correspond to the geometrical center of the liquid reference activity.

3.2.6 The phantom and any necessary auxiliary parts shall be designed to permit the liquid reference activity or capsule reference activity to be placed only at the proper position within the neck phantom.

3.2.7 A means shall be provided to minimize air

gaps within the neck phantom when either the liquid reference activity or capsule reference activity is in place.

4. Equipment

4.1 Detector. The detector should be a NaI (Tl) crystal not less than 2.5 cm (1 in) in any dimension.

4.2 Collimator

4.2.1 The collimator should have a field of view at the selected patient-detector distance (see 5.1.2) that will adequately encompass the region of the thyroid gland, but not introduce large regions of extrathyroidal activity. A field of view with radius R at least 6 cm and no more than 7.5 cm (2.36 to 2.95 in) satisfies these conditions in most cases. Within this field of view, the count rate from a point source of ^{131}I should not fall below 50% of the maximum count rate at the center of the field.

4.2.2 The count rate should fall to 50% or less as the distance from the axis increases to $1.2R$ and to 5% or less at this distance increases to $1.4R$. For this measurement the source shall initially be located on the axis at the working distance (see 5.1.2) in air and shall be moved away from the axis perpendicularly.

4.2.3 Sufficient side shielding should be provided so that the count rate will fall below 1% of the maximum value at distances further off the axis. Sufficient rearward shielding should be provided so that the field of view directly behind the crystal does not exceed 1π steradians and that within this region the count rate does not exceed 15% of the maximum value.

4.3 Counting Equipment

4.3.1 A scintillation counting system with a window (single-channel analyzer) or a lower-level discriminator should be used.

4.3.2 When only a lower-level discriminator is used it shall be set no lower than 250 keV.

5. Procedure

5.1 Distance Between Patient and Detector

5.1.1 The distance between the patient and the detector shall be the same as the phantom-detector distance.

5.1.2 The distance shall be measured from the surface of the detector to the skin overlying the inferior margin of the patient's thyroid cartilage or to the surface of the neck phantom. The distance should be between 25 and 50 cm (10 to 20 in).

5.2 Time of Measurement

5.2.1 A 24-hour uptake measurement can yield reliable results when performed in accordance with these recommendations. Uptake measurements made earlier than 6 hours after administration of radioiodine may be subject to errors due to high extrathyroidal activity.

5.2.2 The time of measurement should be included in a statement of thyroid uptake; for example, 24-hr TU (%), 6-hr TU (%), etc.

5.3 Activity Background

5.3.1 While radioactivity in the gland is being counted, background counts due to room background, photons from the patient that pass through the detector shielding, and other extrathyroidal activity within the field of view will be recorded. These may be summed together by using the "B" filter technique and thus provide a single correction for room background and all other extrathyroidal activity.

5.3.2 The "B" filter shall be a piece of lead 10.2 × 10.2 × 1.3 cm thick (4 × 4 × 1/2 in).

5.3.3 The "B" filter shall be positioned over the thyroid (reference activity) against the surface of the patient's neck (neck phantom) between the detector and the patient (neck phantom).

5.4 Equation for Calculation of Percent Thyroid Uptake. Percent thyroid uptake (TU) shall be calculated from the following equation:

$$TU = \frac{P - P_B}{S - S_B} \times 100 \times K$$

where

P = counts per unit time from the patient

P_B = counts per unit time from the patient with the "B" filter in place

S = counts per unit time from the reference activity in the neck phantom

S_B = counts per unit time from the reference activity in the neck phantom with the "B" filter in place

K = ratio of reference activity to the activity administered to the patient

LIMITED WARRANTY

This instrument and its accessories, excluding those listed below, are warranted by VICTOREEN, INC. against defects in materials and workmanship for a period of one year* from the date of original shipment. During the warranty period, VICTOREEN will repair or, at its option, replace, at no charge, an instrument containing such defect provided it is returned, transportation prepaid, to the VICTOREEN repair facility listed below. Instruments repaired in warranty will be returned transportation prepaid.

In addition, the calibration of each instrument is warranted to be within its specified accuracy at the time of shipment. If an error in this initial calibration is discovered, the instrument will be recalibrated at no charge, provided it is returned as described above. This does not apply to any calibration deviation that may result from normal use.

THERE ARE NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS, WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF. THIS EXPRESS WARRANTY EXCLUDES COVERAGE OF, AND DOES NOT PROVIDE RELIEF FOR, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND OR NATURE, INCLUDING BUT NOT LIMITED TO LOSS OF USE, LOSS OF SALES OR INCONVENIENCE. THE EXCLUSIVE REMEDY OF THE PURCHASER IS LIMITED TO REPAIR, RECALIBRATION OR REPLACEMENT OF THE INSTRUMENT AT VICTOREEN'S OPTION.

This warranty does not apply if the product, as determined by VICTOREEN, is defective because of normal wear, accident, misuse, or as a result of service or modification by other than an authorized VICTOREEN repair facility. This warranty is void if the unit is subjected to temperatures above 60° C.

*This warranty specifically excludes any items covered by their original manufacturer's warranty: photomultiplier, geiger and proportional tubes, crystal and other solid state detectors, batteries and major ancillary items of instrument systems such as, but not limited to, recorders, pumps, computers and peripherals.

NON-WARRANTY SERVICE

If repairs or replacement not covered by this warranty are required, a repair estimate will be submitted for approval before proceeding with the repair or replacement.

REPAIR SERVICE: Return the product, prepaid, to:
Nuclear Associates, Division of Victoreen, Inc.
100 Voice Road • Carle Place, N.Y. 11514-1593

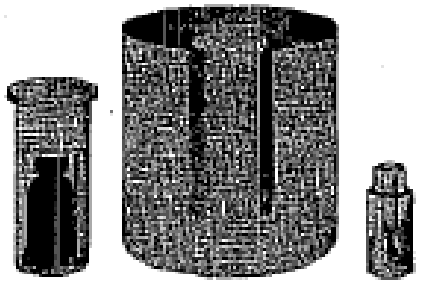
IMPORTANT: To expedite your repair, please supply the following: (1) Complete detailed description of problem. (2) Purchase Date. (3) Name of Vendor. (4) Order Number. Also indicate which, if any, accessory items (batteries, carrying case, check source, collimator, etc.) are included in the return.

1-185 74-365

INSTRUCTION MANUAL

Standard Thyroid Uptake Neck Phantom

MODEL 74-365



NUCLEAR ASSOCIATES

A Division of VICTOREEN, INC.
100 VOICE ROAD
CARLE PLACE, NY 11514-1593
A Subsidiary of Shelter Corp. 516
Repairs (516) 741-2942 • Sales (516) 741-6360

The Standard Neck Phantom includes the phantom, a bottle carrier, a capsule-holding dummy bottle, and 12 polyethylene bottles.

In using the phantom, the radioactive iodine standard (capsule or liquid) is dissolved and/or diluted up to 30 ml in a polyethylene bottle. To dissolve the capsule, it may be necessary to add a few drops of hydrochloric acid. After filling, cap the bottle and tighten securely.

The bottle containing the standard is then placed in the carrier which, in turn, is inserted into the body of the phantom. Make sure that the bottle is positioned near the perimeter of the phantom. Turn the carrier until the red line on the top of the carrier aligns with the red line on the phantom (see diagram). The front of the phantom is also marked for proper alignment of bottle, phantom, and detector. The small flat edge on the rear of the phantom permits the phantom to be used horizontally without rolling.

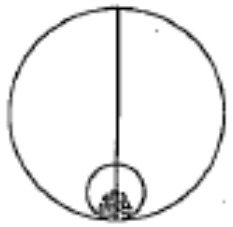
A lucite capsule holder, in the form of a dummy bottle, is also included so that the user may, if desired, count his stock of capsules to ascertain their relative activity.

CAUTION: Do not use organic solvents to clean the phantom --- they will damage the plastic. Detergents and most decontaminating solutions may be used safely.

Also Available...

Polyethylene Bottles Model# 74-361
(100 to a pack)

58 F54



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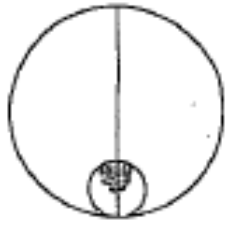


wrong

Appendix J

RMC II Transfer Phantom

Appendix J
RMC II Transfer Phantom

The Canberra RMC-II
(Model 2257) Transfer Phantom

Canberra RMC-II (Model 2257) Transfer Phantom

This is an inexpensive and easy-to-use phantom that is intended for use during efficiency calibrations of Canberra's various "linear geometry" *in vivo* counters. This phantom has been designed to adequately duplicate the counting geometries of the ANSI N13.30 (later published as HPS N13.30-1996) reference phantom configurations when used to calibrate the standard Canberra Fastscan, Accuscan (Bed), and Accuscan-II counting systems. The reference phantom counting geometries duplicated by the Canberra Transfer Phantom include the Livermore Realistic torso lungs, the BOMAB total body, and the ANSI-N44.3 thyroid. The original test counts performed to verify the suitability of the Canberra Transfer Phantom are summarized in the following pages.

The Canberra Transfer Phantom can be used to accurately simulate lung, GI region, whole body, or thyroid source activity distributions. It is easy to use because it needs no assembly and requires only a single "mixed-gamma" source in a 20-ml liquid scintillation vial for all calibration geometries.

This phantom can provide accurate efficiency calibration results when properly used with standard Canberra Fastscan, Accuscan (Bed), and Accuscan-II counting systems, as well with standard Nuclear Data "People Mover" systems. This phantom is not appropriate for calibrations involving low-energy photon measurements (attempted quantification of nuclide activity based on detection of photons with energies less than 100 keV), or for counting geometries involving one or more detectors positioned behind the subject.

VERIFICATION OF THE Canberra RMC-II CALIBRATION Phantom

For proper calibration of whole body counter (WBC) systems, it is necessary to simulate the photon emanation and absorption characteristics of a human counting subject with internally deposited radioactive material. This is accomplished by loading standard nuclides of known activities in a "phantom" absorber matrix, placed at a designated position relative to the shield and detectors of the WBC system.

Canberra has developed an inexpensive and easy-to-handle phantom appropriate for calibrating linear-geometry fission and activation product WBC systems. This phantom closely approximates the source/absorber configurations provided by the more expensive and complex reference phantoms specified by ANSI N13.30 (later published as HPS N13.30-1996) and ANSI N44.3 as appropriate for WBC calibrations. This phantom is intended for use with small-volume radioactive sources (typically prepared in one-inch diameter liquid scintillation vials). These sources may be loaded in any one of four standard positions within the phantom, thereby simulating reference configurations for lung, thyroid, G.I. region, and whole body activity distributions. This phantom is hereafter referred to as the "RMC-II" phantom [with the "II" added to indicate a significant design change from the REMCAL Transfer Phantom previously developed by Radiation Management Corporation (RMC) prior to acquisition of RMC by Canberra].

The RMC-II phantom consists of two basic components: a "torso" section, and a "neck" section. The torso section is constructed from flat sheets of cast acrylic material (e.g., Lexan or Plexiglass), with the front sheet thickness chosen to provide the proper amount of absorber between the calibration source and the WBC system detector(s). Three interior source cavities provide lung-equivalent, G.I. region-equivalent, and whole body-equivalent configurations. The neck section is a cast acrylic cylinder with a thyroid-equivalent source cavity, with dimensions specified in ANSI N44.3. This configuration provides the ANSI-approved reference thyroid counting geometry.

The RMC-II phantom must be properly positioned in the WBC shield when performing calibration counts. The base of the torso section must be placed near "waist level" of a reference counting subject in the WBC shield. For Canberra Fastscan and Accuscan-II counters, the base of the torso section must be flat against the rear interior shield wall, centered between the molded guide ridges, at a height of 36 inches above the interior shield floor pad. For Canberra Accuscan (Bed) systems, the back of the phantom must be centered and flat on the bed pad, and the base of the torso section placed 36 inches from the foot plate.

PRELIMINARY TESTING OF THE RMC-II PHANTOM

The optimum values of cast acrylic sheet thickness and source cavity dimensions were determined by direct comparison of WBC system response using ANSI-specified reference phantoms and an adjustable RMC-II phantom prototype. To determine the efficiency vs. photon energy response for the reference lung configuration, a Livermore Realistic torso phantom was used (purchased by RMC from Humanoid Systems). Lung inserts simulating a uniform activity distribution of Eu-152 were loaded in the phantom, and three chest wall thickness values ranging from 16 mm to 39 mm were used.

Initially, test counts were performed using a standard Fastscan system assembled with two 4" x 4" x 16" NaI detectors). Efficiency values were calculated for six prominent Eu-152 photopeak

energies, and smooth-curve functions were fitted to these measured efficiency values. The efficiency curve for the 22.5 mm chest thickness configuration was accepted as the reference "lung efficiency" response to be duplicated by the RMC-II phantom lung configuration.

Next, a series of test counts was performed using a Eu-152 point source and various thickness values of cast acrylic absorber. The source was mounted at a position near the midpoint of the lungs in a reference subject, 54 inches above the interior shield floor pad. The thickness of absorber material between the source and the detectors was varied in 0.25-inch increments until the resulting efficiency values fit a smooth curve with shape similar to that of the reference lung efficiency curve. The cast acrylic sheets were sufficiently large to intercept all straight-line photon paths between the source and detectors. The distance between the source and the back wall of the Fastscan shield was then varied until the efficiency values calculated for the RMC-II phantom were in good agreement with those for the reference phantom. This process resulted in the selection of 1.85 inches of acrylic absorber and 3.5 inches distance from back of the phantom to source midline as the optimum dimensions for simulating the Livermore Realistic phantom lung configuration (with 22.5 mm chest wall thickness).

A second series of test counts was performed to simulate the reference "BOMAB" whole body phantom configuration. For this activity distribution, a 10-piece cylindrical and ellipsoidal polyethylene jug phantom was filled with uniform activity concentration Eu-152 solution (60 liters total volume). This 10-component phantom represents the head, neck, upper torso, arms, lower torso, thighs and lower legs of a counting subject. The phantom was supported in a standing configuration in the Fastscan shield, and efficiency values were determined for six photon energies as done previously for the reference lung configuration. Test counts performed with the adjustable RMC-II phantom prototype resulted in the selection of 1.85 inches of acrylic absorber, and 0.5 inches distance from the back of the phantom to the source midline, as the optimum dimensions for simulating the reference BOMAB whole body configuration.

A third series of test counts was performed to determine an appropriate G.I. region configuration for the RMC-II phantom. Because of the dynamic nature of the G.I. tract, and the lack of a specific ANSI recommendation for simulating this organ, defining a "reference" G.I. region phantom is somewhat problematic. Test counts were performed using the following three phantoms: 1) the Livermore Realistic torso phantom with 19 line-geometry sources loaded in the abdominal insert, 2) the Alderson Research Laboratories REMCAL phantom with a single line-geometry source loaded in the "G.I. cavity", and 3) the 10-piece BOMAB polyethylene jug body phantom with Eu-152 activity distributed in the lower torso component only. Efficiency values obtained with these three phantoms were fitted with smooth-curve functions.

Test counts were then performed with the adjustable RMC-II phantom prototype. The absorber thickness and source position was varied until the resulting efficiency values closely approximated the values obtained with the lower torso component of the 10-piece BOMAB phantom. (This also provided good agreement with the average of the Livermore Realistic abdominal cavity and REMCAL G.I. cavity efficiency values.) An absorber thickness of 1.85 inches and a 5.5-inch distance between the point source and back of the phantom were selected for the optimum RMC-II phantom G.I. region configuration, based on these comparative counts.

A production model of the RMC-II phantom was then prepared by Webb Plastics in Northbrook, Illinois. This production model of the RMC-II phantom was then tested using three standard Canberra linear-geometry WBC systems (Fastscan, Accuscan[Bed], and AccuScan-II)

to confirm adequate similarity of the RMC-II phantom and the three reference phantoms, as explained below.

VERIFICATION OF RMC-II PHANTOM DESIGN

Final verification of the RMC-II phantom design was completed in February 1988. Comparative test counts were performed using three WBC systems at the Canberra Industries, Meriden, CT facility. The intent was to document RMC-II phantom and reference phantom equivalence for Fastscan systems, Accuscan Bed systems (when configured for horizontal scanning of the entire bed length) and Accuscan-II systems (when configured for vertical scanning of the entire shield height).

The Livermore Realistic torso phantom, 10-piece BOMAB total body phantom, and lower torso component of the BOMAB phantom were again used as reference lung, whole body, and G.I. region phantom configurations, respectively. Eu-152 sources with activity distributions appropriate for each phantom were used in the comparative test counts. Efficiency values determined for the three counter types, using the reference phantoms and the RMC-II phantom production model, are summarized in Table 1. Efficiency ratio values were calculated (RMC-II phantom efficiency divided by the corresponding reference phantom efficiency) and are also shown in Table 1.

CONCLUSIONS

Results of the verification test counts show acceptable agreement between the RMC-II phantom efficiency and the reference phantom efficiency for the three counter types tested. All efficiency ratio values listed in Table 1 are within a range of 0.79-1.20, and the average ratio (all values weighted equally) is 1.02.

When evaluating the performance of WBC systems, measured nuclide activity values will be inversely proportional to system efficiency values. If the RMC-II phantom is used for WBC system calibration, a bias in measured activity values will be expected, relative to those activity values that would have been calculated if the reference phantoms had been used for efficiency calibration. Table 2 summarizes these relative bias values for each configuration and counter type tested.

The results shown in Table 2 confirm that the RMC-II phantom provides an acceptable approximation of the ANSI-specified reference phantoms. All relative bias values shown are well within the WBC performance criteria limits for measurement accuracy specified in ANSI N13.30 (i.e., $-0.25 <$ relative bias < 0.50). Proper use of the RMC-II phantom will allow valid WBC system efficiency calibrations and ensure accurate WBC measurement results. A diagram showing the relative location of the four source cavities in the RMC-II phantom is shown in Figure 1.

Table 1. Summary of Phantom comparison test count results.

TABLE 1

SUMMARY OF PHANTOM COMPARISON TEST COUNT RESULTS

	Geometry	Measured Response	122 keV	245 keV	344 keV	779 keV	964 keV	1408 keV
FASTSCAN	Lung [1]	Ref. Eff.[4] (% 2 s.d.)	8.21E-3 (5.1)	7.67E-3 (8.0)	8.12E-3 (2.4)	5.95E-3 (5.0)	6.71E-3 (3.9)	6.53E-3 (1.9)
		Test Eff.[4] (% 2 s.d.)	7.55E-3 (5.0)	7.98E-3 (8.4)	7.52E-3 (2.1)	5.93E-3 (4.9)	6.58E-3 (3.2)	6.32E-3 (1.5)
		Ratio +/- % 2 s.d.	0.92 +/- 7.1%	1.04+/- 12%	0.93 +/- 3.2%	1.00 +/- 7.1%	0.98 +/- 5.0%	0.97 +/- 2.4%
	Total Body [2]	Ref. Eff. (% 2 s.d.)	5.16E-3 (4.4)	5.23E-3 (8.9)	5.57E-3 (1.7)	4.37E-3 (4.6)	4.81E-3 (3.4)	4.47E-3 (1.5)
		Test Eff. (% 2 s.d.)	5.56E-3 (4.7)	6.02E-3 (5.3)	5.73E-3 (2.6)	4.82E-3 (5.0)	5.37E-3 (2.6)	4.83E-3 (1.2)
		Ratio +/- % 2 s.d.	1.08 +/- 6.4%	1.15 +/- 10%	1.03 +/- 3.1%	1.10 +/- 6.8%	1.12 +/- 4.3%	1.08 +/-1.9%
	GI [3]	Ref. Eff. (% 2 s.d.)	7.30E-3 (5.9)	7.53E-3 (9.6)	8.11E-3 (1.5)	6.25E-3 (5.4)	6.77E-3 (3.8)	6.33E-3 (1.4)
		Test Eff. (% 2 s.d.)	7.43E-3 (5.6)	7.71E-3 (6.0)	8.04E-3 (2.5)	6.83E-3 (5.0)	7.85E-3 (2.8)	7.15E-3 (1.1)
		Ratio +/- % 2 s.d.	1.02+/- 8.1%	1.02 +/- 11%	0.99 +/- 2.9%	1.09 +/- 7.4%	1.16 +/- 4.7%	1.13 +/- 1.8%
ACCUSCAN	Lung	Ref. Eff. (% 2 s.d.)	1.71 E-3 (9.2)	2.04E-3 (11.1)	1.98E-3 (3.4)	1.38E-3 (7.1)	1.34E-3 (7.6)	1.44E-3 (3.2)
		Test Eff. (% 2 s.d.)	1.41 E-3 (10.3)	1.95E-3 (11.6)	1.73E-3 (3.9)	1.34E-3 (6.5)	1.31E-3 (5.7)	1.37E-3 (3.5)
		Ratio +/- % 2 s.d.	0.82 +/- 14%	0.96 +/- 16%	0.87 +/- 5.2%	0.97 +/- 9.6%	0.98 +/- 9.5%	0.95 +/- 4.7%
	Total Body	Ref. Eff. (% 2 s.d.)	1.51E-3 (6.4)	1.73E-3 (7.7)	1.69E-3 (2.9)	1.25E-3 (6.0)	1.27E-3 (3.8)	1.24E-3 (2.0)
		Test Eff. (% 2 s.d.)	1.46E-3 (8.6)	2.02E-3 (6.3)	1.70E-3 (3.2)	1.31E-3 (5.6)	1.30E-3 (4.6)	1.24E-3 (2.4)
		Ratio +/- % 2 s.d.	0.97 +/- 11%	1.17 +/- 9.9%	1.01 +/- 4.3%	1.05 +/- 8.2%	1.02 +/- 6.0%	1.00 +/- 3.1%
	GI	Ref. Eff. (% 2 s.d.)	1.46E-3 (8.3)	1.69E-3 (9.8)	1.69E-3 (2.8)	1.30E-3 (4.8)	1.28E-3 (4.3)	1.28E-3 (2.3)
		Test Eff. (% 2 s.d.)	1.66E-3 (9.0)	1.97E-3 (9.1)	2.02E-3 (2.5)	1.55E-3 (5.0)	1.47E-3 (4.6)	1.47E-3 (2.1)
		Ratio +/- % 2 s.d.	1.14 +/- 12%	1.17 +/- 13%	1.20 +/- 3.8%	1.19 +/- 6.9%	1.15 +/-6.3%	1.15 +/- 3.1%
ACCUSCAN-II	Lung	Ref. Eff. (% 2 s.d.)	2.57E-4 (2.8)	2.33E-4 (6.5)	1.94E-4 (3.1)	1.24E-4 (5.1)	1.11E-4 (4.9)	9.66E-5 (4.4)
		Test Eff. (% 2 s.d.)	2.15E-4 (6.6)	2.09E-4 (14.2)	1.83E-4 (5.7)	1.03E-4 (11.5)	1.01E-4 (10.6)	8.81E-5 (8.6)
		Ratio +/- % 2 s.d.	0.84 +/- 7.2%	0.90 +/- 16%	0.94 +/- 6.5	0.83 +/- 13%	0.91 +/- 12%	0.91 +/- 9.7%
	Total Body	Ref. Eff. (% 2 s.d.)	2.52E-4 (4.3)	2.03E-4 (8.5)	1.80E-4 (3.7)	1.21E-4 (6.6)	9.52E-5 (8.2)	8.09E-5 (6.0)
		Test Eff. (% 2 s.d.)	1.98E-4 (4.0)	1.94E-4 (8.5)	1.52E-4 (4.1)	1.07E-4 (7.4)	9.41E-5 (7.4)	7.75E-5 (6.3)
		Ratio +/- % 2 s.d.	0.79 +/- 5.9%	0.96 +/- 12%	0.84 +/- 5.5%	0.88 +/- 9.9%	0.99 +/- 11%	0.96 +/- 8.7%
	GI	Ref. Eff. (% 2 s.d.)	2.59E-4 (3.3)	2.21E-3 (7.4)	1.84E-3 (3.4)	1.21E-3 (6.2)	1.05E-4 (7.2)	8.93E-5 (5.4)
		Test Eff. (% 2 s.d.)	2.59E-4 (3.8)	2.32E-3 (7.8)	2.07E-3 (3.5)	1.24E-3 (6.6)	1.22E-4 (6.1)	1.06E-4 (5.2)
		Ratio +/- % 2 s.d.	1.00 +/- 5.0%	1.05 +/- 11%	1.12 +/- 4.9%	1.02 +/- 9.1%	1.16 +/- 9.4%	1.19 +/- 7.5%

NOTES

1) Reference Lung geometry provided by planar source inserts in the Livermore Realistic torso phantom to simulate uniform lung activity distribution.

2) Reference Total Body geometry provided by the 10-compartment poly-bottle phantom with uniform activity concentration in a water matrix.

3) Reference G.I geometry provided by a uniform activity concentration in the lower torso compartment of the poly-bottle phantom, and a blank water matrix absorber in the upper torso and thigh compartments.

4) Efficiency was measured in units of counts per gamma emitted by the source matrix.

Table 2. Comparison of RMC-II and ANSI N13.30 reference phantoms.

EFFICIENCY RATIO VALUES AND CORRESPONDING RELATIVE BIAS VALUES

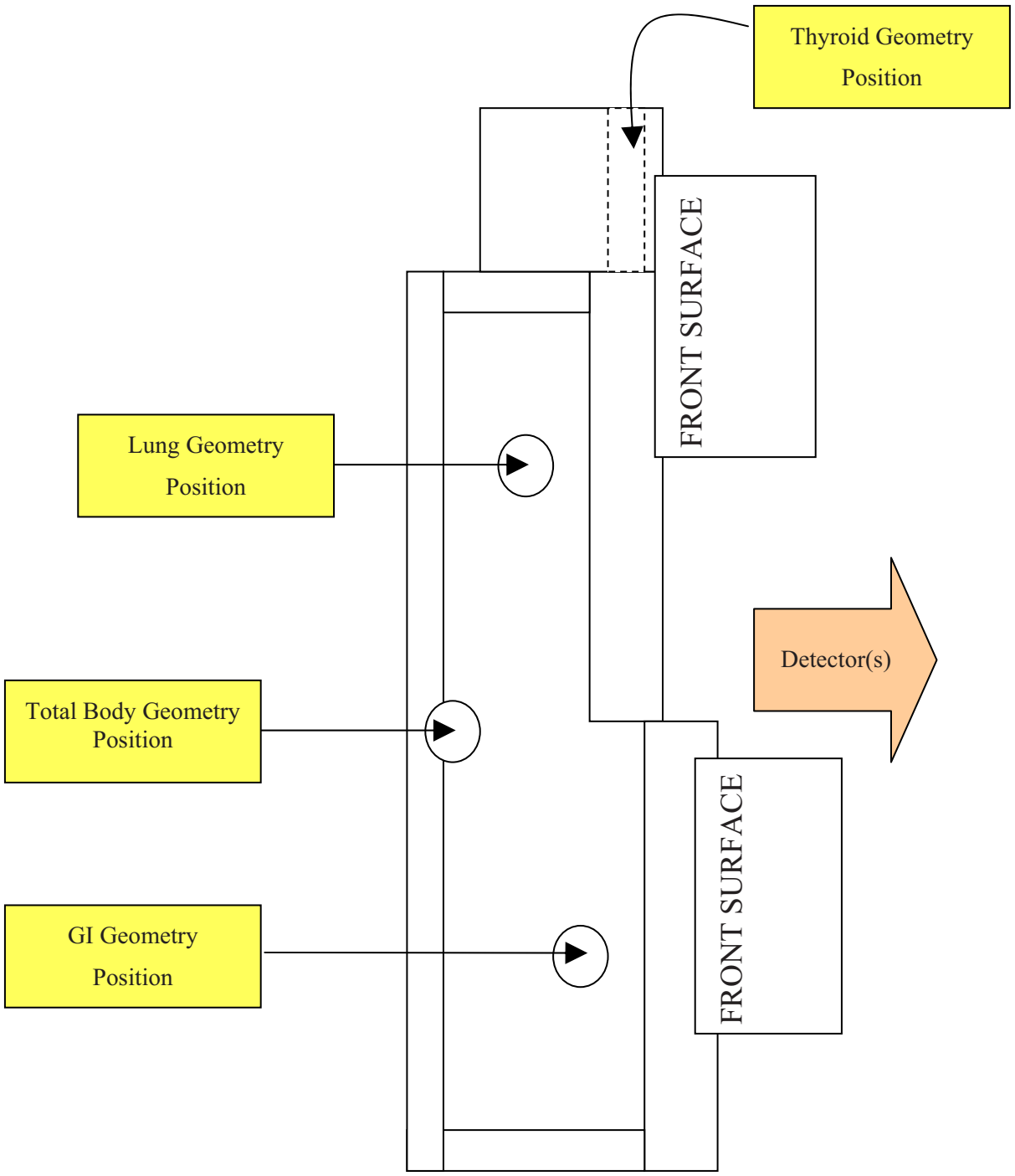
Counter Configuration	Source Type	Range of Efficiency	Range of Measures Activity Relative Bias Values[2]
Fastscan	Lung	0.92 to 1.04	-0.04 to 0.09
	Total Body	1.03 to 1.15	-0.13 to -0.03
	G.I. Region	0.99 to 1.16	-0.14 to 0.01
Accuscan Bed (Full Bed Scan Mode)	Lung	0.82 to 0.98	0.02 to 0.22
	Total Body	0.97 to 1.17	-0.15 to 0.03
	G.I. Region	1.14 to 1.20	-0.17 to -0.12
Accuscan-II (Full Shield Scan Mode)	Lung	0.83 to 0.94	0.06 to 0.20
	Total Body	0.79 to 0.99	0.01 to 0.27
	G.I. Region	1.00 to 1.19	-0.16 to 0.00

NOTES: 1) Efficiency Ratio = (RMC-II phantom Effic.)/(Reference phantom Effic.) (Range shows lowest and highest values listed in Table 1 for photon energies between 122 and 1408 keV.)

2) Relative Bias = (A2 – A1)/(A1)

where A1 = measured activity value if reference phantom used for efficiency calibration

A2 = measured activity value if RMC-II phantom used for efficiency calibration


Thyroid Geometry Position
FRONT SURFACE
Lung Geometry Position
Detector(s)
Total Body Geometry Position
FRONT SURFACE
GI Geometry Position

SIDE VIEW