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Revision 0

Calibration of the Accuscan II In Vivo System for I-125 Thyroid Counting

O. R. Perry

July 2011

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Health Physics Dosimetry Laboratory

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Approved by:

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ABSTRACT

This report describes the March 2011 calibration of the Accuscan II HpGe In Vivo system for I-125 thyroid counting. The source used for the calibration was a DOE manufactured Am-241/Eu-152 source contained in a 22 ml vial # BEA Am-241/Eu-152 RMC II-1 with energies from 26 keV to 344 keV. The center of the detector housing was positioned 64" from the vault floor. This position places the approximate center line of the detector housing at the center line of the source in the phantom thyroid tube. The energy and efficiency calibration were performed using an RMC II phantom (Appendix J). Performance testing was conducted using source # BEA Am-241/Eu-152 RMC II-1 and Validation testing was performed using an I-125 source in a 30 ml vial (#I-125 BEA Thyroid 002) and an ANSI N44.3 phantom (Appendix I). This report includes an overview introduction and records for the energy/FWHM and efficiency calibration including performance verification and validation counting. The Accuscan II system was successfully calibrated for counting the thyroid for I-125 and verified in accordance with ANSI/HPS N13.30-1996 criteria.

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FIGURES

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-125 Thyroid Counting

1. INTRODUCTION

This document describes the March 2011 calibration of the Accuscan II in vivo system for thyroid counting of I-125. 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-125.

The energy/FWHM-Low Tail calibration was performed on March 16, 2011. A DOE manufactured 22 ml source # BEA Am-241/Eu-152 RMC II-1 was used together with an RMC II phantom to establish a thyroid counting geometry. This source (BEA Am-241/Eu-152 RMC II-1) is NIST traceable and is presented in Appendix A. The source has a reference date of March 14, 2011 with the current activity presented in Appendix B. The RMC II phantom was used for both the energy and efficiency calibrations. The source vial was positioned in the RMC II phantom thyroid tube and counted for 7223.15 seconds for both the energy and efficiency calibrations with the center line of the detector housing positioned 64" from the vault floor.

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 16, 2011 is expressed as an Empirical fit using a 4^{th} order polynomial with no cross over. 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 (see Reference 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-125 source (# I-125 BEA Thyroid 002) manufactured by DOE. The validation counts Relative Bias and Relative Precision were tested to ANSI/HPS N13.30-1996 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 operates from a Genie 2000 operating system 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 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 -185ºC by an electrically refrigerated cryostat system.

3. CALIBRATION SOURCES AND PHANTOMS

A NIST traceable DOE manufactured source # BEA Am-241/Eu-152 RMC II-1 was used. The certification for this source is described in Appendix A. The source is uniformly distributed in a WaterWork crystal SP 400 matrix in a 22 ml vial.

The source activity was decayed to the efficiency calibration date of March 16, 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 thyroid phantom, Realistic torso phantom and Bottle Manikin Absorber model and is described in described in Appendix J.

An ANSI N44.3 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.

Validation counting of the calibration was performed using DOE manufactured I-125 source # I-125 BEA Thyroid 002. The source certification is described in Appendix A. The source is uniformly distributed in a Water Work matrix in a Liquid Scintillation Vial (~ 30 ml).

4. DETECTOR AND LYNX DIGITAL AMPLIFIER TESTING

A Pole Zero was performed in accordance with MCP-3336 for both detectors during the I-131 calibration of March 1, 2011. No additional pole zero is needed since both calibrations use the same detector.

5. ENERGY/FWHM CALIBRATION

An energy/FWHM calibration was performed March 16, 2011. The mixed The BEA Am-241/Eu-152 RMC II -1 source was positioned in the RMC II thyroid tube and counted for 7223 seconds with the detector housing midline at 64" from the vault floor. The detectors were in a fixed position for the count. The count was used to develop the energy/FWHM and Low Tail equations in accordance with MCP-3336 (Reference 2). The results and graphs of the calibrations are documented in Appendix C.

6. EFFICIENCY CALIBRATION

An efficiency calibration was conducted March 16, 2011 in accordance with MCP-3336 (Reference 2) and the Canberra Apex-InVivo User's Manual (Reference 3) 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 3/16/2011 4:31 PM" as the ID number. The efficiency calibration used library Am-241/Eu-152. NLB and ASF file CALWBCGE for I-125.

7. CALIBRATION COUNT REANALYSIS

Subsequent to the energy and efficiency calibrations the calibration count (performed on 3/6/2011 4:31 PM) was analyzed using the new calibrations. The results indicated a relative bias between 0.31 and -0.01. This result is well within the bias criteria of Reference 1. Except for the very low 26 keV energy line of Am-241, 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 BEA Am-241/Eu-152 RMC II-1. A set of five replicate verification test of the radionuclides in certificate BEA Am-241/Eu-152 RMC II-1 were performed March 16, 2011 with 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 I-125 Thyroid.nlb. Relative bias and relative precision, as defined in ANSI/HPS N13.30-1996 (Reference 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 -6.9% to 1.82%. The relative precision for these verification counts ranged from 12.77% to 3.56%. These results are well within the ANSI/HPS N13.30-1996 criteria (–25% to +50% for the relative bias and less than or equal to 40% for the relative precision).

9. MDA CALCULATIONS

MDA testing was conducted on March 23, 2011. The RMC-II phantom (with no sources installed) was counted three times with the Apex-In Vivo Analysis Sequence File (ASF) counting file (Thyroid ASF for I-125.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

Although the performance test indicated acceptable results based on ANSI/HPS N13.30-1996 criteria, the calibration was tested against an I-125 source manufactured by DOE as # I-125 BEA Thyroid 002. The I-125 source was placed in the ANSI N44.3 phantom. The center of the thyroid tube of the ANSI N44.3 phantom was placed 61.25" 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 as positioned 64" from the vault floor (the counter floor is 2 ¾" from the vault floor). The initial test results indicated a severe under response from 46% (27 keV energy line) to 82% (35.5 keV energy line). The efficiency calibration derivation was evaluated as a dual function, with varying cross over energies and polynomial values and as an empirical function with varying degrees of polynomial values. No reassessment made any significant changes to the I-125 activity resolution. The results of the low yield 35.5 keV energy line (6.67%) made this response vary from -11% to +14% and proved to be very unstable. The solution was to add a calibration constant or to adjust the yield of the energy lines to bring the reported I-125 values to the known activity level. Counting results were tested from 3/16/2011 to 3/23/2011 with a variety of yields introduced for the 27 and 31 keV energy lines. The yield corrections varied from 38.25% to 43.12% for the 27 keV energy line. The final yield % correction was 40.12% and was tested against all collected count data. See Tables 1, 2, and 3. The yield correction for the 31 keV energy line varied from 11.7% to 13.12%. The final correction was 12.5% and was tested against all collected count data. See Tables 4, 5, and 6.

At the completion of establishing correction yield values for the 27 and 31 keV energy lines, a second set of tests were conducted using the I-125 source # I-125 BEA Thyroid 002. These tests were termed Validation Tests. The tests were conducted using the ANSI N44.3 phantom and a 30 ml vial containing I-125. The front of the ANSI N44.3 phantom was placed 61.25" 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 64" from the vault floor (the counter floor is approximately 2 3/4" from the vault floor). The results of the I-125 tests are attached as Appendix H. The summary notes a Relative Bias of -4.7% and a Relative Precision of 1.1% for the 27 keV peak and a Relative Bias of -3.2% and a Relative Precision of 7.3% for the 31 keV peak. The average Relative Bias was -4.0% and Relative Precision of 0.42%.

11. SUMMARY AND CONCLUSION

Final review of all calibration and verification count results confirmed that the thyroid calibration created on March 16, 2011 for the Accuscan II counter is satisfactory for I-125 counting where the detectors are positioned in-accordance-with Reference 4 (center of the individual's throat). A summary of current calibration files for this counter is shown in Table 7.

The I-125 Thyroid.nlb nuclide library file is the default for thyroid counting of I-125. Non-systematic and systematic errors for the in vivo system are described and quantified in Reference 5 – TEV-1275 (INL In Vivo System Counting Uncertainty).

The overall percent (%) counting uncertainty using the Accuscan II for I-125 counting is:

$$\text{Total \% Uncertainty (Accuscan II) for I-125} = \sqrt{(\%\,\text{counting uncertainty})^2 + (3.63)^2 + (18.0)^2}$$

Table 1. Testing the 27 keV energy line with a derived yield of 43.12%.

Testing the 27keV energy line with a derived yield of 43.12%

g/sec	Adjusted Yield=43.12% Activity (nCi)	Maximum 50% Limit	Minimum -25% Limit	% Bias relative to activity	Test Date
1730.08	108.4390513	163.95	81.975	-0.788	3/17/2011
1728.91	108.3657173	163.95	81.975	-0.855	3/17/2011
1741.08	109.1285163	163.95	81.975	-0.157	3/17/2011
1717.89	107.6749987	163.95	81.975	-1.487	3/17/2011
1783.97	111.8168029	163.95	81.975	2.303	3/17/2011
1737.93	108.9310786	163.95	81.975	-0.338	3/17/2011
1789.18	112.1433586	163.95	81.975	2.601	3/17/2011
1710.19	107.1923733	163.95	81.975	-1.928	3/17/2011
1705.97	106.9278694	163.95	81.975	-2.17	3/17/2011
1728	108.3086797	163.95	81.975	-0.907	3/17/2011
3/17/2011	Source Activity (nCi)	109.3			

Table 2. Testing the 27 keV energy line with a derived yield of 38.25%.

Testing the 27keV energy line with a derived yield of 38.25%

gammas/sec	Adjusted Yield=38.25% Activity (nCi)	Maximum 50% Limit	Minimum -25% Limit	% Bias relative to activity	Test Date
1439.96	101.7459813	153	76.5	-0.249	3/23/2011
1443.81	102.018018	153	76.5	0.018	3/23/2011
1438.86	101.6682565	153	76.5	-0.325	3/23/2011
1469.61	103.8410175	153	76.5	1.805	3/23/2011
1427.96	100.8980745	153	76.5	-1.08	3/23/2011
1487	105.0697757	165.9	82.95	-5	3/16/2011
1489.57	105.251369	165.9	82.95	-4.836	3/16/2011
1498.2	105.8611553	165.9	82.95	-4.285	3/16/2011
1445.48	102.1360184	165.9	82.95	-7.653	3/16/2011
1515.23	107.0644762	165.9	82.95	-3.197	3/16/2011
3/16/2011	Source Activity (nCi)	110.6			
3/23/2011	Source Activity (nCi)	102			

Table 3. Testing the 27 keV energy line with a derived yield of 40.5%.

Testing the I-125 27 keV Energy Line Response to an Adjusted Yield of 40.25%

gammas/sec	nCi	Test Date	Bias %
1730.08	116.1712271	3/17/2011	6.287
1728.91	116.0926641	3/17/2011	6.215
1741.08	116.909854	3/17/2011	6.962
1717.89	115.3526943	3/17/2011	5.538
1783.97	119.7898271	3/17/2011	9.597
1737.93	116.6983381	3/17/2011	6.769
1789.18	120.1396676	3/17/2011	9.917
1710.19	114.8356555	3/17/2011	5.065
1705.97	114.5522914	3/17/2011	4.805
1728	116.0315595	3/17/2011	6.159
1439.96	96.69028034	3/23/2011	-5.206
1443.81	96.94879973	3/23/2011	-4.952
1438.86	96.61641766	3/23/2011	-5.278
1469.61	98.68121538	3/23/2011	-3.254
1427.96	95.88450562	3/23/2011	-5.996
1487	99.84891724	3/16/2011	-9.721
1489.57	100.0214873	3/16/2011	-9.565
1498.2	100.6009736	3/16/2011	-9.041
1445.48	97.06093671	3/16/2011	-12.241
1515.23	101.7445023	3/16/2011	-8.007
3/17/2011	Source Activity (nCi)	109.3	
3/16/2011	Source Activity (nCi)	110.6	
3/23/2011	Source Activity (nCi)	102	

Table 4. Testing the 31 keV energy line with a derived yield of 13.12%.

Testing the 31keV energy line with a derived yield of 13.12%

g/sec	Adjusted Yield=13.12% Activity (nCi)	Maximum 50% Limit	Minimum -25% Limit	% Bias relative to activity	Test Date
510.36	105.1334871	163.95	81.975	-3.812	3/17/2011
542.8	111.8160844	163.95	81.975	2.302	3/17/2011
538.41	110.9117502	163.95	81.975	1.475	3/17/2011
544.07	112.0777027	163.95	81.975	2.541	3/17/2011
537.45	110.7139914	163.95	81.975	1.294	3/17/2011
537.34	110.6913316	163.95	81.975	1.273	3/17/2011
556.63	114.6650461	163.95	81.975	4.909	3/17/2011
519.98	107.1151945	163.95	81.975	-1.999	3/17/2011
503.42	103.7038563	163.95	81.975	-5.12	3/17/2011
497.22	102.4266645	163.95	81.975	-6.289	3/17/2011
3/17/2011	Source Activity (nCi)	109.3			

Table 5. Testing the 31 keV energy line with a derived yield of 12.0%.

Testing the 31keV energy line with a derived yield of 12.0%

g/sec	Adjusted Yield=12.0% Activity (nCi)	Maximum 50% Limit	Minimum -25% Limit	% Bias relative to activity	Test Date
367.39	82.7454955	153	76.5	-18.877	3/23/2011
480.42	108.2027027	153	76.5	6.081	3/23/2011
459.42	103.472973	153	76.5	1.444	3/23/2011
439.25	98.93018018	153	76.5	-3.01	3/23/2011
466.55	105.0788288	153	76.5	3.018	3/23/2011
517.79	116.6193694	153	76.5	14.333	3/23/2011
418.26	94.2027027	153	76.5	-7.644	3/23/2011
451.73	101.740991	153	76.5	-0.254	3/23/2011
378.9	85.33783784	153	76.5	-16.335	3/23/2011
508.73	114.5788288	153	76.5	12.332	3/23/2011
3/23/2011	Source Activity (nCi)	102			

Table 6. Testing the 31 keV energy line with a derived yield of 12.5%.

Testing the I-125 31 keV Energy Line Response to an Adjusted Yield of 12.5%

gammas/sec	nCi	Test Date	Bias %
510.36	110.3481081	3/17/2011	0.959
542.8	117.3621622	3/17/2011	7.376
538.41	116.412973	3/17/2011	6.508
544.07	117.6367568	3/17/2011	7.627
537.45	116.2054054	3/17/2011	6.318
537.34	116.1816216	3/17/2011	6.296
556.63	120.3524324	3/17/2011	10.112
519.98	112.4281081	3/17/2011	2.862
503.42	108.8475676	3/17/2011	-0.414
497.22	107.507027	3/17/2011	-1.64
367.39	79.43567568	3/23/2011	-22.122
480.42	103.8745946	3/23/2011	1.838
459.42	99.33405405	3/23/2011	-2.614
439.25	94.97297297	3/23/2011	-6.889
466.55	100.8756757	3/23/2011	-1.102
517.79	111.9545946	3/23/2011	9.759
418.26	90.43459459	3/23/2011	-11.339
451.73	97.67135135	3/23/2011	-4.244
378.9	81.92432432	3/23/2011	-19.682
508.73	109.9956757	3/23/2011	7.839

3/17/2011	Source Activity (nCi)	109.3
3/23/2011	Source Activity (nCi)	102

Table 7. Calibration summary table.

Facility:	Idaho National Laboratory, Building HPDL CFA-1618
Counting System:	Accuscan II Thyroid Stationary Position
Counter Arrangement:	Accuscan II for I-125

Detector	Energy Calibration Date	Time
Accuscan II BE Detectors	03/16/2011	3:02 PM

Efficiency Calibration:

Detector	Energy Calibration Date	Time
Accuscan II BE Detectors	03/16/2011	4:31 PM

12. REFERENCES

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

Appendix A

Source Certificate

Appendix A
Source Certificate

BEA Am-241/Eu-152 RMC II-1

Certified Reference Material

Certificate of Traceability

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

Standard Identification: BEA Am-241/Eu-152 RMCII-1

Radionuclide	Activity
Eu-152	(1.799± 0.015) E2 nCi
Am-241	(2.10±0.04) 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

March 14, 2011
Reference Date

Supplemental Information

BEA Am-241/Eu-152 RMCII-1

Final weight of vial with sticker and tape: 38.790 grams

Weight of solution in vial: 19.599 +/- 0.002 grams

Solution in vial: Solidified with 0.369 grams of WaterWorks Crystal SP400.

Half life Am-241: 4.327E+02 years
Half life Eu-152: 1.348E+01 years

DOE Source Certificate I-125 BEA Thyroid 002

Certified Reference Material

Certificate of Traceability

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

Standard Identification: I-125 BEA Thyroid 002

Radionuclide	Activity
I-125	(1.33± 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

February 28, 2011
Reference Date

Supplemental Information

I-125 BEA Thyroid 002

Final weight of vial with sticker and tape: 38.885 grams

Weight of solution in vial: 29.955 +/- 0.002 grams

Solution Used: I-125-80943-370

Solution in vial: Solidified with 0.432 grams of WaterWorks Crystal SP400.

Half life: 59.40 days

Certificate and dilution information attached.

Prepared by Guy Backstrom, 2/28/2011

Appendix B

Source Decay

Appendix B
Source Decay

BEA Am-241/Eu-152 RMC II-1 Source Decay

Am241/Eu152 RMC II-1
Reference Date 3/14/2011
Current Date 3/16/2011
Elapsed Time 2

Identity	Energy (keV)	Reference Activity (nCi)	Yield %	T1/2 Days	G/nCi	Reference GPS	Current Activity (nCi)
	13.93	210	24.4	157835.5	37	1.90E+03	2.10E+02
	17.51	210	30.5	157835.5	37	2.37E+03	2.10E+02
	20.98	210	7.31	157835.5	37	5.68E+02	2.10E+02
Am-241	26.34	210	2.4	157835.5	37	1.86E+02	2.10E+02
	59.54	210	35.7	157835.5	37	2.77E+03	2.10E+02
Eu-152	121.783	179.9	28.4	4946.2	37	1.89E+03	1.80E+02
	244.699	179.9	7.51	4946.2	37	5.00E+02	1.80E+02
	344.281	179.9	26.6	4946.2	37	1.77E+03	1.80E+02

DOE Manufactured Source # I-125 BEA Thyroid 002 Decay

I-125 BEA Thyroid 002

Reference date	2/28/2011
Current Date	3/16/2011
Days	16.00

Energy (keV)	Reference Activity (nCi)	Yield %	T1/2 Days	G/nCi	Reference GPS	Current Activity (nCi)
27	133	113.9	60.14	37	5605.019	110.606552
31	133	25.5	60.14	37	1254.855	110.606552
35.492	133	6.67	60.14	37	328.2307	110.606552

I-125 BEA Thyroid 002

Reference date	2/28/2011
Current Date	3/23/2011
Days	23.00

Energy (keV)	Reference Activity (nCi)	Yield %	T1/2 Days	G/nCi	Reference GPS	Current Activity (nCi)
27	133	113.9	60.14	37	5605.019	102.035168
31	133	25.5	60.14	37	1254.855	102.035168
35.492	133	6.67	60.14	37	328.2307	102.035168

Appendix C

Energy/FWHM and Low Tail Calibration Documentation

Appendix C
Energy/FWHM and Low Tail Calibration Documentation

Energy Calibration

Calibration Information

Calibration Title	Energy Calibration (I-125) 3/16/2011 3:00 PM
Calibration Date	3/16/2011 3:01:08 PM
Performed By	David Georgeson
Count Used	Calibration Count 3/16/2011 12:56 PM
Is Default	Yes

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle

Detector Group Information

Detector Group Name	Left
Calibration Source	Am241/Eu152 RMC II-1
Analysis Sequence File	
Nuclide Library	Am-241/Eu-152.NLB
Peak Search Library	Am-241/Eu-152.NLB

Energy Calibration Coefficients

Energy = - 0.375273 + 0.462746 * ch - 6.01373e-07 * ch^2

FWHM = 1.14092 + 0.0173155 * E^1/2

LOW TAIL = 4.01565 - 0.012525 * E

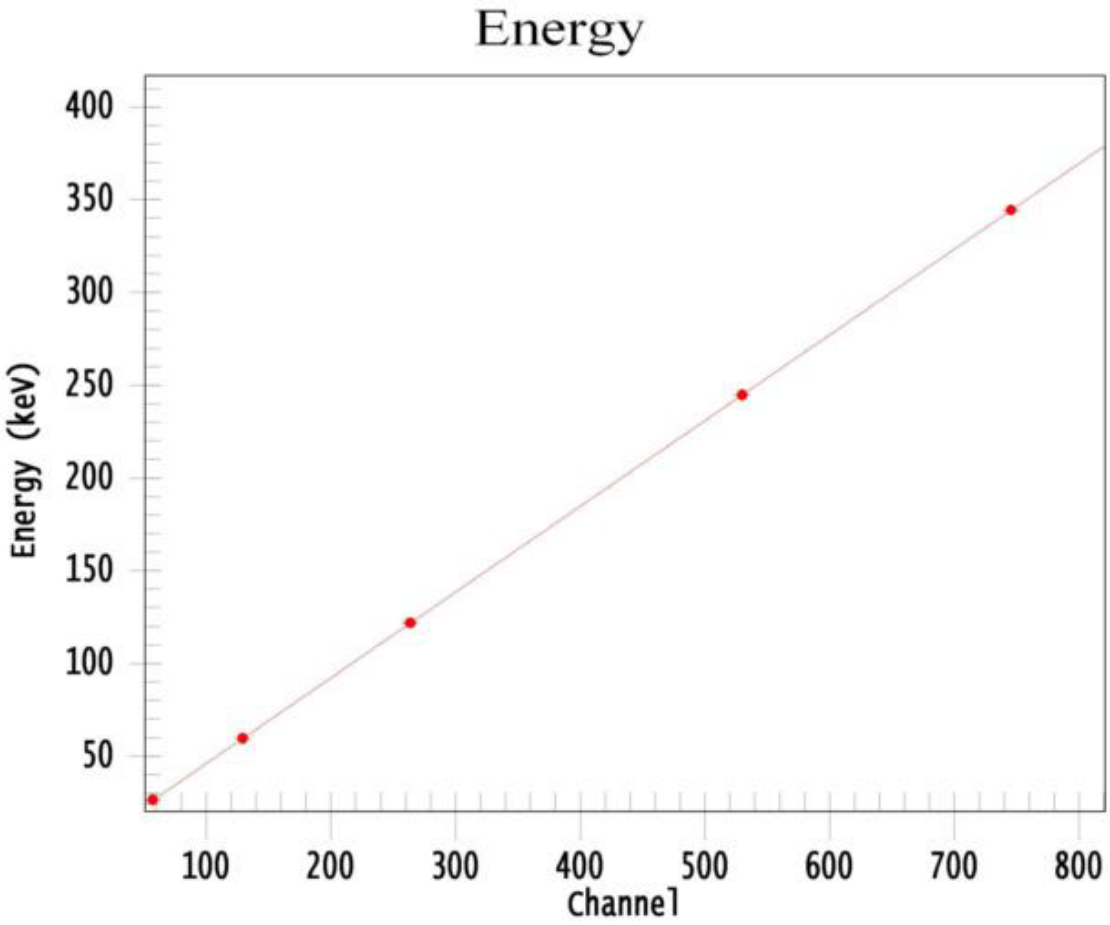
Energy Calibration Results Table

Centroid Channel	Centroid Error	Energy (keV)
57.41	0.25	26.34
129.51	0.01	59.54
264.06	0.01	121.78
530.03	0.02	244.70
745.52	0.01	344.28

Approved by: _____

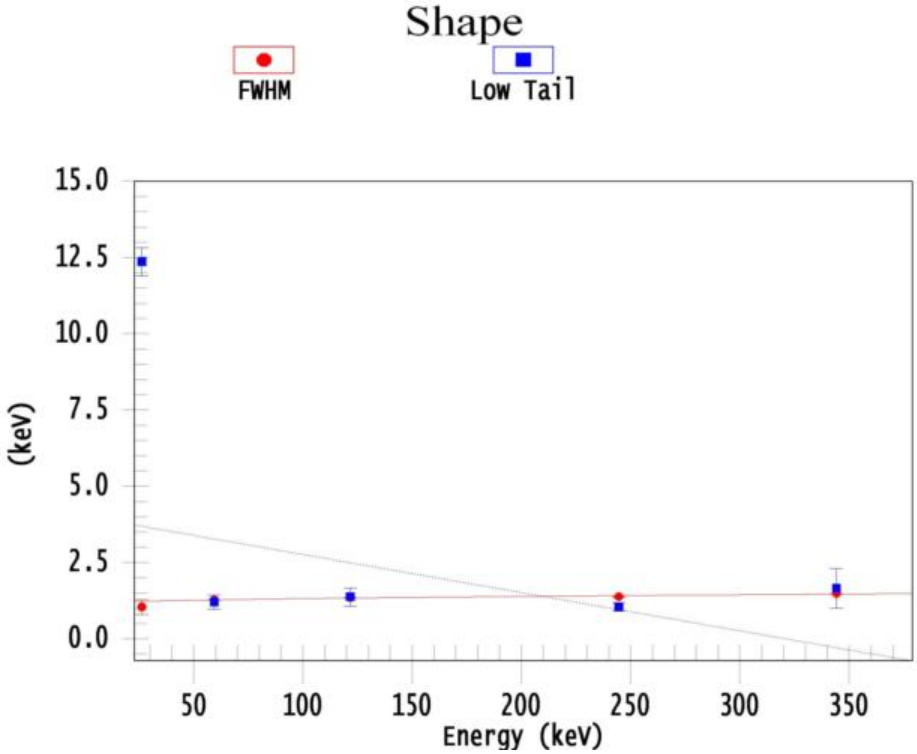
Date: _____

User: David Georgeson



Energy Calibration Results Table

Energy (keV)	FWHM Channels	FWHM Error
26.34	2.24	0.54
59.54	2.75	0.02
121.78	2.89	0.02
244.70	2.96	0.05
344.28	3.17	0.03



User: David Georgeson

Energy Calibration

Calibration Information

Calibration Title	Energy Calibration (I-125)3/16/2011 3:02 PM
Calibration Date	3/16/2011 3:02:15 PM
Performed By	David Georgeson
Count Used	Calibration Count 3/16/2011 12:56 PM
Is Default	Yes

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle

Detector Group Information

Detector Group Name	Right
Calibration Source	Am241/Eu152 RMC II-1
Analysis Sequence File	
Nuclide Library	Am-241/Eu-152.NLB
Peak Search Library	Am-241/Eu-152.NLB

Energy Calibration Coefficients

Energy = - 0.346161 + 0.46233 * ch - 2.30088e-07 * ch^2

FWHM = 0.631027 + 0.0248655 * E^1/2

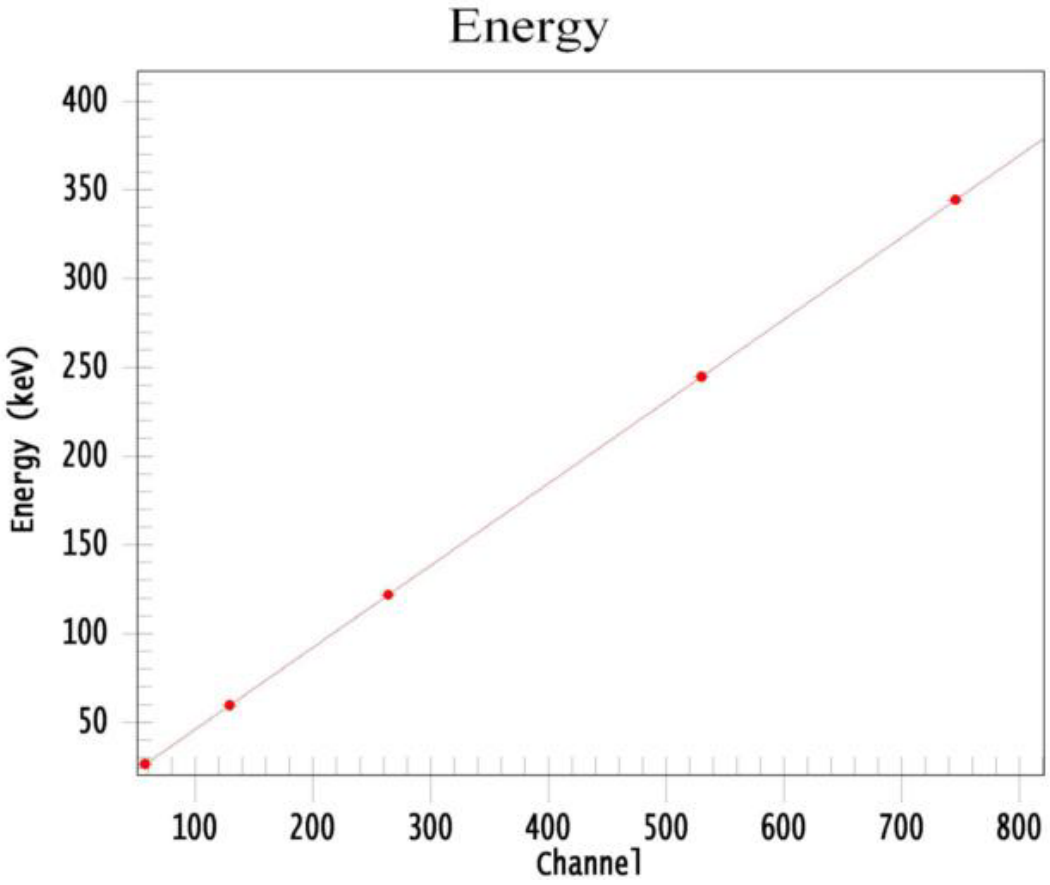
LOW TAIL = 0.519347 + 0.00136678 * E

Energy Calibration Results Table

Centroid Channel	Centroid Error	Energy (keV)
57.52	0.12	26.34
129.55	0.01	59.54
264.19	0.01	121.78
530.19	0.02	244.70
745.69	0.01	344.28

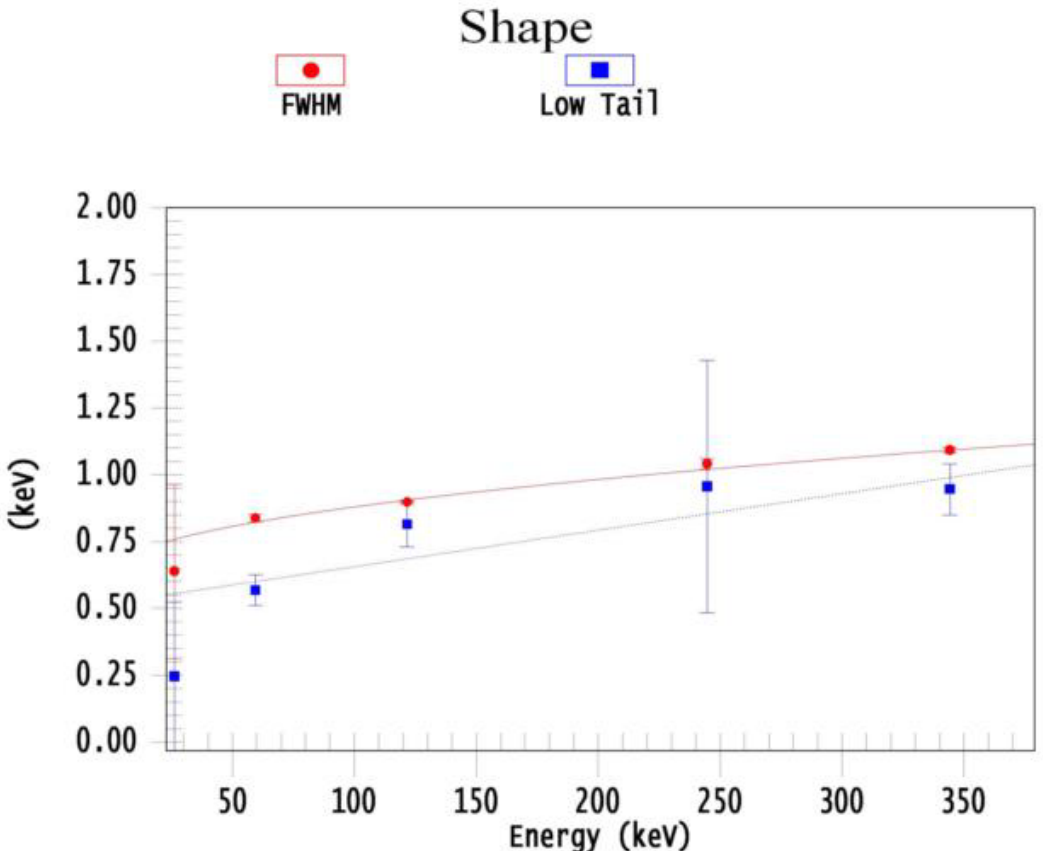
Approved by: _____

Date: _____



Energy Calibration Results Table

Energy (keV)	FWHM Channels	FWHM Error	TAIL Channels	TAIL Error
26.34	1.38	0.71	0.53	0.60
59.54	1.81	0.03	1.23	0.12
121.78	1.94	0.02	1.76	0.18
244.70	2.25	0.04	2.07	1.02
344.28	2.36	0.02	2.05	0.21


Shape
FWHM
Low Tail
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
(keV)
50
100
150
200
250
300
350
Energy (keV)

Energy Calibration

Calibration Information

Calibration Title	Energy Calibration (I-125) 3/16/2011 3:02 PM
Calibration Date	3/16/2011 3:03:00 PM
Performed By	David Georgeson
Count Used	Calibration Count 3/16/2011 12:56 PM
Is Default	Yes

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle

Detector Group Information

Detector Group Name	Summed
Calibration Source	Am241/Eu152 RMC II-1
Analysis Sequence File	
Nuclide Library	Am-241/Eu-152.NLB
Peak Search Library	Am-241/Eu-152.NLB

Energy Calibration Coefficients

$$\text{Energy} = -0.365335 + 0.46262 * ch - 4.49624e\text{-}07 * ch^2$$

$$\text{FWHM} = 0.848541 + 0.025188 * E^{1/2}$$

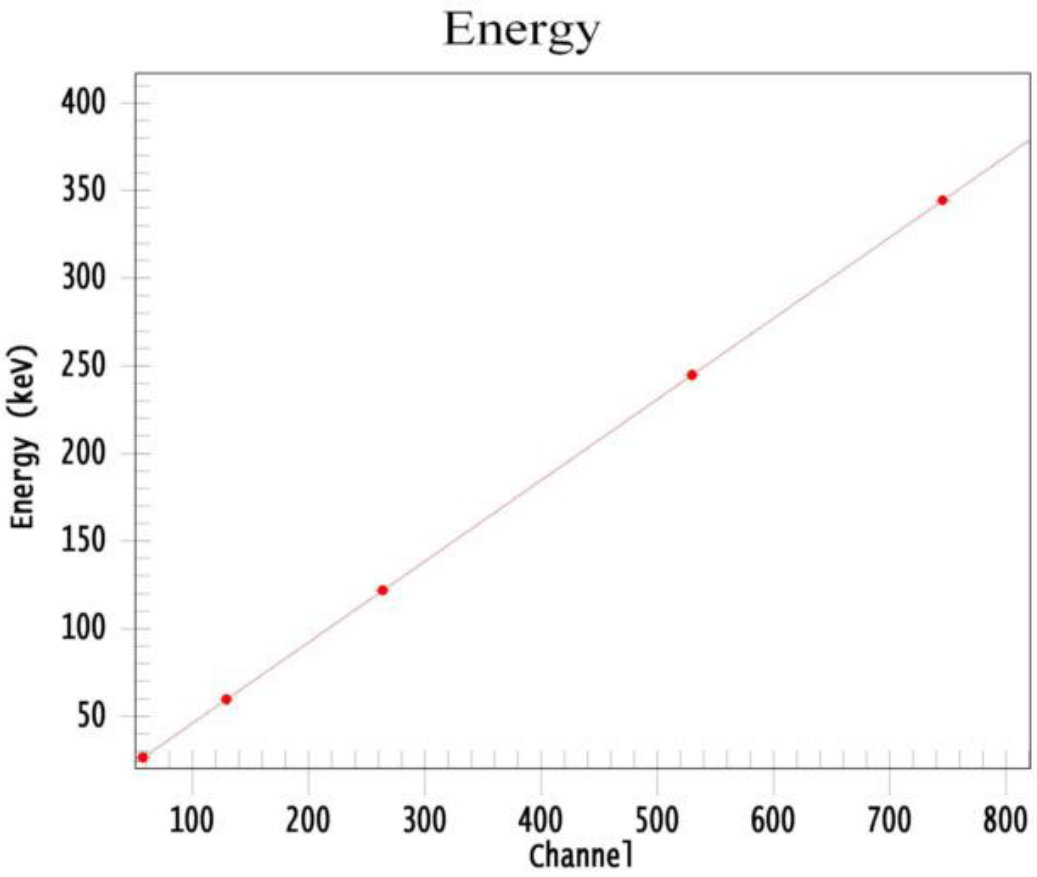
$$\text{LOW TAIL} = 0.623077 + 0.00135443 * E$$

Energy Calibration Results Table

Centroid Channel	Centroid Error	Energy (keV)
57.52	0.17	26.34
129.52	0.01	59.54
264.08	0.02	121.78
530.03	0.02	244.70
745.53	0.01	344.28

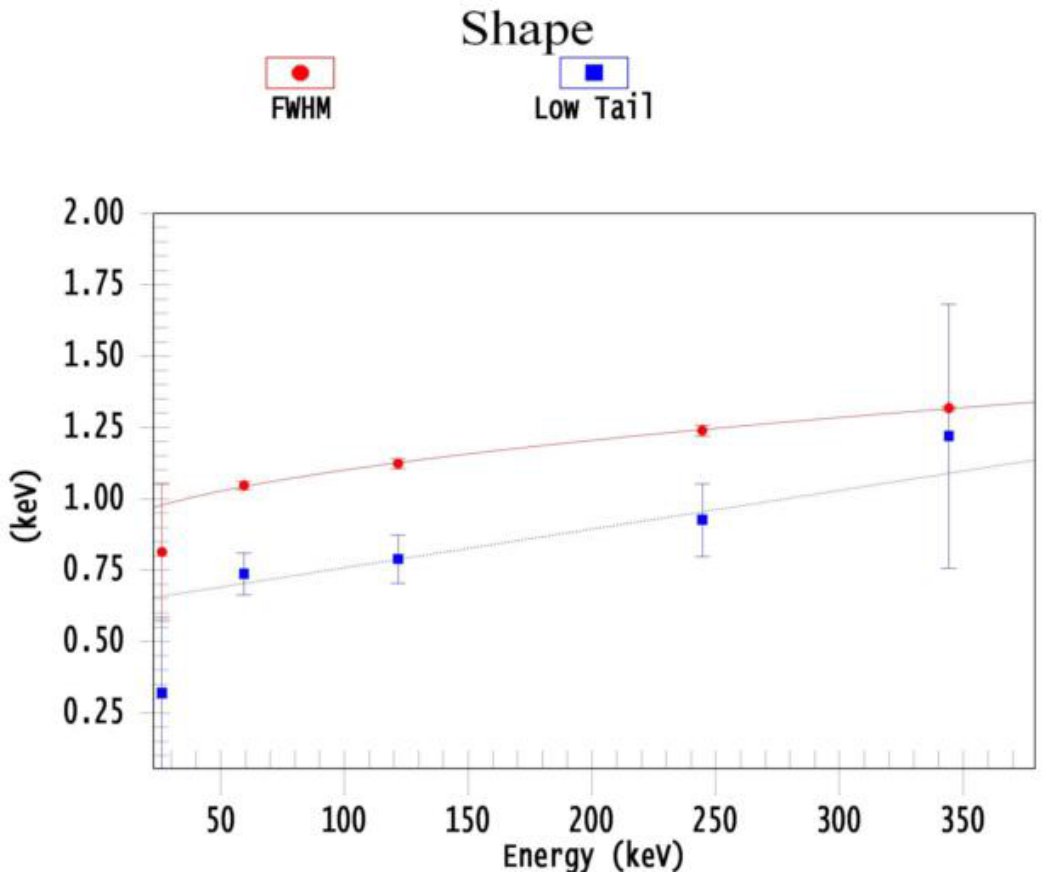
Approved by: _____

Date: _____



Energy Calibration Results Table

Energy (keV)	FWHM Channels	FWHM Error	TAIL Channels	TAIL Error
26.34	1.76	0.52	0.69	0.57
59.54	2.26	0.03	1.59	0.16
121.78	2.43	0.04	1.70	0.18
244.70	2.68	0.04	2.00	0.27
344.28	2.85	0.02	2.64	1.00


Shape
FWHM
Low Tail
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
(keV)
50
100
150
200
250
300
350
Energy (keV)

Appendix D

Efficiency Calibration Documentation

Appendix D
Efficiency Calibration Documentation

Efficiency Calibration

Calibration Information

Calibration Title	Efficiency Calibration (I-125) 3/16/2011 4:31 PM
Calibration Date	3/16/2011 4:29:50 PM
Performed By	David Georgeson
Count Used	Calibration Count 3/16/2011 12:56 PM
Approved	3/16/2011 4:31:59 PM by David Georgeson
Is Default	Yes
Is Multi Curve	No

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle
Counter Configuration	Thyroid - I-125

Detector Group Information

Detector Group Name	Summed
Calibration Source	Am241/Eu152 RMC II-1
Analysis Sequence File	CALWBCGE for I-125.ASF
Nuclide Library	Am-241/Eu-152.NLB
Peak Search Library	Am-241/Eu-152.NLB

Approved by: _____

Date: _____

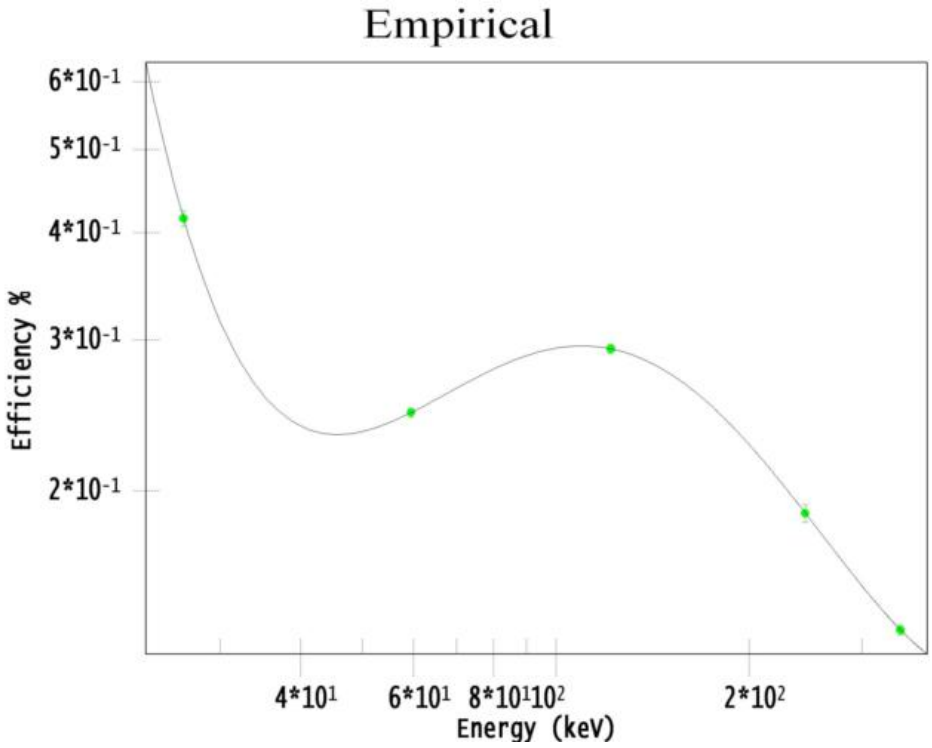
User: David Georgeson

Efficiency Triplets

Energy (keV)	Efficiency	Error	Dual	Difference
2.634E+001	4.155E-003	8.731E-005	3.389E-003	18.43 %
5.954E+001	2.468E-003	2.964E-005	3.031E-003	-22.83 %
1.218E+002	2.928E-003	3.550E-005	2.444E-003	16.55 %
2.447E+002	1.883E-003	4.280E-005	1.782E-003	5.38 %
3.443E+002	1.377E-003	1.824E-005	1.470E-003	-6.78 %

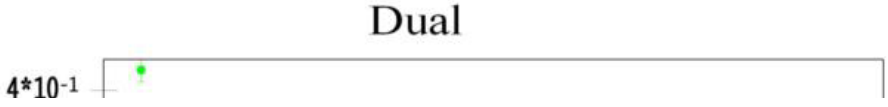
Empirical

ln(eff) = - 6.02946 + 0.756669 * x - 0.579472 * x^2 - 0.381448 * x^3 + 0.283555 * x^4
where x = ln(185.311 / E)
where E = Energy in keV



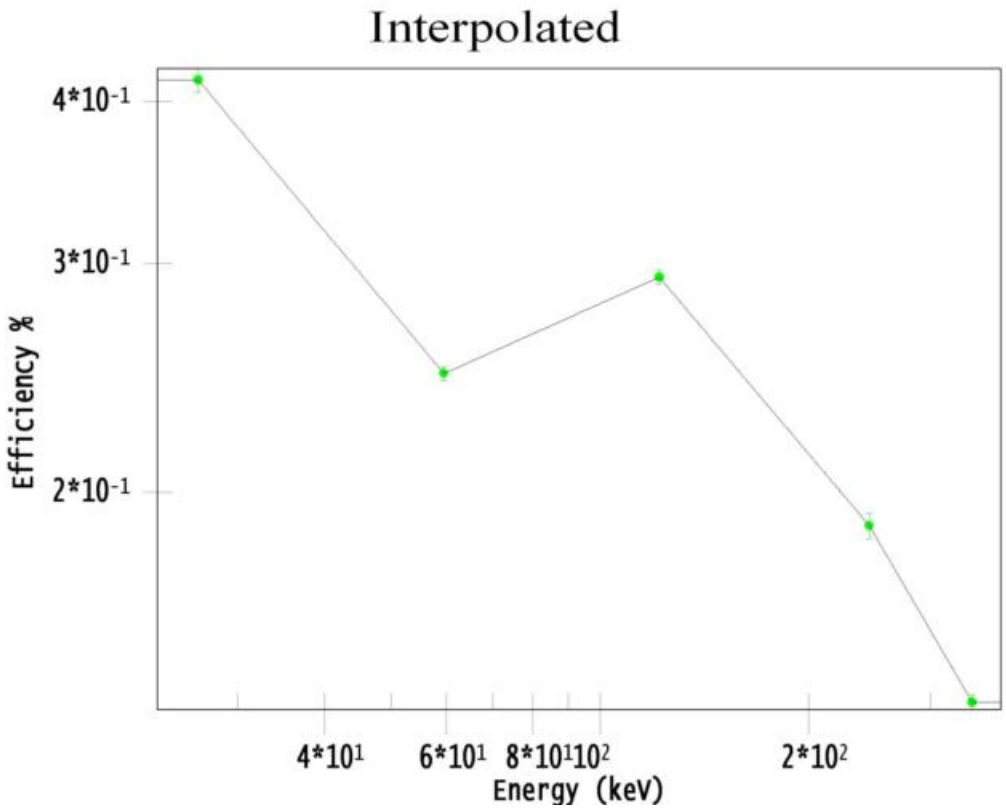
Dual

ln(eff) = - 6.67176 + 0.651547 * ln(E) - 0.107164 * (ln(E))^2
where E = Energy in keV



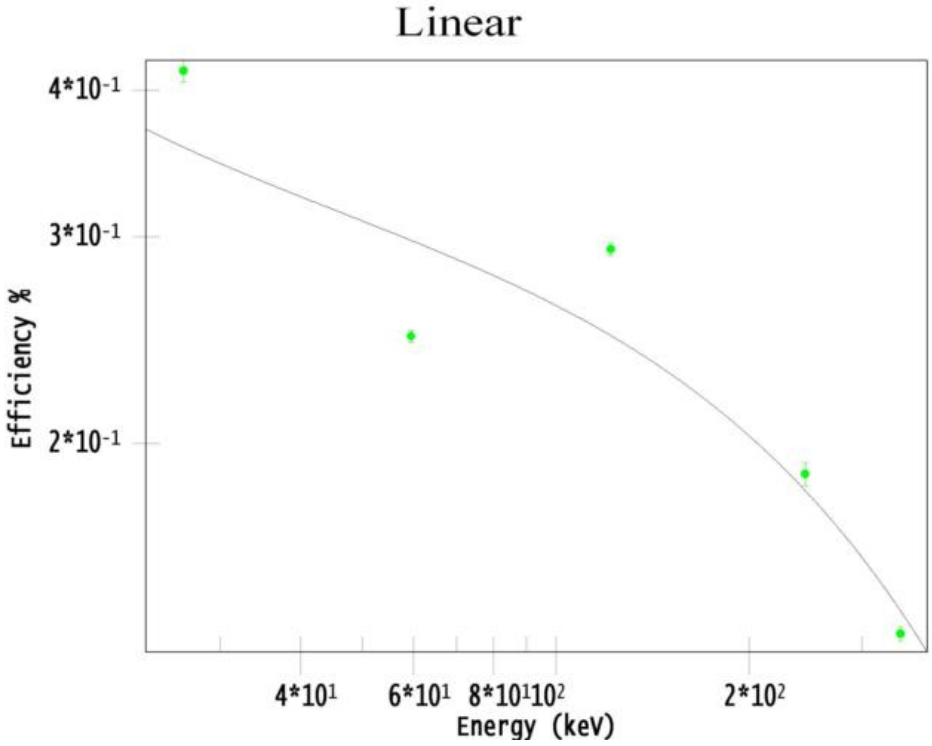
User: David Georgeson

Interpolated



Linear

log(eff) = - 0.00100278 * E - 2.50288 + 2.17845 / E
where E = Energy in keV



User: David Georgeson

Appendix E

I-125 Calibration Count Reanalysis Summary

Appendix E
I-125 Calibration Count Reanalysis Summary

Summary of the Reanalysis of the Efficiency Calibration Count
For I-125 Calibration Using Am-241/Eu152

Arrangement/Geometry: Accuscan II
Analysis Library: Am-241/Eu-152 for I-125.NLB
Energy Calibration Time: 03/16/2011 3:02 PM
Efficiency Calibration Time: 03/16/2011 4:31 PM
Count Live Time: 7223 Seconds
Count Start Time: 3/16/2011 12:56 PM

Nuclide/ Energy (keV)	Expected Activity (µCi)	Observed Activity (µCi)	Relative Bias
Am-241/26.26	210	275.3	0.311
Am-241/59.54	210	211.9	0.009
Eu-152/121.8	180	180.400	0.002
Eu-152/244.7	180	181.100	0.006
Eu-152/344.3	180	178.200	-0.010
		average	0.064

Created 4/27/2011 10:28:10 AM
Idaho Falls Id.
Battelle Energy Alliance LLC

Analysis Report - Calibration Count 3/16/2011 12:56 PM

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Thyroid - I-125

COUNT INFORMATION

Count Operation	Calibration Count
Comment	
Intake Date	
Acquisition Started	3/16/2011 12:56:49 PM
Acquisition Time	7223.15
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate	Live Time	Analyzed	Analyzed Date	File Name
Left	60.77	1 - 4096	7200.0	No		b065b30a1256.cnf
Right	61.51	1 - 4096	7200.0	No		11cc05321256.cnf
Summed	0.00	1 - 4096	7200.0	Yes	4/27/2011 10:27:59 AM	0d528c651256.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 10:27:59 AM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	Am241/Eu152 for I-125
Tentative NID Library	Am241/Eu152 for I-125
Peak Search Library	Am241/Eu152 for I-125
Analysis Limits (channels)	20 - 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	26.55	11.92	1.37E+003	8.21E+003	Unknown	5.788608E-003		100.00
M	2	57.55	26.26	7.37E+003	7.18E+003	Am-241	2.752849E+002	2.51 %	2.40
m	3	65.54	29.95	4.19E+003	1.20E+004	Unknown	4.971242E+000		100.00
m	4	75.78	34.69	8.06E+003	1.45E+004	Unknown	1.158900E+001		100.00
m	5	80.20	36.73	1.07E+004	1.65E+004	Unknown	1.607184E+001		100.00
m	6	86.89	39.83	5.92E+004	2.14E+004	Unknown	9.303807E+001		100.00
M	7	99.00	45.43	1.07E+004	1.89E+004	Unknown	1.733585E+001		100.00
m	8	107.88	49.54	5.45E+002	2.17E+004	Unknown	8.741777E-001		100.00
	9	129.50	59.54	4.97E+004	1.49E+004	Am-241	2.119438E+002	1.43 %	35.70
	10	264.08	121.77	4.00E+004	9.77E+003	EU-152	1.804203E+002	1.44 %	28.40
	11	530.03	244.71	6.81E+003	4.09E+003	EU-152	1.811926E+002	3.58 %	7.49
	12	640.53	295.77	3.66E+002	2.31E+003	Unknown	8.751176E-001		100.00
	13	745.55	344.29	1.74E+004	1.94E+003	EU-152	1.782479E+002	1.68 %	26.60
	14	796.32	367.74	3.29E+002	1.65E+003	Unknown	9.400238E-001		100.00
	15	890.16	411.08	1.27E+003	1.15E+003	Unknown	3.833098E+000		100.00
	16	961.38	443.97	1.50E+003	1.09E+003	Unknown	4.647649E+000		100.00
	17	1058.58	488.85	2.34E+002	1.05E+003	Unknown	7.219349E-001		100.00
	18	1106.81	511.12	7.33E+002	1.08E+003	Unknown	2.223503E+000		100.00
	19	1221.17	563.90	1.86E+002	8.24E+002	Unknown	5.279418E-001		100.00
	20	1491.24	688.51	2.61E+002	5.71E+002	Unknown	5.430381E-001		100.00
	21	1557.27	718.97	1.27E+002	6.09E+002	Unknown	2.381721E-001		100.00
	22	1686.70	778.66	3.94E+003	8.74E+002	Unknown	5.839245E+000		100.00
	23	1878.37	867.02	1.16E+003	7.36E+002	Unknown	1.145140E+000		100.00
M	24	1990.58	918.73	1.26E+002	4.11E+002	Unknown	9.486010E-002		100.00
m	25	2005.07	925.41	8.29E+001	4.16E+002	Unknown	6.002627E-002		100.00

	26	2087.90	963.58	3.83E+003	4.69E+002	Unknown	2.239571E+000		100.00
	27	2177.45	1004.84	1.38E+002	3.31E+002	Unknown	6.315312E-002		100.00
M	28	2351.65	1085.07	2.39E+003	3.56E+002	Unknown	6.641177E-001		100.00
m	29	2360.33	1089.07	3.33E+002	4.61E+002	Unknown	9.008405E-002		100.00
	30	2408.52	1111.26	3.21E+003	3.52E+002	Unknown	7.509426E-001		100.00
	31	2628.00	1212.29	2.69E+002	3.15E+002	Unknown	3.146647E-002		100.00

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 (%)**
	32	3052.74	1407.70	4.05E+003	1.32E+002	Unknown	1.092345E-		100.00
M	33	3161.55	1457.74	3.17E+002	7.80E+001	Unknown	5.747485E-		100.00
m	34	3167.10	1460.29	3.50E+002	7.65E+001	Unknown	6.232102E-		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)**
	EU-152	1.000	1.796259E+00	1.05 %	Not Performed	Not Performed	2.545E+000
	Am-241	1.000	2.221031E+00	1.25 %			3.074E+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

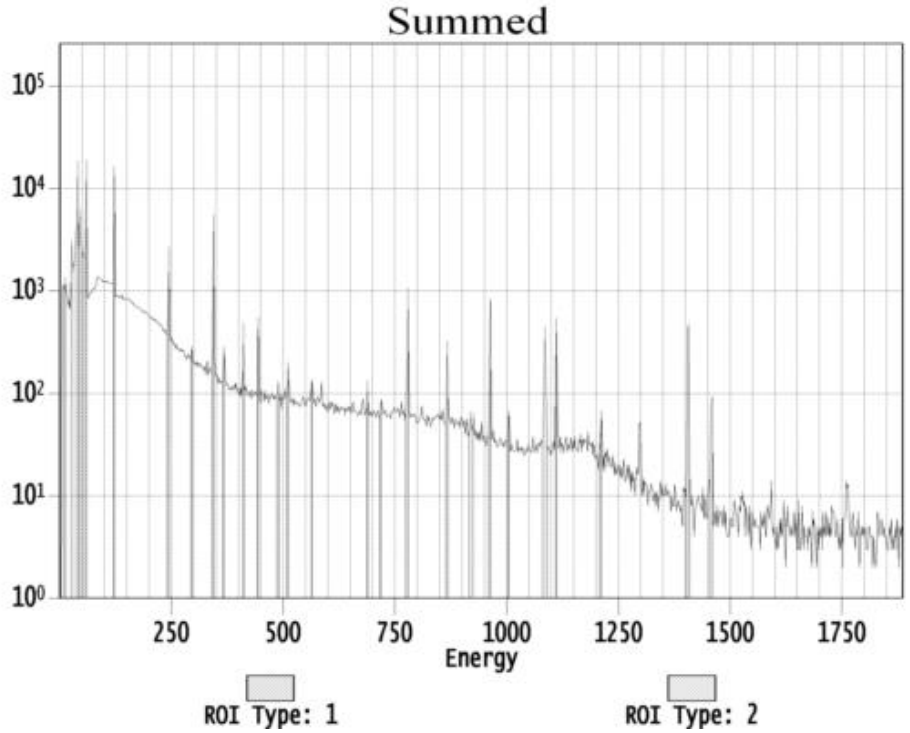
! = Nuclide was corrected for parent/daughter

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide	**Energy (keV)**	**Yield (%)**	**Line MDA**	**Nuclide MDA**	**Activity (nCi)**
+	EU-152	121.78 *	28.40	2.5446E+000		1.8042E+002
+		244.70 *	7.49	1.0491E+001	2.5446E+000	1.8119E+002
+		344.28 *	26.60	2.8828E+000		1.7825E+002
+	Am-241	26.30 *	2.40	1.0422E+001	3.0736E+000	2.7528E+002
+		59.54 *	35.70	3.0736E+000		2.1194E+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
ROI Type: 2

Appendix F

Accuscan II I-125 Calibration Verification

Appendix F
Accuscan II I-125 Calibration Verification

Created 4/26/2011 5:22:10 PM
Idaho Falls Id.
Battelle Energy Alliance LLC

Efficiency Verification

Calibration Information

Calibration Title	Efficiency Calibration (I-125) 3/16/2011 4:31 PM
Calibration Date	3/16/2011 4:29:50 PM
Operator Name	David Georgeson
Detector Group	Summed
Detector Group	Thyroid Screening
Source Distribution	Thyroid

Counter Information

Counter Name	Accuscan II
Counter Location	Battelle
Counter	Thyroid - I-125

Count List

Num	Date	Name
1	3/16/2011	Verification Count 3/16/2011 3:13 PM (1/5)
2	3/16/2011	Verification Count 3/16/2011 3:13 PM (2/5)
3	3/16/2011	Verification Count 3/16/2011 3:13 PM (3/5)
4	3/16/2011	Verification Count 3/16/2011 3:13 PM (4/5)
5	3/16/2011	Verification Count 3/16/2011 3:13 PM (5/5)

Source Certificate Am241/Eu152 RMC II-1

Nuclide	Energy	Certificate Activity (g/s)	Half Life	Count 1	Count 2	Count 3	Count 4	Count 5	Relative Bias (%)	Relative Precision (%)
Am-241	13.93	1900.00	432.19 y	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	-	-
Am-241	17.51	2370.00	432.19 y	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	-	-
Am-241	20.98	568.00	432.19 y	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	-	-
Am-241	26.34	186.00	432.19 y	0.00 0.00	163.88 186.00	165.68 186.00	189.54 186.00	0.00 0.00	-6.97 %	6.29 %
Am-241	59.54	2770.00	432.19 y	2787.36 2769.97	2734.35 2769.97	2786.32 2769.97	2727.81 2769.97	3065.74 2769.97	1.82 %	4.52 %
EU-152	121.78	1890.00	4946.21 d	1796.42 1889.30	1991.97 1889.30	1855.09 1889.30	1938.08 1889.30	1902.02 1889.30	0.39 %	3.56 %
EU-152	244.70	500.00	4946.22 d	421.53 499.82	443.33 499.81	471.88 499.81	570.06 499.81	573.26 499.81	-0.76 %	12.77 %
EU-152	344.28	1770.00	4946.22 d	1783.19 1769.35	1770.16 1769.34	1635.56 1769.34	1851.77 1769.34	1785.85 1769.34	-0.23 %	4.00 %
								|xbar| =	2.03 %	6.23 %

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 SUMMARY CALCULATIONS FROM COUNT DATA

MDA CALCULATION For I-125

ACCUSCAN II COUNTER

MDA Calculations

Arrangement Geometry: Thyroid
Analysis Library: I-125 Thyroid.nlb
Energy Calibration Time: 3/16/2011 3:02 PM
Efficiency Calibration Time: 3/16/2011 4:31 PM
Count Type/Live Time: 600 Seconds
Count Start Times:

1. 3/23/11 4:19 PM
2. 3/23/11 4:32 PM
3. 3/23/11 4:44 PM

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 = 600 seconds

Nuclide/Energy	#1 Count (MDA) (nCi)	#2 Count (MDA) (nCi)	#3 Count (MDA) (nCi)	Average (nCi)
I-125/27 keV	1.99E+00	2.03E+00	3.10E+00	2.57E+00
I-125/31 keV	6.01E+00	7.35E+00	6.59E+00	6.97E+00

Analysis Report - I-125 Validation Count [000-125]

SOURCE INFORMATION

Primary ID	000-125
Last Name	Validation Count
First Name	I-125
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Thyroid - I-125

COUNT INFORMATION

Count Operation	Individual 10 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/23/2011 4:19:49 PM
Acquisition Time	601.24
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
Left	13.30	1 - 4096	600.0	No
Right	14.40	1 - 4096	600.0	No
Summed	27.65	1 - 4096	600.0	Yes

Primary Review by: _____

Date: _____

User: David Georgeson

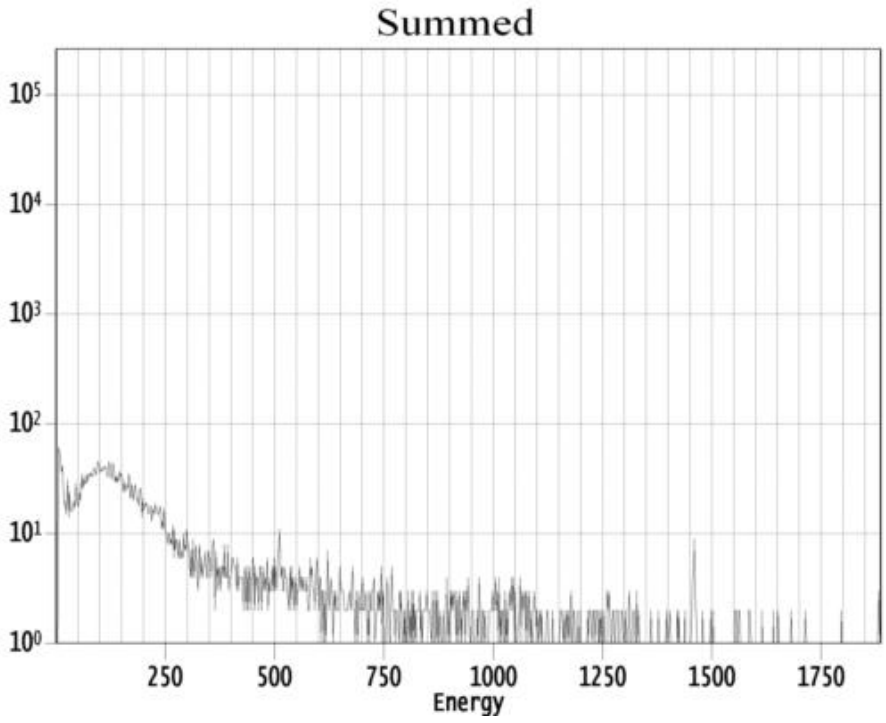
DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/23/2011 4:19:39 PM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	I-125 Thyroid.nlb
Tentative NID Library	I-125 Thyroid.nlb
Peak Search Library	I-125 Thyroid.nlb
Analysis Limits (channels)	20 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide Name	Energy (keV)	Yield (%)	Line MDA (nCi)
	I-125	27.00	40.25	1.9877E+000
		31.00	12.50	6.0148E+000

* = Energy Line found in the spectrum



Analysis Report - I-125 Validation Count [000-125]

SOURCE INFORMATION

Primary ID	000-125
Last Name	Validation Count
First Name	I-125
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Thyroid - I-125

COUNT INFORMATION

Count Operation	Individual 10 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/23/2011 4:32:40 PM
Acquisition Time	601.35
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
Right	14.62	1 - 4096	600.0	No
Left	13.44	1 - 4096	600.0	No
Summed	27.98	1 - 4096	600.0	Yes

Primary Review by: _____

Date: _____

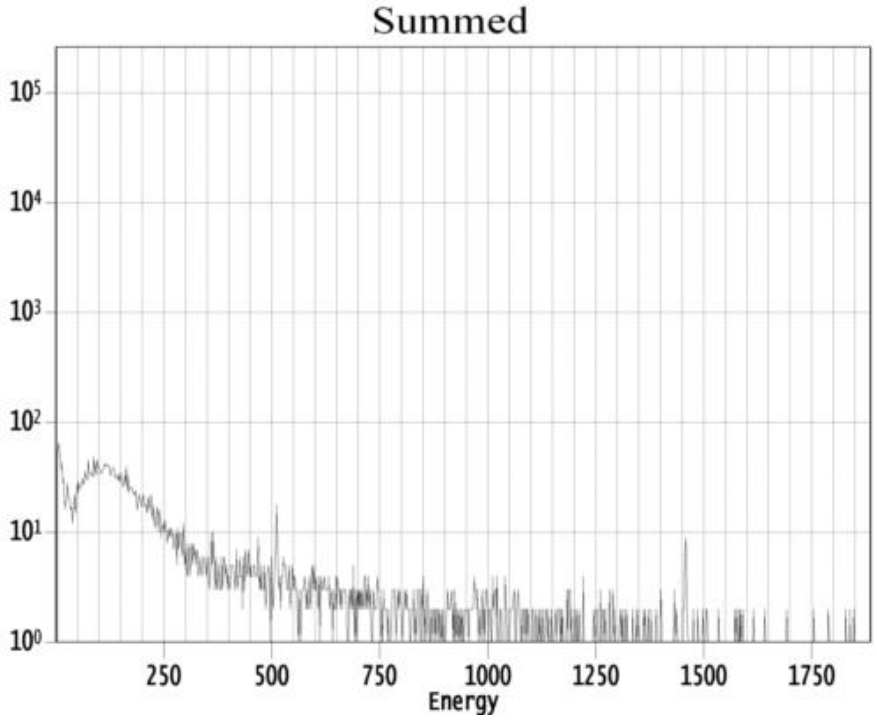
DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/23/2011 4:32:13 PM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	I-125 Thyroid.nlb
Tentative NID Library	I-125 Thyroid.nlb
Peak Search Library	I-125 Thyroid.nlb
Analysis Limits (channels)	20 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide Name	Energy (keV)	Yield (%)	Line MDA (nCi)
	I-125	27.00	40.25	2.0337E+000
		31.00	12.50	7.3530E+000

* = Energy Line found in the spectrum



User: David Georgeson

Analysis Report - I-125 Validation Count [000-125]

SOURCE INFORMATION

Primary ID	000-125
Last Name	Validation Count
First Name	I-125
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Thyroid - I-125

COUNT INFORMATION

Count Operation	Individual 10 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/23/2011 4:44:28 PM
Acquisition Time	601.4299999
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
Left	13.44	1 - 4096	600.0	No
Right	14.72	1 - 4096	600.0	No
Summed	28.11	1 - 4096	600.0	Yes

Primary Review by: _____

Date: _____

User: David Georgeson

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/23/2011 4:44:20 PM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	I-125 Thyroid.nlb
Tentative NID Library	I-125 Thyroid.nlb
Peak Search Library	I-125 Thyroid.nlb
Analysis Limits (channels)	20 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis					
	No	**Peak Centroid**	**Energy (keV)**	**Net Peak Area**	**Continuum Counts**
	1	57.75	26.35	7.98E+001	1.06E+002

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)**
	I-125	0.987	2.152364E+000	32.42 %

? = Nuclide is part of an undetermined solution

X = Nuclide rejected by the interference analysis

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

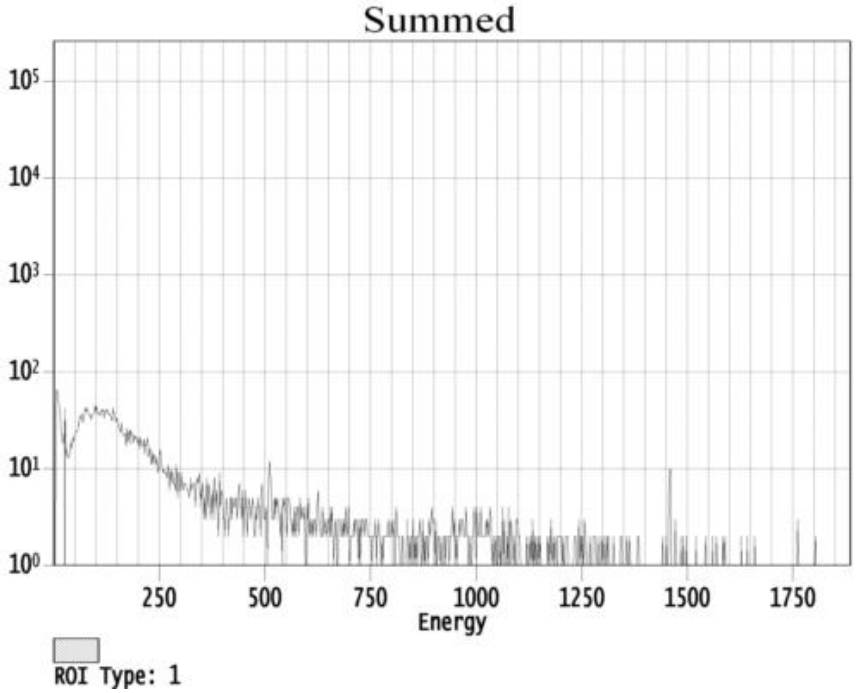
! = Nuclide was corrected for parent/daughter

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide Name	**Energy (keV)**	**Yield (%)**	**Line MDA (nCi)**
+	I-125	27.00 *	40.25	3.1088E+000
+		31.00	12.50	6.5948E+000

+ = Nuclide Identified during the nuclide identification

* = Energy Line found in the spectrum



User: David Georgeson

Appendix H

Calibration Validation using I-125

Appendix H
Calibration Validation using I-125

Summary

Calibration Validation Counts
Accuscan II Calibration Validation for I-125 Thyroid

Arrangement/Geometry: Thyroid
Analysis Library: I-125 Thyroid.nlb
Energy Calibration Date: 3/16/2011 3:02 PM
Efficiency Calibration Date: 3/16/2011 4:31 P
Count Live Time: 600 Seconds
Count Start Times:
Count # 1 - 03/23/2011 3:09 PM
Count # 2 - 03/23/2011 3:25 PM
Count # 3 - 03/23/2011 3:41 PM
Count # 4 - 03/23/2011 3:53 PM
Count # 5 - 03/23/2011 4:05 PM

Nuclide/ Energy (keV)	Expected Activity (nCi)	Observed Activity (nCi) #1	#2	#3	#4	#5	Relative Bias	Relative Precision
I-125/27	102.0000	98.600	97.800	95.600	97.300	96.700	-0.047	0.011
I-125/31	102.0000	102.600	105.100	101.900	98.000	86.200	-0.032	0.073
						Average	-0.040	0.042

COUNT 1

Created 3/23/2011 3:27:01 PM
Idaho Falls Id.
Battelle Energy Alliance LLC

Analysis Report - I-125 Validation Count [000-125]

SOURCE INFORMATION

Primary ID 000-125
Last Name Validation Count
First Name I-125
Height (in)
Weight (lb)
Chest Wall Thickness (cm)

COUNTER INFORMATION

Counter Name Accuscan II
Counter Location Battelle
Configuration Name Thyroid - I-125

COUNT INFORMATION

Count Operation Individual 10 minutes
Count Reason Routine operation
Frequency
Comment
Intake Date
Acquisition Started 3/23/2011 3:09:07 PM
Acquisition Time 601.5
Operator Name David Georgeson
Count Status Not Reviewed
Primary Review No
Secondary Review No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate	Live Time	Analyzed	Analyzed Date	File Name
Left	18.69	1 - 4096	600.0	No		9dab9d661508.cnf
Right	20.50	1 - 4096	600.0	No		0cbf77fc1508.cnf
Summed	39.07	1 - 4096	600.0	Yes	3/23/2011 3:08:58 PM	03ddb8681508.cnf

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

Date: _____ **Date:** _____

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/23/2011 3:08:58 PM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	I-125 Thyroid.nlb
Tentative NID Library	I-125 Thyroid.nlb
Peak Search Library	I-125 Thyroid.nlb
Analysis Limits (channels)	20 - 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	59.77	27.28	3.36E+003	9.29E+002	I-125	9.859657E+001	3.75 %	40.25
m	2	67.89	31.04	8.51E+002	5.16E+002	I-125	1.026382E+002	9.08 %	12.50
m	3	77.23	35.36	2.48E+002	2.24E+002	Unknown	4.359149E+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>

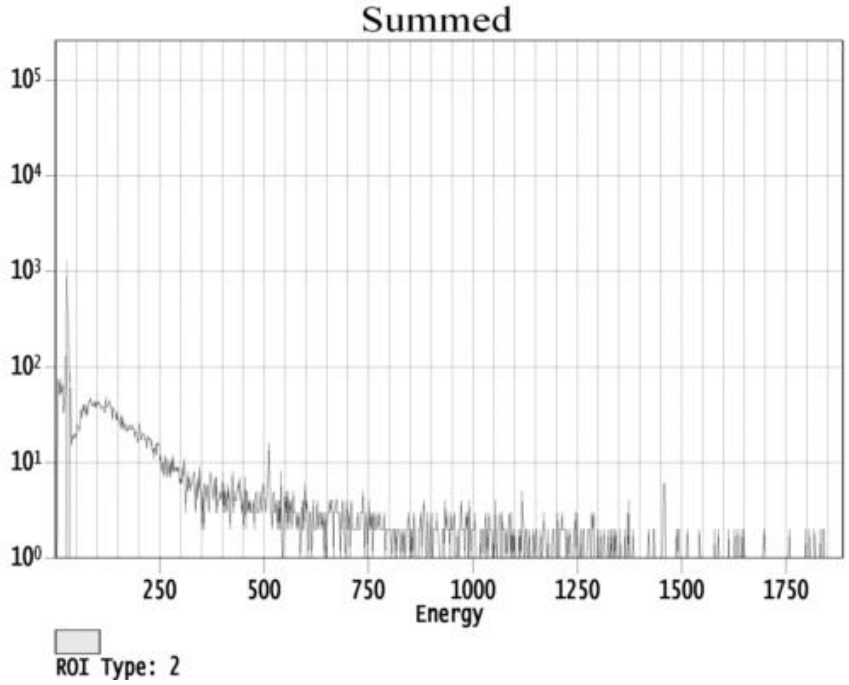
	Nuclide Name	**Id Confidence**	**Wt Mean Activity (nCi)**	**Error (1SD)**	**Action Level 1**	**Action Level 2**	**MDA (nCi)**
	I-125	0.997	9.914710E+001	3.47 %	Not Performed	Not Performed	5.971E+000

? = 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	**Energy (keV)**	**Yield (%)**	**Line MDA**	**Nuclide MDA**	**Activity (nCi)**
+	I-125	27.00 *	40.25	5.9705E+000	5.9705E+000	9.8597E+001
+		31.00 *	12.50	1.8374E+001		1.0264E+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: 2

COUNT 2

Analysis Report - I-125 Validation Count [000-125]

SOURCE INFORMATION

Primary ID	000-125
Last Name	Validation Count
First Name	I-125
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Thyroid - I-125

COUNT INFORMATION

Count Operation	Individual 10 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/23/2011 3:25:54 PM
Acquisition Time	601.42
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate	Live Time	Analyzed
Right	20.18	1 - 4096	600.0	No
Left	18.42	1 - 4096	600.0	No
Summed	38.58	1 - 4096	600.0	Yes

Primary Review by: _____

Date: _____

User: David Georgeson

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/23/2011 3:25:12 PM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	I-125 Thyroid.nlb
Tentative NID Library	I-125 Thyroid.nlb
Peak Search Library	I-125 Thyroid.nlb
Analysis Limits (channels)	20 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

Peak Analysis					
	No	**Peak Centroid**	**Energy (keV)**	**Net Peak Area**	**Continuum Counts**
	1	38.01	17.22	1.76E+002	2.72E+002
M	2	59.80	27.30	3.33E+003	8.10E+002
m	3	67.75	30.98	8.74E+002	4.47E+002
m	4	77.55	35.51	2.67E+002	1.90E+002

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)**
	I-125	0.997	9.878515E+001	3.47 %

? = 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

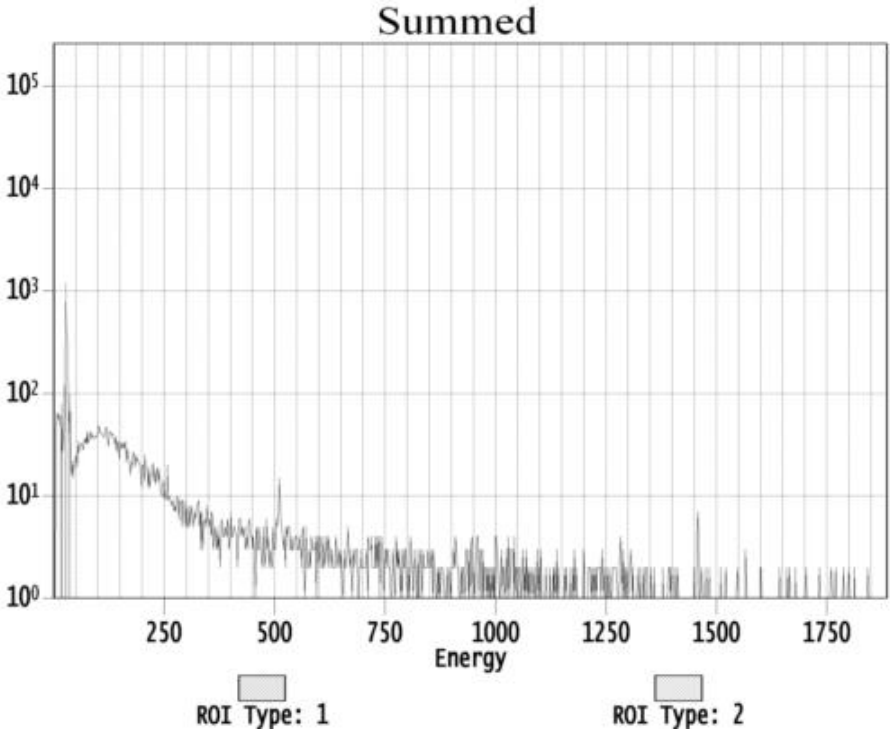
NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide	**Energy (keV)**	**Yield (%)**	**Line MDA**
+	I-125	27.00 *	40.25	5.5885E+000
+		31.00 *	12.50	1.7075E+001

+ = Nuclide Identified during the nuclide identification

* = Energy Line found in the spectrum

User: David Georgeson



User: David Georgeson

COUNT 3

Created 3/23/2011 4:06:05 PM
Idaho Falls Id.
Battelle Energy Alliance LLC

Analysis Report - I-125 Validation Count [000-125]

SOURCE INFORMATION

Primary ID	000-125
Last Name	Validation Count
First Name	I-125
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Thyroid - I-125

COUNT INFORMATION

Count Operation	Individual 10 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/23/2011 3:41:45 PM
Acquisition Time	601.39
Operator Name	David Georgeson
Count Status	Not Reviewed
Primary Review	No
Secondary Review	No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate	Live Time	Analyzed	Analyzed Date	File Name
Left	18.73	1 - 4096	600.0	No		88d02fc81541.cnf
Right	19.87	1 - 4096	600.0	No		348d689d1541.cnf
Summed	38.53	1 - 4096	600.0	Yes	3/23/2011 3:41:36 PM	644e5f9c1541.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	3/23/2011 3:41:36 PM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	I-125 Thyroid.nlb
Tentative NID Library	I-125 Thyroid.nlb
Peak Search Library	I-125 Thyroid.nlb
Analysis Limits (channels)	20 - 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	59.79	27.29	3.26E+003	8.19E+002	I-125	9.564766E+0	3.76 %	40.25
m	2	67.83	31.01	8.46E+002	6.11E+002	I-125	1.018599E+0	9.10 %	12.50
m	3	77.51	35.49	2.19E+002	2.87E+002	Unknown	3.853039E+0		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)**
	I-125	0.997	9.645958E+001	3.47 %	Not Performed	Not Performed	5.614E+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

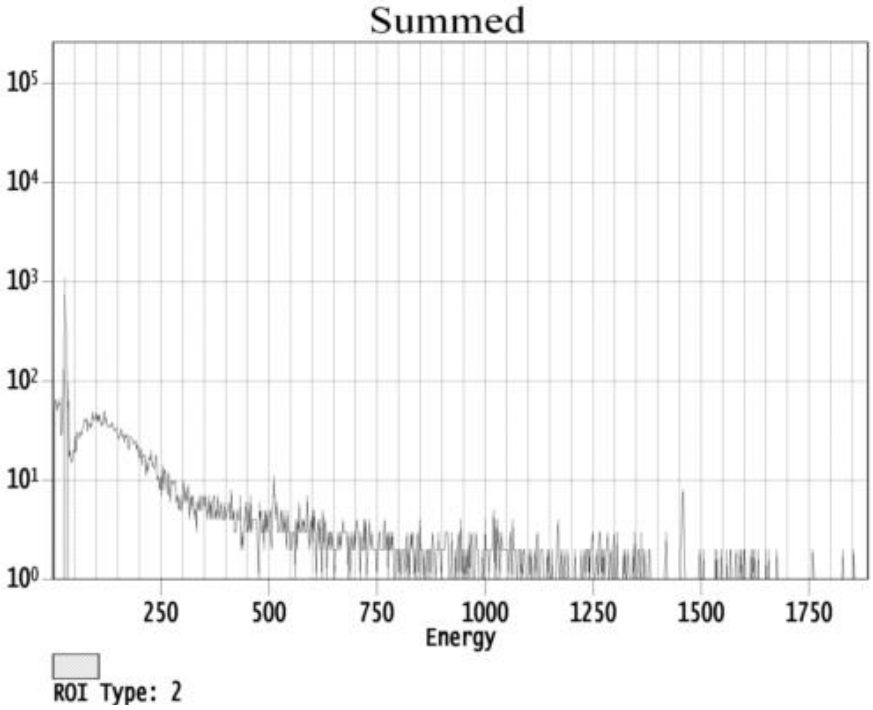
! = Nuclide was corrected for parent/daughter

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide Name	**Energy (keV)**	**Yield (%)**	**Line MDA (nCi)**	**Nuclide MDA (nCi)**	**Activity (nCi)**
+	I-125	27.00 *	40.25	5.6137E+000	5.6137E+000	9.5648E+001
+		31.00 *	12.50	1.9942E+001		1.0186E+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: 2

COUNT 4

Created 3/23/2011 4:07:12 PM
Idaho Falls Id.
Battelle Energy Alliance LLC

Analysis Report - I-125 Validation Count [000-125]

SOURCE INFORMATION

Primary ID 000-125
Last Name Validation Count
First Name I-125
Height (in)
Weight (lb)
Chest Wall Thickness (cm)

COUNTER INFORMATION

Counter Name Accuscan II
Counter Location Battelle
Configuration Name Thyroid - I-125

COUNT INFORMATION

Count Operation Individual 10 minutes
Count Reason Routine operation
Frequency
Comment
Intake Date
Acquisition Started 3/23/2011 3:53:09 PM
Acquisition Time 601.41
Operator Name David Georgeson
Count Status Not Reviewed
Primary Review No
Secondary Review No

DETECTOR COUNT RATE REPORT

Detector Name	Count Rate	Count Rate	Live Time	Analyzed	Analyzed Date	File Name
Left	18.83	1 - 4096	600.0	No		5a8847391553.cnf
Right	19.97	1 - 4096	600.0	No		6f5c18931553.cnf
Summed	38.48	1 - 4096	600.0	Yes	3/23/2011 3:53:00 PM	b314935e1553.cnf

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

Date: _____ **Date:** _____

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/23/2011 3:53:00 PM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	I-125 Thyroid.nlb
Tentative NID Library	I-125 Thyroid.nlb
Peak Search Library	I-125 Thyroid.nlb
Analysis Limits (channels)	20 - 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	38.53	17.46	8.02E+001	2.98E+002	Unknown	1.426229E-		100.00
M	2	59.82	27.31	3.31E+003	7.88E+002	I-125	9.731969E+0	3.74 %	40.25
m	3	67.75	30.97	8.15E+002	5.12E+002	I-125	9.802611E+0	9.08 %	12.50
m	4	77.34	35.41	2.74E+002	1.99E+002	Unknown	4.817942E+0		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)**
	I-125	0.997	9.742112E+00	3.46 %	Not Performed	Not Performed	5.516E+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

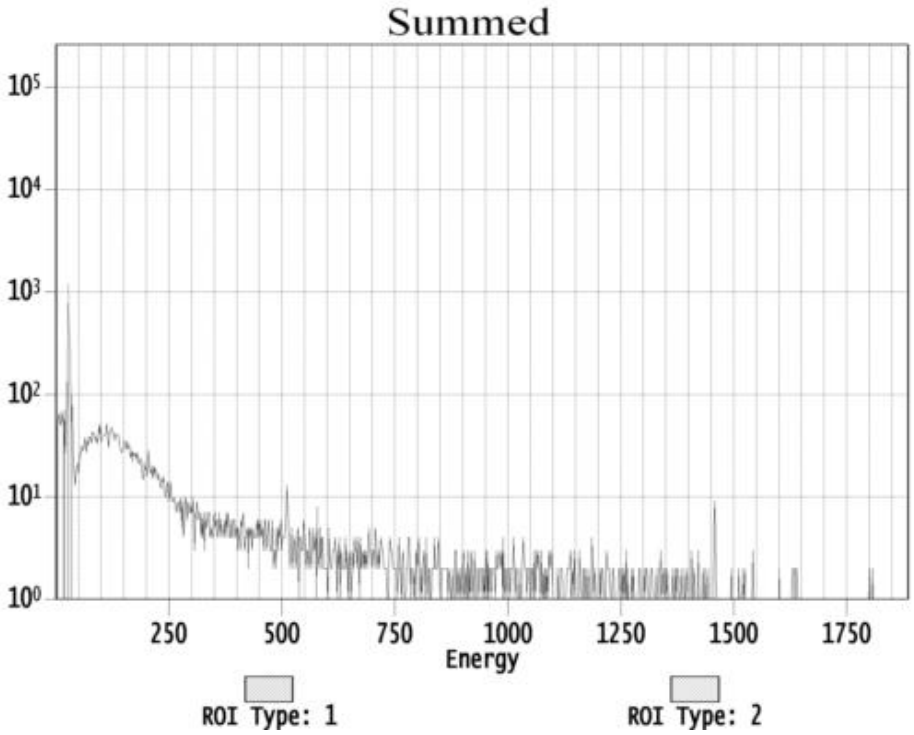
! = Nuclide was corrected for parent/daughter

NUCLIDE MDA RESULTS FOR Accuscan II <Summed>

	Nuclide	**Energy (keV)**	**Yield (%)**	**Line MDA**	**Nuclide MDA**	**Activity (nCi)**
+	I-125	27.00 *	40.25	5.5162E+000	5.5162E+000	9.7320E+001
+		31.00 *	12.50	1.8259E+001		9.8026E+001

+ = 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
ROI Type: 2

COUNT 5

Analysis Report - I-125 Validation Count [000-125]

SOURCE INFORMATION

Primary ID	000-125
Last Name	Validation Count
First Name	I-125
Height (in)	
Weight (lb)	
Chest Wall Thickness (cm)	

COUNTER INFORMATION

Counter Name	Accuscan II
Counter Location	Battelle
Configuration Name	Thyroid - I-125

COUNT INFORMATION

Count Operation	Individual 10 minutes
Count Reason	Routine operation
Frequency	
Comment	
Intake Date	
Acquisition Started	3/23/2011 4:05:06 PM
Acquisition Time	601.51
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
Left	18.59	1 - 4096	600.0	No
Right	19.96	1 - 4096	600.0	No
Summed	38.39	1 - 4096	600.0	Yes

Primary Review by: _____

Date: _____

User: David Georgeson

DETECTOR GROUP INFORMATION

Detector Group Name	Summed
Detector Group Configuration	Thyroid Screening
Analysis Date	3/23/2011 4:04:58 PM
Energy Calibration	Energy Calibration (I-125) 3/16/2011 3:02 PM
Efficiency Calibration	Efficiency Calibration (I-125) 3/16/2011 4:31 PM (Empirical)
Multi Curve	No
Source Distribution	Thyroid
Analysis Sequence File	Thyroid ASF for I-125.ASF
Bkg Acq used for area correction	Not Performed
Nuclide Identification	
Nuclide Identification Library	I-125 Thyroid.nlb
Tentative NID Library	I-125 Thyroid.nlb
Peak Search Library	I-125 Thyroid.nlb
Analysis Limits (channels)	20 - 4095
Energy Tolerance (FWHM)	1.20
Comment	

PEAK SEARCH RESULTS FOR Accuscan II <Summed>

	Peak Analysis				
	No	**Peak Centroid**	**Energy (keV)**	**Net Peak Area**	**Continuum Counts**
M	1	59.81	27.30	3.29E+003	7.58E+002
m	2	67.85	31.02	7.15E+002	5.62E+002
m	3	77.46	35.47	2.34E+002	2.71E+002
	4	3165.65	1459.62	3.79E+001	1.61E+001

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>

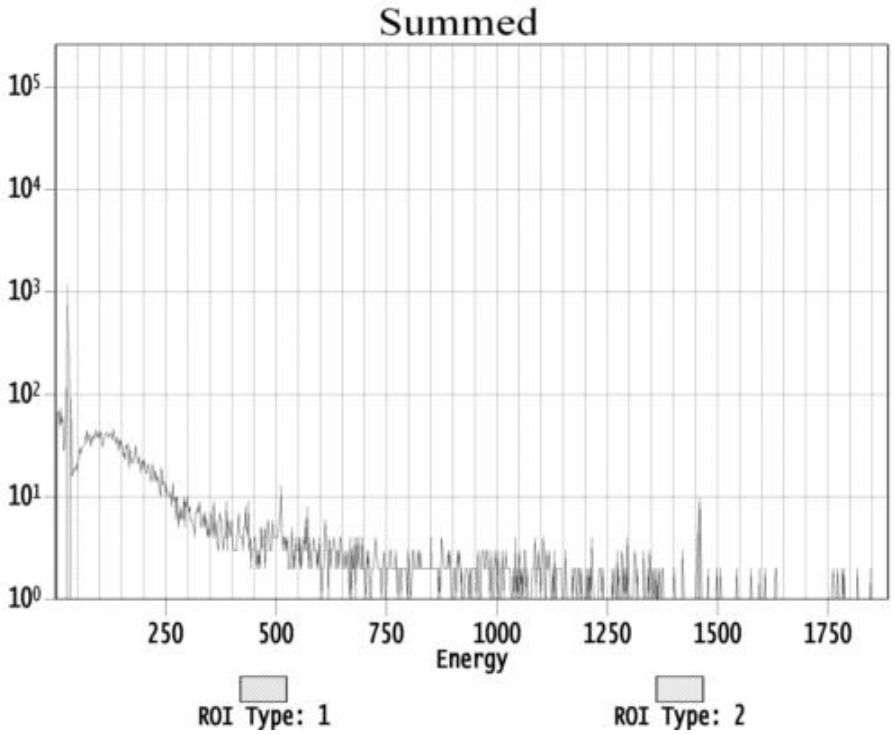
	Nuclide Name	**Id Confidence**	**Wt Mean Activity (nCi)**	**Error (1SD)**
	I-125	0.997	9.487243E+001	3.47 %

? = 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	**Energy (keV)**	**Yield (%)**	**Line MDA (nCi)**
+	I-125	27.00 *	40.25	5.4099E+000
+		31.00 *	12.50	1.9153E+001

+ = Nuclide Identified during the nuclide identification
* = Energy Line found in the spectrum



User: David Georgeson

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

H. Glauser
(Nuclear Associates, Inc)
Robert Goldman
(University of Texas)
C. Craig Harris
(Duke University Medical Center)
John U. Hilditch
(Tulane University)
Gerald J. Hine
(Veterans Administration)

William J. MacIntyre
(University Hospitals of Cleveland)
Robert A. Phillips
(Saint Luke's Hospital Center)
Theodore Vilelela
(Georgetown 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

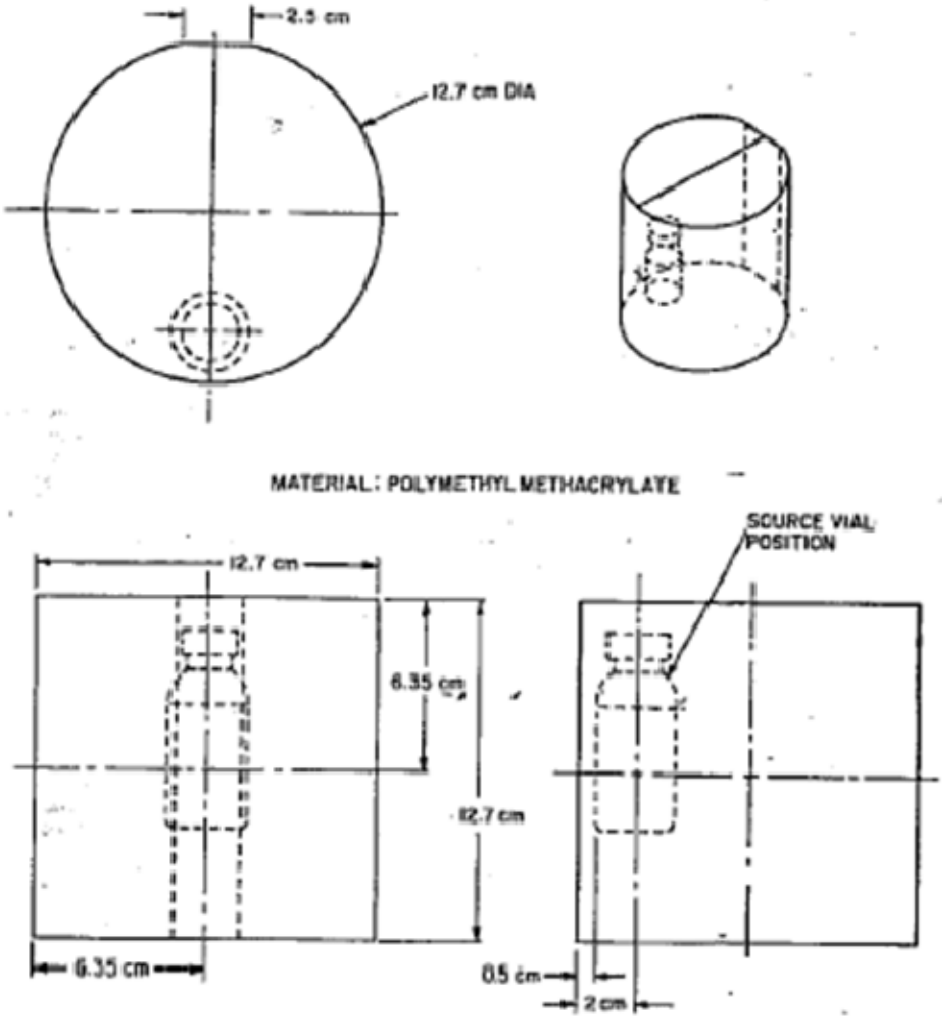
3.2.1 The neck phantom, illustrated in Fig. 1, shall be a right cylinder 12.7 cm (5 in) in diameter and 12.7 cm (5 in) in height and shall be made of polymethyl methacrylate.[1] It shall have a cylindrical cavity to accept the reference activity described in 3.1.

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 as 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, any 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 speed 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, voltage converter, 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 Sheller-Globe
Repairs (516) 741-2842 • 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.

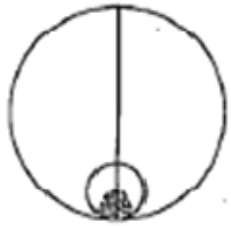
A lucite capsule holder, in the form of a dummy bottle, is also included so that the user may, if desired, count his stock of capsules to ascertain their relative activity.

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

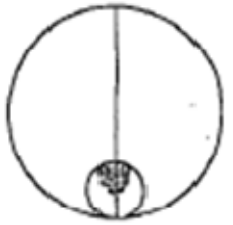
Also Available...

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

58 F54



right



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Appendix J

RMC II Transfer Phantom

Appendix J
RMC II Transfer Phantom

The Canberra RMC-II

(Model 2257) Transfer Phantom

J-1. 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.

J-2. 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.

J-3. 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" × 4" × 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.

J-4. 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 J-1. Efficiency ratio values were calculated (RMC-II phantom efficiency divided by the corresponding reference phantom efficiency) and are also shown in Table J-1.

J-5. 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 J-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 J-2 summarizes these relative bias values for each configuration and counter type tested.

The results shown in Table J-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 J-1.

Table J-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 J-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 Ratio Value00s[a]	Range of Measured Activity Relative Bias Values[b]
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

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

b. 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.

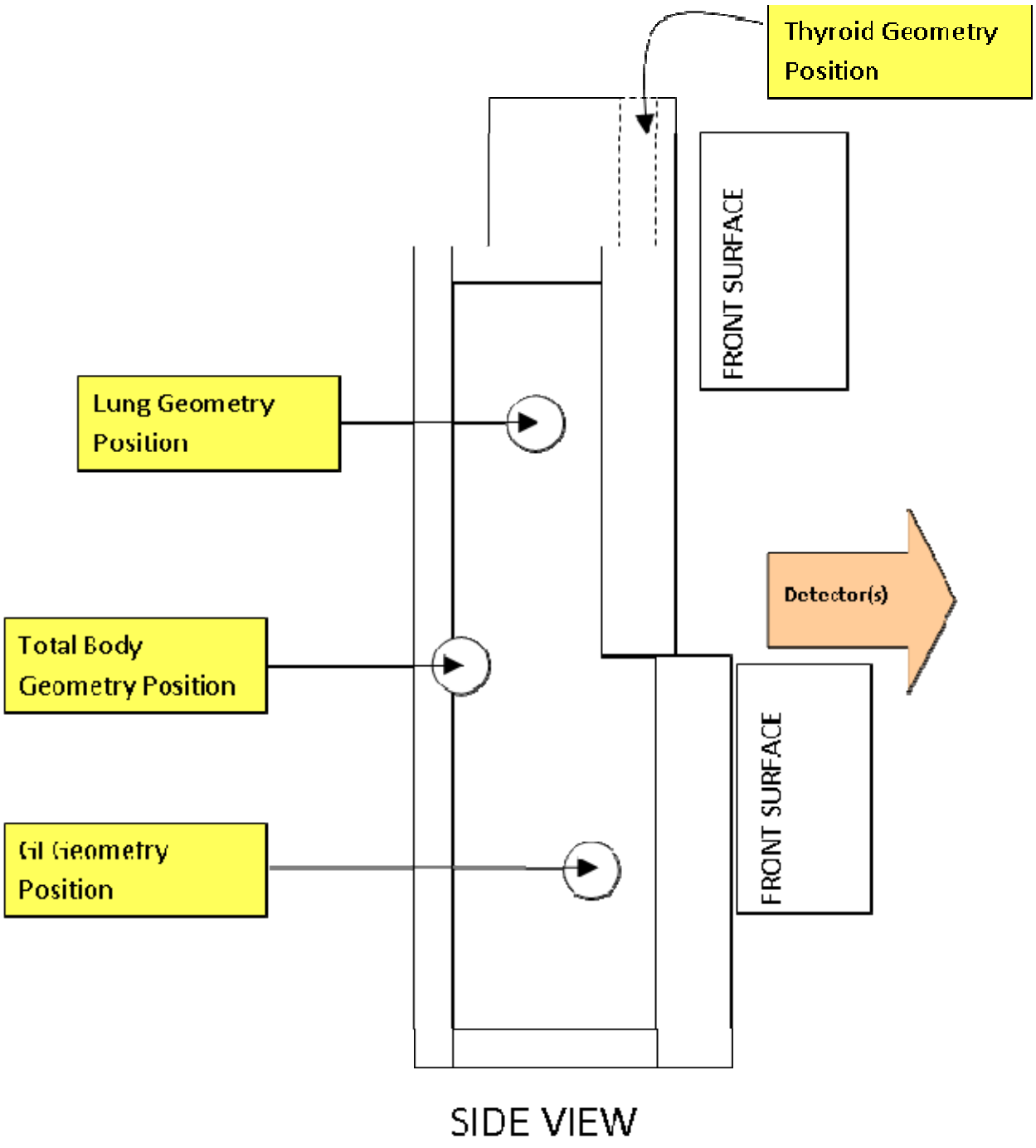

Figure J-1. Canberra RMS-II (Model 2257) WBC calibration phantom.