PARSONS

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March 4, 2002

Ms. Alicia Thorne
New York State Department of Environmental Conse' ... (NYSDEC)
Bureau of Eastern Remedial Action
Division of Hazardous Waste Remediation
625 Broadway, 11th Floor
Albany, NY 12233-7010

00767

37

SUBJECT: **Seneca Army Depot Activity – Use of the Universal Radiation Spectrum Analyzer (URSA)**

Dear Ms. Thorne:

This letter is in response to comments from the New York State Department of Health (NYSDOH) regarding the use of the Universal Radiation Spectrum Analyzer (URSA). This letter was dated September 6, 2001, and was sent under cover of the New York State Department of Environmental Conservation (NYSDEC). The letter is attached as **Attachment A**.

On August 15, 2001, Parsons' Health Physicists Mr. Ronald McConn and Mr. John Hackett gave a presentation to radiation specialists from the NYSDOH and NYSDEC. The purpose of the presentation was to demonstrate the capabilities of the URSA and explain its applications at SEAD-12 during the Phase II building surveys. While the URSA's ability to screen areas of contamination was noted, concerns were raised about its ability to quantify volumetric contamination. These concerns were reiterated in the September 6, 2001 letter from NYSDOH.

This letter addresses State concerns raised during the August 15th meeting and in the September 6th letter regarding 1) the ability of the URSA to quantify contamination; 2) the correlation of material samples and URSA instrument readings; and 3) the use of the NaI-based URSA versus the high purity Germanium (HPGe) detector at SEAD-12.

URSA's Ability to Quantify Contamination

The following issues are discussed in support of the URSA's ability to quantify contamination, if present, at Seneca:

(1) There is very limited potential for volumetric contamination at SEAD-12 or else where at Seneca;
(2) Very little change in the URSA detector response is predicted when radiological contamination is present at probable thicknesses;
(3) The MDAs achieved using the URSA are below DCGLs; and
(4) Background radioactivity can be directly subtracted from instrument readings.

Each of the points are described in detail below.

1) **There is limited potential for volumetric contamination at SEAD-12 or elsewhere at Seneca.** Of particular concern at SEAD-12 is the migration of Plutonium and Americium into porous materials. To determine the potential for Plutonium and Americium contamination intrusion into concrete over a 40-year time frame, solubility/infiltration modeling was completed. This assessment is summarized in **Attachment B** of this letter. This assessment was completed by assuming that a saturated water solution of Plutonium and Americium based on weapons grade Plutonium sits on a concrete surface for 180 days per year for 40 years. This solution would migrate through the concrete and deposit the radioactive materials within the concrete matrix. Plutonium or Americium materials would migrate quickly as liquids or particulates into cracks in the concrete. The initial result of this calculation indicates that deposition within the concrete from this mechanism is negligible (approximately $2x10^{-6}$ pCi/g) over a 40-year time frame. This result was expected as Plutonium and Americium materials are not soluble in water and would require a highly acidic solution to facilitate further intrusion. Additionally, no cracking of the surfaces was observed such as pitting of walls or floors that is typical when concrete is subjected to highly acidic conditions, and the use of acid solutions is inconsistent with the activities in the facility. Because there is no indication that acid solutions were used in the buildings in SEAD-12, appreciable migration of Plutonium and Americium into concrete structures is not likely.

2) **Very little change in the URSA detector response is predicted when radiological contamination is present at probable thicknesses.** Monte Carlo analyses modeling the potential extent of volumetric contamination at SEAD-12 were completed based on the URSA gamma spectroscopy results. The expected thin crystal NaI detector response to volumetric contamination into concrete at various depths was modeled as described in **Attachment C**. The results of the modeling show that for a 60 keV source, a 30% change in detector response may be expected at 1 cm (scenario 1) and less than 10% may be expected at the 0.25 cm thickness (scenario 2). As discussed above, migration of radionuclides into materials is highly unlikely and therefore radionuclides embedded at a thickness of 1 cm (scenario 1) is unlikely. Scenario 2 is more probable, where a surface may have been painted over. The modeling shows that in this scenario, less than a 10% change in the detector response is expected. Based on the outcome of the modeled detector responses and the unlikelihood of scenario 1, it was determined that the SEAD-12 gamma spectroscopy data could reliably be compared to the DCGLs as surface contamination.

3) **The MDAs achieved using the URSA are below DCGLs.** The minimum detectable activities (MDAs) for the primary materials found in SEAD-12 buildings are adequate using a thin window NaI-based system. The NaI-based system can produce results below the DCGLs for the building materials using a 60 to 70 -minute count time. The graphs in **Figure 1** and **Figure 2** illustrate this point. The URSA measurements are being used as part of a multi-tiered survey approach at the SEAD-12 buildings to determine if any contamination exists. If elevated levels were found during the initial alpha, beta, or gamma surveys those areas were then surveyed with a FIDLER that was setup with an electronic window to discriminate the Am-241 59.5 keV photon energy. The survey with the Am-241 windowed FIDLER was followed by an URSA measurement having a count time of sufficient length to meet the DCGL requirements for the material being examined.

4) **Background radioactivity can be subtracted from instrument readings.** Material specific background in situ gamma measurements can be subtracted from the site in situ measurement to show activity above background. A graphical example of this is shown in **Figure 3**. The decay gamma energy spectra are consistent with what is expected from naturally occurring uranium and thorium. The ability to subtract background spectra can be used to eliminate elevated readings that may have been encountered during gross measurements to truly determine whether or not elevated radiation exists or not.

Material Sample Results Compared to URSA Readings at SEAD-12

Material samples analyzed with the URSA in the field were sent to General Engineering Laboratories, Inc. for isotopic analysis so that a correlation could be drawn. Locations were sampled where field survey equipment indicated an area to be potentially elevated. The laboratory analysis indicated that there were no elevated concentrations present in the seven material samples that were analyzed for Americium-241 and Plutonium-239/240. These results confirmed the determination based on gamma spectroscopy using the URSA that the material samples did not contain elevated levels of these radionuclides. **Table 1** reports both the laboratory analytical results and the URSA results for the seven material samples that were collected. No correlation factor could be derived since neither the field nor analytical results detected anything significant.

Use of the NaI-Based URSA Versus the High Purity Germanium (HPGe) System

NYSDEC had expressed concern about using the NaI-based URSA system instead of a high purity germanium (HPGe) system. At the end of this letter is a reference list citing several studies have been done on the use and performance of NaI-based spectroscopy systems. Some of the topics that are covered in the articles are:

- The adequacy of NaI detectors for analysis of natural background measurements (HASL-258, 1972);
- The use of the NaI spectroscopy, including making of NaI crystals, electronics development, calibration, analysis, and interferences. There is also discussion on the efficiencies of various crystal geometries (Crouthamel, 1960); and
- A comparison of NaI and Ge measurements for various radionuclides with different energy photons (Lowder, 1972).

The NaI-based system has several advantages over the HPGe system. The high expense of purchasing germanium-based systems, limited availability of HPGe rentals, and additional logistics concerns, such as system mobility, make an HPGe system an impractical solution for the isotopic analysis at SEAD-12. In addition, the gamma-emitting radionuclides of concern at SEAD-12 are low-energy gamma emitters that can be adequately detected by a thin crystal NaI-based system. The data collection needs at SEAD-12 do not justify the additional expense of an HPGe system.

Parsons is determined to satisfy the regulators' concerns about the application of the URSA at the SEAD-12 buildings. We are confident that the URSA/NaI-based system is capable of radiological quantification at a level of certainty that demonstrates it effectiveness. We would like to continue to use the URSA in field investigations at Seneca to (1) take specific measurements at elevated gross readings identified during survey efforts, and (2) to determine if levels detected are (i) distinguishable from background, (ii) above DCGLs, and (iii) to identify

the particular isotope(s) of concern. If residual radioactivity is above the DCGLs, material samples will be collected and analyzed for the isotope of concern to confirm actual quantities of radioisotopes present. The ex-situ sample analysis will provide confirmatory data, and is consistent with the NYSDOH requests for assessing contamination.

In order to standardize the data collection/identification/quantification process with the URSA, we have provided "A Guidance for Spectrum Analysis Process" document that has been developed by Parsons' Certified Health Physicist, Mr. Steve Woolfolk. This document, which is provided as **Attachment D** to this letter, gives instruction in the process of selecting, using, and analyzing energy-specific radiation emissions data using spectroscopy. Included is information on the use of the URSA with a NaI detector for gamma spectroscopy.

Should you have any questions regarding this letter, please do not hesitate to call me at (781) 401-2535 to discuss them.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.

Jacqueline Travers

Jacqueline Travers, P.E.
Task Order Manager

cc: S. Absolom, SEDA
K. Hoddinott - USACHPPM
J. Mullikin - USACHPPM
T. Sydelko, Argonne Nat'l Lab
E. Kashdan, Gannett Fleming
J. Vazquez, USEPA
T. Enroth, USACOE – NY District
Marshall Greene, USACOE
C. Kim, USAEC
B. Wright, USAIOC
K. Healy, USACE

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Figure 1

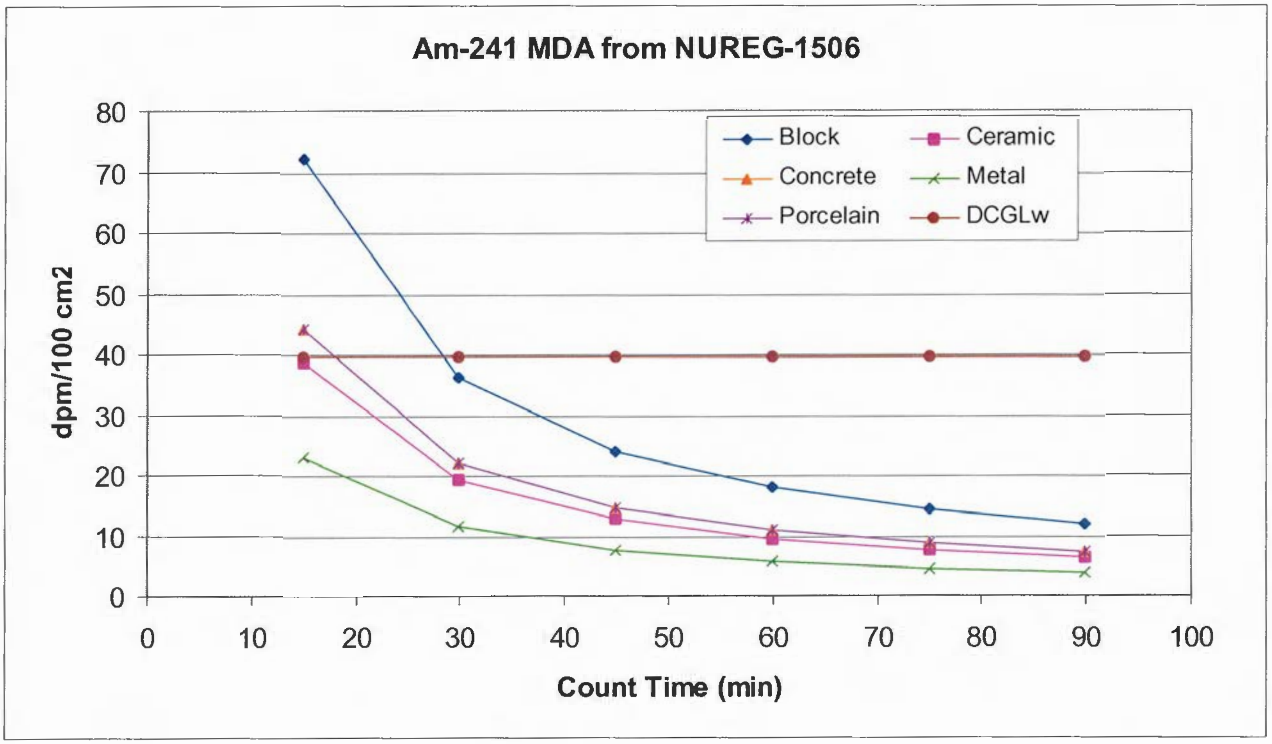


Figure 2

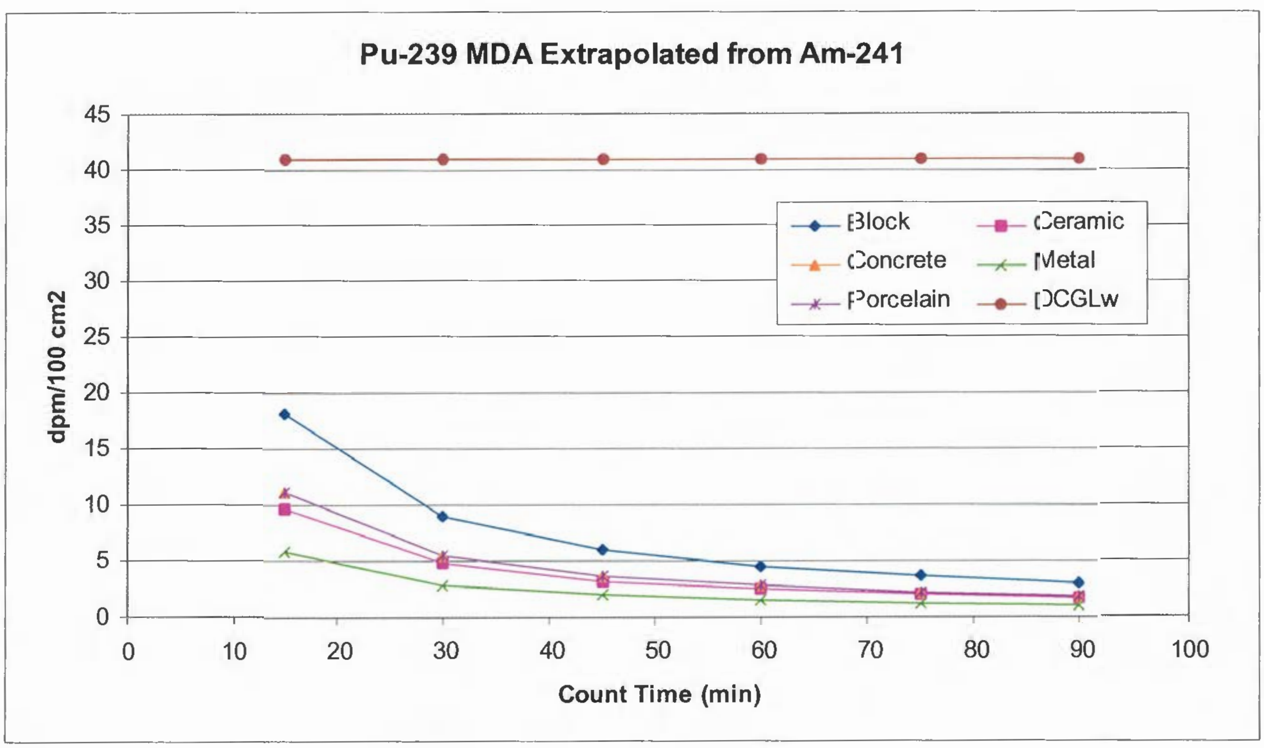
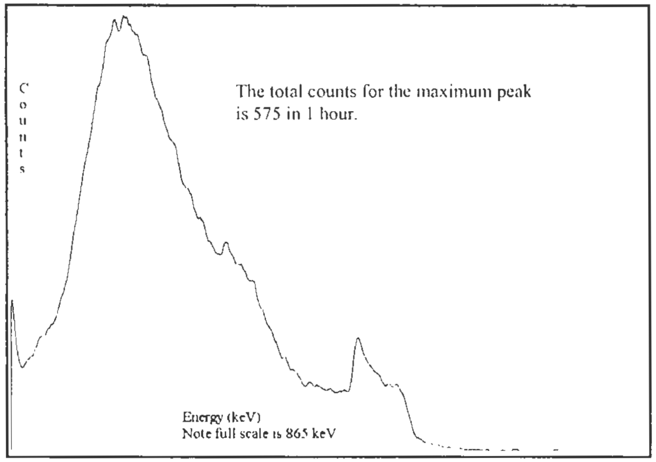
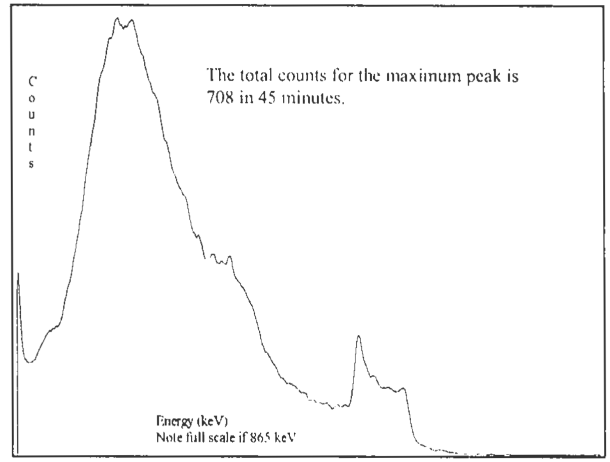


Figure 3
URSA Background and SEAD-12 Spectra
Seneca Army Depot Activity

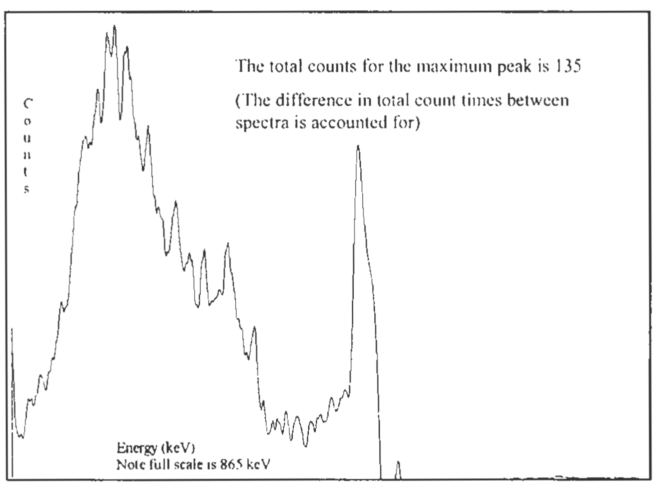
Raw Concrete Spectrum



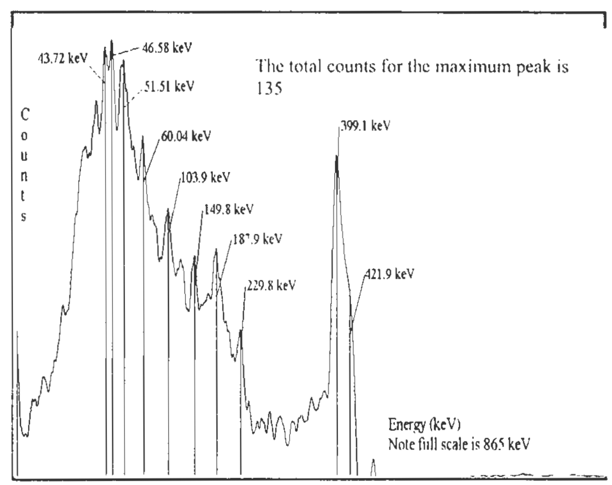
Background Concrete Spectrum



Raw Spectrum with Background Spectrum Subtracted



Raw Spectrum with Background Spectrum Subtracted with Energy Peaks Identified



Notes:

1) This spectrum is of concrete from building 804, room 1, grid 10, location C9.

P Pit Projects Seneca S12ri Comments URSA spectra.ppt

Table 1
Analytical and URSA Results for Material Samples
SEAD-12 Building Survey
Seneca Army Depot Activity

Building		804				804			
Location ID		804-1-C8				804-3-C3			
Grid ID		804-1-5				804-3-14			
Matrix		Misc Solid				Misc Solid			
Date collected		8/23/2001				8/28/2001			
Type		SA				SA			
	Parameter	**Result (pCi/g)**	**Error (+/-)**	**Qualifier**	**MDA**	**Result (pCi/g)**	**Error (+/-)**	**Qualifier**	**MDA**
Laboratory Analytical Data	Americium-241	0 0143	0 0107		0.0122	0 00571	0 0151	U	0 0273
	Plutonium-239/240	-0 0122	0.0139	U	0 0297	-0 0137	0 012	U	0.0288
URSA Data	Americium-241	Not Identified			0.06	Not Identified			0.07
	Plutonium-239/240	Not Identified			0 04	Not Identified			0 04
Field Data[4]	FIDLER scanning data (open energy window)	13900-15300 cpm				17000-20000 cpm			
	FIDLER direct measurement data (open energy window)	14896 cpm				19106 cpm			
	FIDLER scanning data (closed Am-241 window)	300-600 cpm				300-800 cpm			
	FIDLER direct measurement data (closed Am-241 window)	485 cpm				581 cpm			

1) In the laboratory analysis the "U" qualifiers indicate that the reported results are below the MDA and are non-detectable activity.

2) "Not Identified" indicates that there is no discernable activity detected above the MDA to allow the radionucludes to be identified

3) The identification for BKGD-CB1 of Pu-239, Am-241 is complicated by the presence of multiple radionuclides having a gamma emission at the 13 keV energy level Also identified were U-233 at 1 88pCi/g (+/- 0 94), U-238 at 0.83pCi/g (+/-0.42), Th-208 at 0.81pCi/g (+/-0 94), and Pb-210 at 1 65pCi/g (+/- 0 83) The correct identification is most likely U-238 based on the other radionuclides that are present in the sample; however, the background building was never used for radiological activities

4) Grids were selected for material sampling because the FIDLER measurements were either the highest gamma in a room the exceeded background based on Wilcoxon Rank Sum (WRS) statistics or the room was one of the highest elevated gamma readings (based on the open FIDLER energy window)

5) NA Not applicable Background measurements for comparison against material samples were collected with the URSA.

Table 1
Analytical and URSA Results for Material Samples
SEAD-12 Building Survey
Seneca Army Depot Activity

Building		819				819				819			
Location ID		819-5-C11				819-5-C13				819-12D-C27			
Grid ID		819-5-15				819-5-11				819-12D-5			
Matrix		Misc Solid				Misc Solid				Misc Solid			
Date collected		8/23/2001				8/23/2001				8/28/2001			
Type		SA				SA				SA			
	Parameter	**Result (pCi/g)**	**Error (+/-)**	**Qualifier**	**MDA**	**Result (pCi/g)**	**Error (+/-)**	**Qualifier**	**MDA**	**Result (pCi/g)**	**Error (+/-)**	**Qualifier**	**MDA**
Laboratory Analytical Data	Americium-241	0.0118	0.0103	U	0.0141	0.0123	0.00989	U	0.0136	0.0104	0.0139	U	0.0233
	Plutonium-239/240	-0.0166	0.0126	U	0.0288	0.00136	0.00273	U	0.0299	0.00542	0.0109	U	0.0163
URSA Data	Americium-241	Not Identified			0.08	Not Identified			0.08	Not Identified			0.08
	Plutonium-239/240	Not Identified			0.04	Not Identified			0.05	Not Identified			0.05
Field Data[4]	FIDLER scanning data (open energy window)	12000-16000 cpm				14000-17000 cpm				12800-14500 cpm			
	FIDLER direct measurement data (open energy window)	15839 cpm				16014 cpm				14211 cpm			
	FIDLER scanning data (closed Am-241 window)	350-500 cpm				300-700 cpm				300-450 cpm			
	FIDLER direct measurement data (closed Am-241 window)	418 cpm				492 cpm				406 cpm			

Table 1
Analytical and URSA Results for Material Samples
SEAD-12 Building Survey
Seneca Army Depot Activity

Building		BKGD				BKGD			
Location ID		BKGD CB1				BKGD FL			
Grid ID		NA				NA			
Matrix		Misc Solid				Misc Solid			
Date collected		8/22/2001				8/23/2001			
Type		SA				SA			
	Parameter	**Result (pCi/g)**	**Error (+/-)**	**Qualifier**	**MDA**	**Result (pCi/g)**	**Error (+/-)**	**Qualifier**	**MDA**
Laboratory Analytical Data	Americium-241	0.0141	0.0116	U	0.0169	0.019	0.0159	U	0.024
	Plutonium-239/240	0.0193	0.0225		0.0193	0.011	0.0156	U	0.0165
URSA Data	Americium-241	0.37 [3]	0.19		0.09	Not Identified			0.12
	Plutonium-239/240	1.67 [3]	0.83		0.05	Not Identified			0.06
Field Data[4]	FIDLER scanning data (open energy window)	NA[5]				NA			
	FIDLER direct measurement data (open energy window)	NA				NA			
	FIDLER scanning data (closed Am-241 window)	NA				NA			
	FIDLER direct measurement data (closed Am-241 window)	NA				NA			

References:

"Standard Practice for NaI(Tl) Gamma-Ray Spectrometry of Water", ASTM D 4962 – 95, American Society for Testing and Materials.

Dickson, 1976. "Environmental Gamma-Ray Measurements Using In Situ and Core sampling Techniques", Dickson et. al., Health Physics Journal, Vol. 30, pp. 221-227, 1976.

"In Situ Ge(Li) and NaI(Tl) Gamma-Ray Spectrometry", HASL-258, Health and Safety Laboratory (AEC), New York, New York, 1972.

"Comparison of In-Situ and Laboratory Measurement Methods for Radium-226 in Soils", Marutzky et. al., U.S. DOE, UC-70A, 1986.

"International Series of Monographs on Analytical Chemistry, Vol.2, Applied Gamma-Ray Spectrometry", C.E. Crouthamel, Pergamon Press, 1960.

"Experimental Investigations of the Environmental Field", W. M. Lowder et. al., U.S. DOE, Conf-720805-P1, 1972.

ATTACHMENT A

September 6, 2001 letter from the New York State Department of Environmental Conservation (NYSDEC)

New York State Department of Environmental Conservation
Division of Environmental Remediation
Bureau of Eastern Remedial Action, 11th Floor
625 Broadway, Albany, New York 12233-7015
Phone: (518) 402-9623 • **FAX:** (518) 402-9627
Website: www.dec.state.ny.us

Erin M. Crotty
Commissioner

September 6, 2001

Mr. Stephen Absolom
Chief, Engineering and Environmental Division
Seneca Army Depot Activity (SEDA)
5786 State Route 96
Romulus, NY 14541-5001

Re: Seneca Army Depot Activity
NYS Inactive Hazardous Waste Disposal Site No. 8-50-006

Dear Mr. Absolom,

Enclosed are the New York State Department of Health's comments on the Universal Radiation Spectrum Analyzer (URSA) demonstration performed on August 15, 2001. A facsimile of this letter will be sent to you today. If you have any questions, please contact me at (518) 402-9623 or by email at ajthorne@gw.dec.state.ny.us

Sincerely,

Alicia Thorne

Alicia Thorne
Bureau of Eastern Remediation Action
Division of Environmental Remediation

cc: J. Vazquez, USEPA (w/ attach)
D. Geraghty, NYSDOH (w/ attach)
M. Peachey, NYSDEC Region 8 (w/ attach)
R. Scott, NYSDEC Region 8 (w/ attach)

STATE OF NEW YORK
DEPARTMENT OF HEALTH

Flanigan Square, 547 River Street, Troy, New York 12180-2216

Antonia C. Novello, M.D., M.P.H., Dr.P.H.
Commissioner

Dennis P. Whalen
Executive Deputy Commissioner

August 20, 2001

Ms. Alicia Thorne
Bureau of Eastern Remedial Action
Division of Environmental Remediation
NYS Department of Environmental Conservation
625 Broadway, 11th Floor
Albany, New York 12233

RE: Seneca Army Depot
Site #850006
Romulus, Seneca County

Dear Ms. Thorne:

On August 15, 2001 Mr. Ron McConn and Mr. John Hackett, Health Physicists with Parsons Engineering Science gave a demonstration of the Universal Radiation Spectrum Analyzer (URSA) from Radiation Safety Associates, Inc. The presentation was followed by a discussion of how Parson's intends to use the device to investigate the special weapons area of the Seneca Army Depot. Over twenty radiation professionals from the NYS Departments of Health and Environmental Conservation attended the presentation held at the NYSDOH's Center for Environmental Health in Troy, New York. The following comment is provided by the NYSDOH's Bureau of Environmental Radiation Protection:

After the presentation by Parsons of the "URSA" unit as a means to "quantify" the levels of contamination in or on building materials our staff came to the conclusion that while the system shows some promise in screening areas for contamination and perhaps identifying some of the isotopes, it is, as presently configured, not capable of measuring concentrations of the isotopes of interest in volumetric sources. Parsons has admitted that further work is necessary in calibrating the system with multiple energy standards and comparing in house analysis with the unit and laboratory analysis of material samples. Units such as Canberra's ISOCS, presently being used at the Brookhaven National Laboratory, utilizes a high purity germanium detector and has undergone numerous quality assurance measurements to compare field results with laboratory analysis and has successfully shown that quantification is possible.

Until Parsons can show that the "URSA" unit can be compared to lab analysis and correction factors can be applied to field measurements, we feel that it is premature to depend solely on in-situ measurements for the final status survey and more sampling is required. However, we will re-evaluate this position if further study shows the unit to be capable.

If you have any questions, please contact me by telephone at (518) 402-7890 or by e-mail at drg01@health.state.ny.us.

Sincerely,

Daniel R. Geraghty
Program Research Specialist III
Bureau of Environmental Exposure Investigation

cc: Mr. G. Litwin/Mr. M. Rivara/FILE
Mr. D. Miles
Mr. D. Napier – RFO
Mr. B. Dombrowski – SCHD
Mr. M. Chen – DEC
Ms. M. J. Peachey – DEC, Region 8
Mr. G. Ulirsch – ATSDR
Mr. A. Block – ATSDR

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ATTACHMENT B

Volumetric Contamination and the Effects on the FIDLER Detector Response. Parsons, 2002

Rev	Date	By	Ck	Subject:
0	1/16/02	RJM	[signature]	Volumetric Contamination and the Effect on FIDLER Detector Response

Author: Ronald McConn

Checker: Steven Woolfolk

Calc #: 730047-01001-02

Purpose

The purpose of this calculation was to determine the difference in detector response for a Bicron FIDLER for different thicknesses of volumes of contamination. The response to a FIDLER detector was of specific interest as this was used at the Seneca Army Depot SEAD-12 site in Romulus, New York to determine the presence of radiological contamination on building surfaces. Of specific interest was the radioisotope Am-241 which can be used to identify the presence of weapons grade plutonium.

References, Inputs and Assumptions

Assumptions:

The density of concrete was assumed to by 2.35 g/cc per Ref 2, table 5.4 and 1.5 g/cc to represent a lower density material typical of soil or paint.

The source of contamination was assumed to be an area source 2 inches square and have varying thickness (0.1, 0.25, 0.5, 1 cm).

References:

1. "MCNP 4B Monte Carlo N-Particle Transport Code System", Oak Ridge National Laboratory, contributed by Los Alamos National Laboratory, Los Alamos, New Mexico, UC 705 & UC 700, J.F. Briesmeister.

2. "The Health Physics and Radiological Health Handbook", B. Shleien, Scinta Inc., 1992.

Inputs To Calculation:

Appendix A – Sample MCNP Input File

Appendix B – Excel Workbook Printout

Discussion

The presence of volumetric contamination of building surfaces could result in the underestimation of the assessment of residual contamination that might lead to release of the facility with levels of contamination in exceedence of the release criteria. This underestimation would be based on the difference in the survey instrument efficiency for the detection of surface versus volumetric contamination. Therefore it is desirable to determine the effect on the detector response from varying thickness of volume contamination. It is assumed that the contamination source in question would occupy an area of 2 square inches (5.08 cm) with a varying thickness between 0.1 and 1 cm. Further depth was not deemed necessary based on previous calculation (Woolfolk, 2001), this calculation also determined that the actual penetration of plutonium/americium bearing water to be one the order of 1 mm in depth. These calculations address the infiltration of americium and plutonium into concrete but did not address the movement of material in crack, pores, or other openings in the concrete's surfaces. It should be noted that during the survey activities the surfaces surveyed were intact and did not show signs of cracking or other deteriorate that would also give rise to contamination being present at depth within the surfaces. Determination of the FIDLER detector response is being evaluated to support the building surveys that were completed at the Seneca Army Depot SEAD-12 in Romulus, NY during the summer of 2001.

The impact of a volumetric rather than a surface contamination source on the detector response is quantified by estimating the resultant gross efficiency of the detector giving the various source thickness. This was accomplished through the use of the Monte Carlo modeling software MCNP. A model of a FIDLER probe and the source region was developed (see Figure 1 and Appendix A). The FIDLER, which is a thin crystal detector, was used since it is more effective at detecting and assessing low energy photon fluxes because of the reduced impact of the higher energy photons on the instrument. The FIDLER was setup and calibrated to survey for a narrow band around the 59 keV photon associated with Am-241. An example of the input file used for the MCNP model is attached as Appendix A. The source thickness was varied by changing the source bottom surface (i.e., Surface 20 line in the input deck) and the bottom of the source in the source card "z" dimension (i.e., the last value in the "si3" line of the input deck). A series of these inputs files (see Table 1) were created to cover many different energy sources (10-500 keV), different source thickness (0.1, 0.25, 0.5, and 1 cm), and two different densities of source material (i.e., the density was varied for Cell 10 in the input deck). (Note, the FIDLER probe would be used for photon surveys in the 10 to 350 keV range.) Each source energy required a separate input file in order to account for the down-scatter of photon energy present due to the interaction of the photons with matter (see Table 1). Two different densities were used to determine how this parameter would affect the detector response, and are of particular interest at the lower energy range (<50 keV). The densities used are 2.35 g/cc for concrete and 1.5 g/cc for paint or soil.

Table 1, Input Files

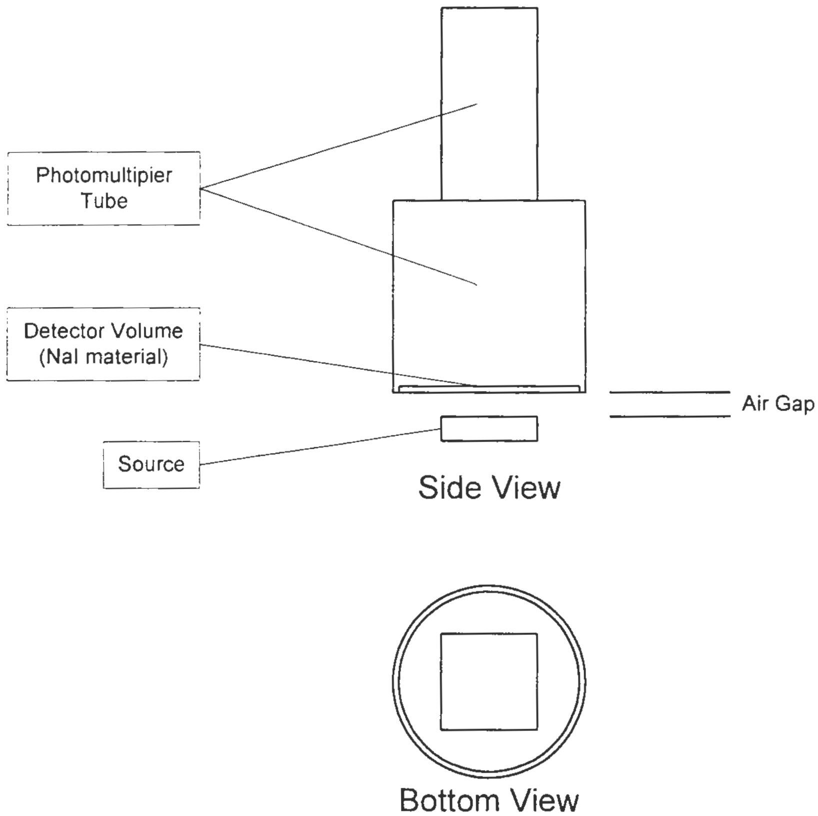
Filename	Source Thickness (cm)	Source Density (g/cm^3)	Energy (keV)	Filename	Source Thickness (cm)	Source Density (g/cm^3)	Energy (keV)
Fid10a	1	1.5 or 2.35	10	Fid100c	0.25	1.5 or 2.35	100
Fid10b	0.5	1.5 or 2.35	10	Fid100d	0.1	1.5 or 2.35	100
Fid10c	0.25	1.5 or 2.35	10	etc…			
Fid10d	0.1	1.5 or 2.35	10	Fid180a	1	1.5 or 2.35	180
etc…				Fid180b	0.5	1.5 or 2.35	180
Fid50a	1	1.5 or 2.35	50	Fid180c	0.25	1.5 or 2.35	180
Fid50b	0.5	1.5 or 2.35	50	Fid180d	0.1	1.5 or 2.35	180
Fid50c	0.25	1.5 or 2.35	50	etc…			
Fid50d	0.1	1.5 or 2.35	50	Fid360a	1	1.5 or 2.35	360
etc…				Fid360b	0.5	1.5 or 2.35	360
Fid100a	1	1.5 or 2.35	100	Fid360c	0.25	1.5 or 2.35	360
Fid100b	0.5	1.5 or 2.35	100	Fid360d	0.1	1.5 or 2.35	360

The geometry of the FIDLER and source MCNP model is depicted in Figure 1, this figure is not to scale. The air gap depicted is 0.08 cm thick while the overall dimensions of the FIDLER are 5" diameter at the detector surface tapering to approximately 2" at the end of the photomultiplier tube. The dimensions used in the model were found in the Bircon product manual and through actual measurement of a Bicron FIDLER probe. The areas of significant importance are the following:

- Source thickness,
- Detector volume and thickness,
- Distance between the source and detector, and
- Relative geometry of the source and the detector.

The other parameters have a relative minor effect.

Figure 1- Basic MCNP Geometry



With the basic geometry defined the input files were run for 60 minutes to ensure that the results would reach statistical convergence (a statistical Monte Carlo error value of <0.01 or <1%)for the F8 MCNP tally, which collects information regarding photon pulses within the detector volume. Note, this error value does not include any assessment of the uncertainty introduced by the accuracy of the model assumed. The data from this F8 tally are the number of photons detected for each photon emitted. The data for each of the source energies for a given source thickness and density are quantified in this MCNP tally. These values were transferred to a spreadsheet and plotted to show how the gross efficiency varies as a function of energy. The output data from the F8 tally was compiled in an Excel workbook so that it could be easily manipulated. This workbook (mcnp volume seneca.xls) is attached as Appendix B. A plot of the gross efficiencies for each density is provided as Figure 2 and Figure 3, note that these plots do not account for the photon yield from an specific radionuclide and are meant only to show the relative response variation due to the source thickness and change in density. Further ratios (i.e., 0.1 cm efficiency/the various efficiencies) are developed to compare the response at 0.1 cm thickness to each of the other thickness, these ratios are given in Table 2. These ratios are the factor you would need to multiply the FIDLER flux by to obtain the true flux for each of these monoenergetic fluxes. From Table 2, it becomes apparent that the difference in detector response is essentially flat beyond 50 keV. This behavior is expected since the shielding of effect (i.e., reduction in flux) of the is determined by:

$$\square \propto e^{-\mu(E) * x}$$

Where $\mu(E)$ is the energy dependent linear attenuation coefficient. It is the decreasing value of the linear attenuation coefficient that results in the curve slope becoming very small.

Therefore the results indicate that the change in response for the lower energies (<30 keV) can change significantly with differences in surface vs. volume and material density while the higher energy photons (>50 keV) are impacted to a much lesser degree (<30% from 50 to 80 keV and <10% above that). Note, the impact of volumetric contamination would be much more significant if substantial thickness (i.e., multiple centimeters) were involved or if there was a substantial thickness of concrete (i.e., multiple centimeters) or soil above the contaminated zone.

This data leads to the conclusion that while the presence of volume contamination does lower the overall detector response it is only significant for the low energy photon range (<30 keV) and in the primary region of interest for the presence of Am-241 at 59 keV with change in response will not adversely affect the detection capabilities of the FIDLER instrument (i.e., <30% reduction in efficiency).

When the thickness of the contamination is considered in relation to the Seneca Army Depot SEAD-12 situation (thickness on the order of 1 mm to 2.5 mm) it is apparent that the effect is flat (i.e., no significant reduction in efficiency occurs) above 30 keV which indicates that the FIDLER probe will respond appropriately to surface and the very shallow volumetric contamination. This of course, relies on the instrument being in place to count for an amount of time sufficient to reach the applicable MDA and level of confidence for the project, whether the contamination is on the surface or is volumetric contamination.

Conclusion

It has been shown that both the density of the source and the thickness of the source affect the detector response for various energies of photon radiation. These two parameters result in the increase of self-shielding by the material that the emitted radiation must pass through in order to reach the detector volume. This effect is more important for the low energy photons (<30 keV) than for the higher energy range. The response to the low energy band is shown to change be as much as a factor of 10 and as little as no change depending on the thickness and density of the material. Therefore if there is a real potential to have volumetric contamination of a building surface the radiological surveys will need to factor in the change in detector response that is appropriate for the material and radionuclides that produce photon at very low energies. For the Seneca Army Depot SEAD-12 buildings there is extremely limited potential for volumetric contamination but this calculation has shown that the change is detector response for the 60 keV source, that is representative of Am-241 is less than 30% at the 1 cm thickness and <10% at the 0.25 cm thickness.

Figure 2 - Detector Response, density = 1.5 g/cc

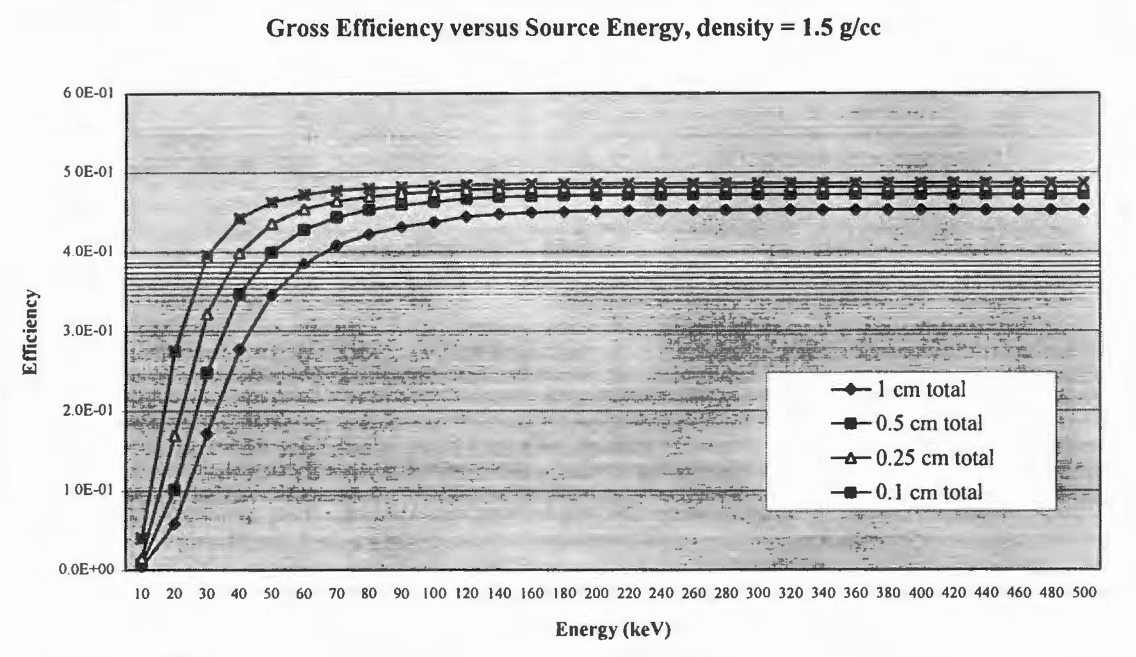


Figure 3 - Detector Response, density = 2.35 g/cc

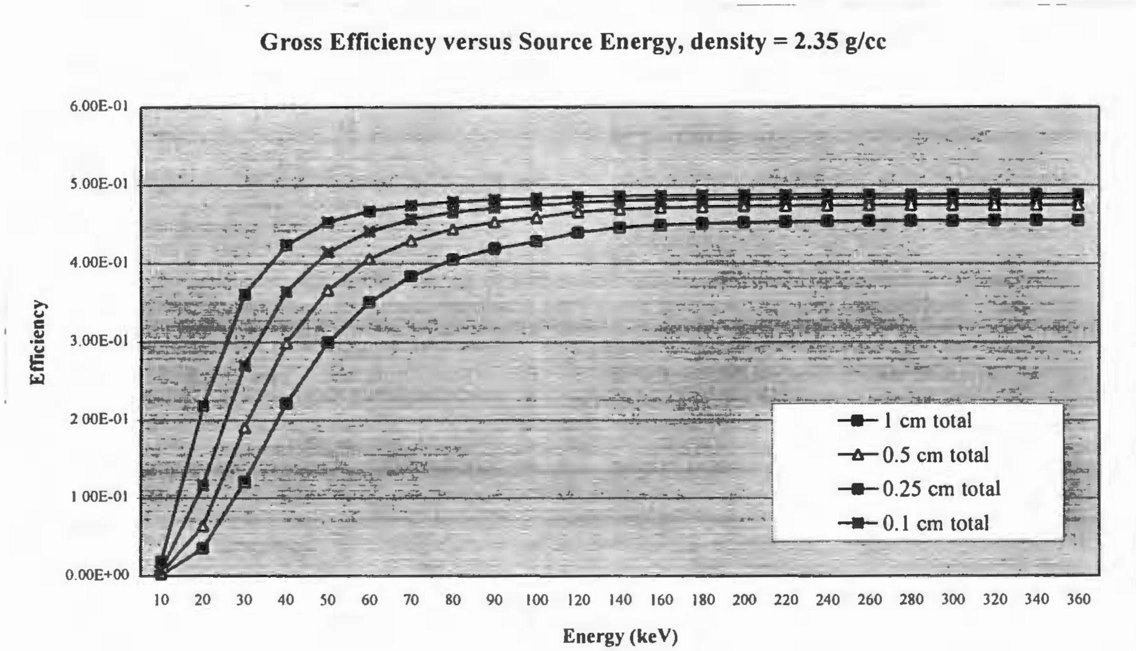


Table 2 - Detector Response Ratios

This set is for the 1.5 g/cc density case

Thickness (cm)	Energy (keV)									
	10	20	30	40	50	60	70	80	90	100
0.1 to 1	9.6	4.7	2.3	1.6	1.3	1 2	1.2	1.1	1.1	1.1
0.1 to 0.5	5.2	2.7	1.6	1.3	1.2	1.1	1.1	1.1	1.1	1.0
0.1 to 0.25	2.7	1.6	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0

Thickness (cm)	Energy (keV)									
	120	140	160	180	200	220	240	260	280	300
0.1 to 1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
0.1 to 0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
0.1 to 0.25	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Thickness (cm)	Energy (keV)									
	320	340	360	380	400	420	440	460	480	500
0.1 to 1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
0.1 to 0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
0.1 to 0.25	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

This set is for the 2.35 g/cc density case

Thickness (cm)	Energy (keV)							
	10	20	30	40	50	60	70	80
0.1 to 1	9.8	6.1	3.0	1.9	1.5	1.3	1.2	1.2
0.1 to 0.5	5.3	3.4	1.9	1.4	1.2	1.1	1.1	1.1
0.1 to 0.25	2.7	1.9	1.3	1.2	1.1	1.1	1.0	1.0

Thickness (cm)	Energy (keV)							
	90	100	120	140	160	180	200	220
0.1 to 1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
0.1 to 0.5	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0
0.1 to 0.25	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Thickness (cm)	Energy (keV)						
	240	260	280	300	320	340	360
0.1 to 1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
0.1 to 0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
0.1 to 0.25	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Appendix A
Sample MCNP Input File

```
This is to approximate a FIDLER (5 in x 1.6 mm NaI) gamma scint
c air shield 0.08 cm thick 100 keV Source
1 2 -0.001293 1 -7 -3 4 -5 6 imp:p=1
c
c photon source 1 cm thick 2 inch square
10 1 -1.5 20 -1 -21 22 -23 24 imp:p=1
c
c 5"x1.6mm NaI detector (scintillation material)
2 4 -3.67 8 -10 -11 imp:p=1
c
c 5"x1.6mm NaI detector
c window (0.254 mm beryllium)
3 6 -1.85 7 -8 -30 imp:p=1
c detector housing
4 5 -2.7 11 -30 8 -10 imp:p=1
c photomultiplier housing
5 5 -2.7 31 -12 -9 imp:p=1
6 5 -2.7 10 -31 -30 imp:p=1
c
c air environment
100 2 -0.001293 -100 #1 #2 #3 #4 #5 #6 #10 imp:p=1
c
c outer void
105 0   100 imp:p=0

C surfaces
c Air shield
1 pz 5
c 2 pz 5.08
3 px 125
4 px -125
5 py 125
6 py -125
c detector window
7 pz 5.08
8 pz 5.105
9 cz 3.175
30 cz 6.83
c NaI material
10 pz 5.265
11 cz 6.35
c detector back
12 pz 30.48
31 pz 15.43
c universe boundary
100 so 200
c source bottom boundary
20 pz 4
c source side boundaries
21 px 2.54
```

```
22 px -2.54
23 py 2.54
24 py -2.54

mode p
sdef cel=10 erg=0.1 x=d1 y=d2 z=d3 par=2
si1  H  -2.53 2.53
sp1  c  0 1
si2  H  -2.53 2.53
sp2  c  0 1
si3  H  4.01 4.99
sp3  c  0 1
c current integrated over surface (particles)
f1:p 8
e1:p 0.01 0.02 0.03 0.04 0.05 0.06 0.08 0.1 0.125 0.15&
    0.175 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55
c flux (part/cm^2)
f4:p 2
e4:p 0.01 0.02 0.03 0.04 0.05 0.06 0.08 0.1 0.125 0.15&
    0.175 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55
c pulses created in detector
f8:p 2
e8:p 0 0.01 0.02 0.03 0.04 0.05 0.06 0.08 0.1 0.125 0.15&
    0.175 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55
c soil (concrete used for composition)
m1  1000. -0.0056  8000. -0.4983  11000. -0.0171  12000. -0.0024&
   13000. -0.0456  14000. -0.3158  16000. -0.0012  19000. -0.0192&
   20000. -0.0826  26000. -0.0122
c air
m2  7000.  -0.755  8000.  -0.232  18000.  -0.013  GAS=1
C     ICRU TISSUE
c m3  1000. -0.102  6000. -0.123  7000. -0.035  8000. -0.72893&
c     11000. -0.0008  12000. -0.0002  15000. -0.002&
c     16000. -0.005  19000. -0.003  20000. -0.00007
c     Sodium Iodide
m4  11000. -0.1534  53000. -0.8466
c     Aluminum
m5  13000. -1
c     Beryllium
m6  4000.  -1
print
ctme 30
```

Appendix B
Excel Workbook Printout
Total Page Count is 108

	A	B	C	D	E	F	G	H	I	J	K
1	This is the MCNP data for the Seneca Army Depot volume contamination study.										
2	The goal is to determine the affect that volume contamination would have on the FIDLER istrument used for gamma spectroscopy.										
3	Filenames use the following format:				fid	energy (keV)	depth				
4		where depth is indicated by: 1) a = 1 cm: 2) b = 0.5 cm; 3) c = 0.25 cm; 4) d = 0.1 cm									
5		as an example fid100c is the 100 keV source that is 0.25 cm thick									
6	An air shield exists between the source and detector that is 0.265 cm (0.1 inch) thick and should not effect the results.										
7	All runs were completed in 60 minutes of run time.										
8	**These run are with the 1.5 g/cc density.**										
9											
10	**Filename**	fid10a				**Filename**	fid20a				**Filename**
11											
12	1tally 8	nps =150042919				1tally 8	nps =113291808				1tally 8
13	tally type 8	pulse height distribution.			un	tally type 8	pulse height distribution.			unit	tally ty
14	tally for photons					tally for photons					tally fo
15											
16	cell 2					cell 2					cell 2
17	energy					energy					energy
18	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
19	5.00E-02	4.22E-03	0.0013			5.00E-02	5.78E-02	0.0004			5.00E-02
20	1.00E-01	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01
21	1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01
22	2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01
23	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
24	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
25	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
26	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
27	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
28	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
29	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
30	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
31	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
32	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
33	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
34	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
35	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
36	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
37	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
38	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
39	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
40	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
41	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
42	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
43	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
44	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
45	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
46	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
47	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
48	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
49	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
50	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
51	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
52	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
53	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
54	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
55	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
56	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
57	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
58	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
59	total	4.22E-03	0.0013			total	5.78E-02	0.0004			total
60											

	A	B	C	D	E	F	G	H	I	J	K
61											
62	**Filename**	fid10b				**Filename**	fid20b				**Filename**
63											
64	1tally 8	nps =150806258				1tally 8	nps =119258362				1tally 8
65	tally type 8	pulse height distribution.			un	tally type 8	pulse height distribution.			unit	tally ty
66	tally for	photons				tally for	photons				tally fo
67											
68	cell 2					cell 2					cell 2
69	energy					energy					energy
70	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
71	5.00E-02	7.73E-03	0.0009			5.00E-02	1.02E-01	0.0003			5.00E-02
72	1.00E-01	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01
73	1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01
74	2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01
75	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
76	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
77	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
78	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
79	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
80	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
81	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
82	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
83	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
84	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
85	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
86	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
87	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
88	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
89	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
90	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
91	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
92	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
93	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
94	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
95	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
96	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
97	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
98	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
99	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
100	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
101	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
102	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
103	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
104	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
105	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
106	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
107	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
108	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
109	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
110	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
111	total	7.73E-03	0.0009			total	1.02E-01	0.0003			total
112											
113											
114	**Filename**	fid10c				**Filename**	fid20c				**Filename**
115											
116	1tally 8	nps =148279575				1tally 8	nps =109009209				1tally 8
117	tally type 8	pulse height distribution.			un	tally type 8	pulse height distribution.			unit	tally ty
118	tally for	photons				tally for	photons				tally fo
119											
120	cell 2					cell 2					cell 2

	A	B	C	D	E	F	G	H	I	J	K
121	energy					energy					energy
122	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
123	5.00E-02	1.50E-02	0.0007			5.00E-02	1.69E-01	0.0002			5.00E-02
124	1.00E-01	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01
125	1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01
126	2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01
127	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
128	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
129	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
130	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
131	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
132	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
133	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
134	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
135	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
136	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
137	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
138	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
139	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
140	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
141	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
142	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
143	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
144	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
145	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
146	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
147	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
148	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
149	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
150	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
151	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
152	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
153	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
154	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
155	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
156	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
157	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
158	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
159	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
160	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
161	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
162	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
163	total	1.50E-02	0.0007			total	1.69E-01	0.0002			total
164											
165											
166	**Filename**	fid10d				**Filename**	fid20d				**Filename**
167											
168	1tally 8	nps =139690778				1tally 8	nps = 96950667				1tally 8
169	tally type 8 pulse height distribution.				un	tally type 8 pulse height distribution.				unit	tally ty
170	tally for photons					tally for photons					tally fo
171											
172	cell 2					cell 2					cell 2
173	energy					energy					energy
174	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
175	5.00E-02	4.04E-02	0.0004			5.00E-02	2.74E-01	0.0002			5.00E-02
176	1.00E-01	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01
177	1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01
178	2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01
179	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
180	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01

	A	B	C	D	E	F	G	H	I	J	K
181	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
182	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
183	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
184	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
185	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
186	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
187	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
188	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
189	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
190	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
191	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
192	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
193	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
194	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
195	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
196	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
197	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
198	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
199	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
200	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
201	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
202	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
203	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
204	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
205	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
206	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
207	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
208	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
209	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
210	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
211	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
212	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
213	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
214	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
215	total	4.04E-02	0.0004			total	2.74E-01	0.0002			total

	L	M	N	O	P	Q	R	S	T	U	V
1											
2											
3											
4											
5											
6											
7											
8											
9											
10	fid30a				**Filename**	fid40a				**Filename**	fid50a
11											
12	ps = 85379370				1tally 8	nps = 59577617				1tally 8	nps = 5254
13	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				un	tally type 8 pulse	
14	photons				tally for photons					tally for photons	
15											
16					cell 2					cell 2	
17					energy					energy	
18	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
19	1.71E-01	0.0002			5.00E-02	2.77E-01	0.0002			5.00E-02	3.45E-01
20	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01	2.29E-04
21	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00
22	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00
23	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00
24	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
25	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
26	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
27	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
28	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
29	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
30	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
31	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
32	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
33	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
34	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
35	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
36	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
37	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
38	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
39	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
40	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
41	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
42	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
43	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
44	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
45	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
46	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
47	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
48	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
49	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
50	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
51	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
52	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
53	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
54	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
55	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
56	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
57	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
58	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
59	1.71E-01	0.0002			total	2.77E-01	0.0002			total	3.45E-01
60											

	L	M	N	O	P	Q	R	S	T	U	V
61											
62	fid30b				**Filename**	fid40b				**Filename**	fid50b
63											
64	ps = 90337828				1tally 8	nps = 63833523				1tally 8	nps = 5893
65	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				un	tally type 8	pulse
66	photons				tally for photons					tally for photons	
67											
68					cell 2					cell 2	
69					energy					energy	
70	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
71	2.48E-01	0.0002			5.00E-02	3.46E-01	0.0002			5.00E-02	3.99E-01
72	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01	2.97E-04
73	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00
74	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00
75	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00
76	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
77	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
78	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
79	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
80	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
81	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
82	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
83	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
84	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
85	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
86	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
87	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
88	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
89	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
90	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
91	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
92	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
93	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
94	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
95	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
96	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
97	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
98	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
99	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
100	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
101	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
102	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
103	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
104	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
105	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
106	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
107	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
108	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
109	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
110	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
111	2.48E-01	0.0002			total	3.46E-01	0.0002			total	3.99E-01
112											
113											
114	fid30c				**Filename**	fid40c				**Filename**	fid50c
115											
116	ps = 86256559				1tally 8	nps = 61525445				1tally 8	nps = 5913
117	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				un	tally type 8	pulse
118	photons				tally for photons					tally for photons	
119											
120					cell 2					cell 2	

	L	M	N	O	P	Q	R	S	T	U	V
121					energy					energy	
122	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
123	3.21E-01	0.0002			5.00E-02	3.99E-01	0.0002			5.00E-02	4.35E-01
124	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01	3.25E-04
125	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00
126	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00
127	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00
128	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
129	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
130	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
131	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
132	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
133	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
134	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
135	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
136	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
137	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
138	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
139	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
140	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
141	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
142	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
143	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
144	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
145	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
146	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
147	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
148	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
149	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
150	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
151	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
152	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
153	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
154	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
155	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
156	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
157	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
158	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
159	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
160	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
161	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
162	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
163	3.21E-01	0.0002			total	3.99E-01	0.0002			total	4.36E-01
164											
165											
166	fid30d				**Filename**	fid40d				**Filename**	fid50d
167											
168	ps = 81988313				1tally 8	nps = 59784935				1tally 8	nps = 5839
169	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				un	tally type 8 pulse	
170	photons				tally for photons					tally for photons	
171											
172					cell 2					cell 2	
173					energy					energy	
174	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
175	3.95E-01	0.0001			5.00E-02	4.43E-01	0.0001			5.00E-02	4.63E-01
176	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01	2.81E-04
177	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00
178	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00
179	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00
180	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00

	L	M	N	O	P	Q	R	S	T	U	V
181	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
182	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
183	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
184	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
185	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
186	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
187	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
188	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
189	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
190	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
191	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
192	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
193	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
194	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
195	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
196	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
197	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
198	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
199	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
200	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
201	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
202	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
203	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
204	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
205	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
206	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
207	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
208	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
209	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
210	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
211	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
212	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
213	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
214	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
215	3.95E-01	0.0001			total	4.43E-01	0.0001			total	4.63E-01

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1											
2											
3											
4											
5											
6											
7											
8											
9											
10				**Filename**	fid60a				**Filename**	fid70a	
11											
12	15			1tally 8	nps = 52052452				1tally 8	nps = 51759015	
13	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
14				tally for photons					tally for photons		
15											
16				cell 2					cell 2		
17				energy					energy		
18	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
19	0.0002			5.00E-02	7.65E-02	0.0005			5.00E-02	6.76E-02	0.0005
20	0.0091			1.00E-01	3.08E-01	0.0002			1.00E-01	3.41E-01	0.0002
21	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0
22	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0
23	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0
24	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0
25	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
26	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
27	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
28	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
29	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
30	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
31	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
32	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
33	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
34	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
35	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
36	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
37	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
38	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
39	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
40	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
41	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
42	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
43	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
44	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
45	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
46	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
47	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
48	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
49	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
50	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
51	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
52	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
53	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
54	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
55	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
56	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
57	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
58	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
59	0.0002			total	3.85E-01	0.0002			total	4.08E-01	0.0002
60											

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
61											
62				**Filename**	fid60b				**Filename**	fid70b	
63											
64	96			1tally 8 nps = 57551805					1tally 8 nps = 56181375		
65	height distribution.		uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height dist		
66				tally for photons					tally for photons		
67											
68				cell 2					cell 2		
69				energy					energy		
70	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
71	0.0002			5.00E-02	8.20E-02	0.0004			5.00E-02	7.33E-02	0.0005
72	0.0076			1.00E-01	3.46E-01	0.0002			1.00E-01	3.71E-01	0.0002
73	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0
74	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0
75	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0
76	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0
77	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
78	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
79	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
80	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
81	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
82	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
83	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
84	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
85	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
86	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
87	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
88	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
89	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
90	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
91	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
92	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
93	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
94	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
95	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
96	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
97	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
98	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
99	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
100	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
101	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
102	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
103	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
104	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
105	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
106	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
107	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
108	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
109	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
110	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
111	0.0002			total	4.28E-01	0.0002			total	4.44E-01	0.0001
112											
113											
114				**Filename**	fid60c				**Filename**	fid70c	
115											
116	01			1tally 8 nps = 58414718					1tally 8 nps = 57955572		
117	height distribution.		uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height dist		
118				tally for photons					tally for photons		
119											
120				cell 2					cell 2		

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
121				energy					energy		
122	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
123	0.0001			5.00E-02	8.50E-02	0.0004			5.00E-02	7.71E-02	0.0005
124	0.0072			1.00E-01	3.69E-01	0.0002			1.00E-01	3.87E-01	0.0002
125	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0
126	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0
127	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0
128	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0
129	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
130	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
131	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
132	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
133	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
134	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
135	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
136	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
137	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
138	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
139	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
140	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
141	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
142	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
143	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
144	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
145	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
146	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
147	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
148	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
149	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
150	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
151	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
152	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
153	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
154	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
155	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
156	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
157	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
158	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
159	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
160	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
161	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
162	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
163	0.0001			total	4.54E-01	0.0001			total	4.64E-01	0.0001
164											
165											
166				**Filename**	fid60d				**Filename**	fid70d	
167											
168	35			1tally 8	nps = 59491988				1tally 8	nps = 59646535	
169	height distribution.		uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height dist		
170				tally for photons					tally for photons		
171											
172				cell 2					cell 2		
173				energy					energy		
174	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
175	0.0001			5.00E-02	8.74E-02	0.0004			5.00E-02	8.05E-02	0.0004
176	0.0078			1.00E-01	3.85E-01	0.0002			1.00E-01	3.97E-01	0.0002
177	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0
178	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0
179	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0
180	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
181	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
182	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
183	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
184	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
185	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
186	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
187	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
188	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
189	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
190	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
191	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
192	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
193	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
194	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
195	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
196	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
197	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
198	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
199	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
200	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
201	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
202	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
203	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
204	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
205	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
206	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
207	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
208	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
209	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
210	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
211	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
212	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
213	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
214	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
215	0.0001			total	4.72E-01	0.0001			total	4.77E-01	0.0001

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1											
2											
3											
4											
5											
6											
7											
8											
9											
10			**Filename**	fid80a				**Filename**	fid90a		
11											
12			1tally 8	nps = 52458766				1tally 8	nps = 51437809		
13	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
14			tally for	photons				tally for	photons		
15											
16			cell 2					cell 2			
17			energy					energy			
18			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
19			5.00E-02	4.41E-02	0.0006			5.00E-02	5.22E-02	0.0006	
20			1.00E-01	3.78E-01	0.0002			1.00E-01	3.79E-01	0.0002	
21			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0	
22			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0	
23			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0	
24			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0	
25			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0	
26			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
27			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
28			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
29			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
30			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
31			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
32			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
33			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
34			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
35			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
36			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
37			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
38			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
39			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
40			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
41			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
42			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
43			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
44			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
45			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
46			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
47			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
48			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
49			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
50			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
51			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
52			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
53			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
54			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
55			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
56			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
57			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
58			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
59			total	4.22E-01	0.0002			total	4.31E-01	0.0002	
60											

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
61											
62			**Filename**	fid80b				**Filename**	fid90b		
63											
64			1tally 8	nps = 55386183				1tally 8	nps = 54119679		
65	bution.	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.			
66			tally for photons					tally for photons			
67											
68			cell 2					cell 2			
69			energy					energy			
70			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
71			5.00E-02	4.45E-02	0.0006			5.00E-02	5.26E-02	0.0006	
72			1.00E-01	4.09E-01	0.0002			1.00E-01	4.06E-01	0.0002	
73			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0	
74			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0	
75			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0	
76			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0	
77			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0	
78			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
79			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
80			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
81			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
82			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
83			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
84			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
85			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
86			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
87			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
88			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
89			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
90			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
91			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
92			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
93			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
94			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
95			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
96			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
97			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
98			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
99			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
100			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
101			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
102			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
103			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
104			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
105			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
106			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
107			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
108			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
109			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
110			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
111			total	4.53E-01	0.0001			total	4.59E-01	0.0001	
112											
113											
114			**Filename**	fid80c				**Filename**	fid90c		
115											
116			1tally 8	nps = 57323455				1tally 8	nps = 56645897		
117	bution.	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.			
118			tally for photons					tally for photons			
119											
120			cell 2					cell 2			

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
121			energy					energy			
122			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
123			5.00E-02	4.41E-02	0.0006			5.00E-02	5.23E-02	0.0006	
124			1.00E-01	4.26E-01	0.0002			1.00E-01	4.21E-01	0.0002	
125			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0	
126			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0	
127			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0	
128			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0	
129			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0	
130			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
131			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
132			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
133			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
134			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
135			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
136			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
137			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
138			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
139			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
140			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
141			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
142			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
143			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
144			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
145			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
146			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
147			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
148			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
149			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
150			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
151			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
152			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
153			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
154			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
155			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
156			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
157			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
158			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
159			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
160			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
161			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
162			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
163			total	4.70E-01	0.0001			total	4.73E-01	0.0001	
164											
165											
166			**Filename**	fid80d				**Filename**	fid90d		
167											
168			1tally 8	nps = 59133953				1tally 8	nps = 58630581		
169	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
170			tally for	photons				tally for	photons		
171											
172			cell 2					cell 2			
173			energy					energy			
174			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
175			5.00E-02	4.34E-02	0.0006			5.00E-02	5.18E-02	0.0006	
176			1.00E-01	4.37E-01	0.0001			1.00E-01	4.30E-01	0.0002	
177			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0	
178			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0	
179			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0	
180			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0	

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
181			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0	
182			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
183			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
184			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
185			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
186			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
187			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
188			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
189			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
190			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
191			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
192			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
193			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
194			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
195			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
196			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
197			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
198			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
199			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
200			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
201			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
202			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
203			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
204			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
205			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
206			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
207			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
208			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
209			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
210			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
211			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
212			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
213			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
214			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
215			total	4.80E-01	0.0001			total	4.82E-01	0.0001	

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC
1											
2											
3											
4											
5											
6											
7											
8											
9											
10		**Filename**	fid100a				**Filename**	fid120a			
11											
12		1tally 8	nps = 50686392				1tally 8	nps = 48707998			
13	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
14		tally for photons					tally for photons				
15											
16		cell 2					cell 2				
17		energy					energy				
18		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
19		5.00E-02	7.32E-02	0.0005			5.00E-02	1.19E-01	0.0004		
20		1.00E-01	3.64E-01	0.0002			1.00E-01	9.05E-02	0.0005		
21		1.50E-01	1.35E-04	0.0121			1.50E-01	2.34E-01	0.0003		
22		2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0		
23		2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0		
24		3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0		
25		3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0		
26		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
27		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
28		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
29		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
30		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
31		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
32		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
33		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
34		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
35		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
36		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
37		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
38		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
39		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
40		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
41		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
42		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
43		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
44		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
45		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
46		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
47		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
48		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
49		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
50		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
51		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
52		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
53		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
54		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
55		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
56		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
57		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
58		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
59		total	4.37E-01	0.0002			total	4.44E-01	0.0002		
60											

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC
61											
62		**Filename**	fid100b				**Filename**	fid120b			
63											
64		1tally 8	nps = 53575368				1tally 8	nps = 51169962			
65	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
66		tally for	photons				tally for	photons			
67											
68		cell 2					cell 2				
69		energy					energy				
70		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
71		5.00E-02	7.48E-02	0.0005			5.00E-02	1.22E-01	0.0004		
72		1.00E-01	3.88E-01	0.0002			1.00E-01	8.48E-02	0.0005		
73		1.50E-01	1.61E-04	0.0108			1.50E-01	2.60E-01	0.0002		
74		2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0		
75		2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0		
76		3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0		
77		3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0		
78		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
79		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
80		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
81		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
82		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
83		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
84		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
85		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
86		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
87		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
88		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
89		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
90		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
91		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
92		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
93		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
94		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
95		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
96		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
97		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
98		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
99		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
100		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
101		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
102		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
103		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
104		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
105		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
106		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
107		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
108		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
109		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
110		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
111		total	4.63E-01	0.0001			total	4.67E-01	0.0001		
112											
113											
114		**Filename**	fid100c				**Filename**	fid120c			
115											
116		1tally 8	nps = 55968025				1tally 8	nps = 53500569			
117	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
118		tally for	photons				tally for	photons			
119											
120		cell 2					cell 2				

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC
121		energy					energy				
122		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
123		5.00E-02	7.53E-02	0.0005			5.00E-02	1.24E-01	0.0004		
124		1.00E-01	4.00E-01	0.0002			1.00E-01	7.91E-02	0.0005		
125		1.50E-01	1.69E-04	0.0103			1.50E-01	2.75E-01	0.0002		
126		2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0		
127		2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0		
128		3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0		
129		3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0		
130		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
131		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
132		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
133		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
134		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
135		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
136		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
137		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
138		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
139		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
140		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
141		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
142		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
143		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
144		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
145		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
146		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
147		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
148		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
149		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
150		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
151		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
152		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
153		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
154		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
155		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
156		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
157		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
158		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
159		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
160		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
161		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
162		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
163		total	4.76E-01	0.0001			total	4.78E-01	0.0001		
164											
165											
166		**Filename**	fid100d				**Filename**	fid120d			
167											
168		1tally 8	nps = 57728771				1tally 8	nps = 54628718			
169	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
170		tally for	photons				tally for	photons			
171											
172		cell 2					cell 2				
173		energy					energy				
174		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
175		5.00E-02	7.54E-02	0.0005			5.00E-02	1.25E-01	0.0004		
176		1.00E-01	4.08E-01	0.0002			1.00E-01	7.38E-02	0.0005		
177		1.50E-01	1.52E-04	0.0107			1.50E-01	2.86E-01	0.0002		
178		2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0		
179		2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0		
180		3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0		

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC
181		3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0		
182		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
183		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
184		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
185		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
186		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
187		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
188		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
189		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
190		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
191		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
192		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
193		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
194		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
195		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
196		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
197		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
198		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
199		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
200		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
201		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
202		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
203		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
204		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
205		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
206		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
207		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
208		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
209		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
210		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
211		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
212		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
213		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
214		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
215		total	4.83E-01	0.0001			total	4.84E-01	0.0001		

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
1											
2											
3											
4											
5											
6											
7											
8											
9											
10	**Filename**	fid140a				**Filename**	fid160a				**Filename**
11											
12	1tally 8 nps = 46811135					1tally 8 nps = 45009897					1tally 8
13	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni	tally ty
14	tally for photons					tally for photons					tally fo
15											
16	cell 2					cell 2					cell 2
17	energy					energy					energy
18	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
19	5.00E-02	1.64E-01	0.0003			5.00E-02	2.00E-01	0.0003			5.00E-02
20	1.00E-01	5.63E-02	0.0006			1.00E-01	4.12E-02	0.0007			1.00E-01
21	1.50E-01	2.27E-01	0.0003			1.50E-01	7.03E-02	0.0005			1.50E-01
22	2.00E-01	0.00E+00	0			2.00E-01	1.38E-01	0.0004			2.00E-01
23	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
24	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
25	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
26	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
27	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
28	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
29	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
30	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
31	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
32	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
33	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
34	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
35	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
36	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
37	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
38	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
39	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
40	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
41	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
42	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
43	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
44	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
45	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
46	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
47	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
48	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
49	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
50	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
51	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
52	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
53	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
54	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
55	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
56	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
57	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
58	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
59	total	4.47E-01	0.0002			total	4.49E-01	0.0002			total
60											

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
61											
62	**Filename**	fid140b				**Filename**	fid160b				**Filename**
63											
64	1tally 8	nps = 49121867				1tally 8	nps = 47330234				1tally 8
65	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
66	tally for	photons				tally for	photons				tally fo
67											
68	cell 2					cell 2					cell 2
69	energy					energy					energy
70	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
71	5.00E-02	1.69E-01	0.0003			5.00E-02	2.06E-01	0.0003			5.00E-02
72	1.00E-01	5.07E-02	0.0006			1.00E-01	3.87E-02	0.0007			1.00E-01
73	1.50E-01	2.49E-01	0.0002			1.50E-01	6.71E-02	0.0005			1.50E-01
74	2.00E-01	0.00E+00	0			2.00E-01	1.58E-01	0.0003			2.00E-01
75	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
76	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
77	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
78	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
79	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
80	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
81	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
82	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
83	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
84	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
85	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
86	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
87	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
88	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
89	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
90	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
91	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
92	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
93	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
94	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
95	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
96	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
97	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
98	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
99	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
100	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
101	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
102	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
103	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
104	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
105	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
106	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
107	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
108	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
109	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
110	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
111	total	4.69E-01	0.0002			total	4.70E-01	0.0002			total
112											
113											
114	**Filename**	fid140c				**Filename**	fid160c				**Filename**
115											
116	1tally 8	nps = 51199327				1tally 8	nps = 49076434				1tally 8
117	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
118	tally for	photons				tally for	photons				tally fo
119											
120	cell 2					cell 2					cell 2

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
121	energy					energy					energy
122	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
123	5.00E-02	1.71E-01	0.0003			5.00E-02	2.08E-01	0.0003			5.00E-02
124	1.00E-01	4.58E-02	0.0006			1.00E-01	3.68E-02	0.0007			1.00E-01
125	1.50E-01	2.62E-01	0.0002			1.50E-01	6.26E-02	0.0006			1.50E-01
126	2.00E-01	0.00E+00	0			2.00E-01	1.73E-01	0.0003			2.00E-01
127	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
128	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
129	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
130	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
131	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
132	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
133	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
134	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
135	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
136	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
137	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
138	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
139	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
140	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
141	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
142	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
143	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
144	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
145	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
146	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
147	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
148	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
149	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
150	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
151	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
152	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
153	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
154	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
155	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
156	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
157	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
158	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
159	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
160	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
161	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
162	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
163	total	4.79E-01	0.0001			total	4.80E-01	0.0001			total
164											
165											
166	**Filename**	fid140d				**Filename**	fid160d				**Filename**
167											
168	1tally 8	nps = 53200898				1tally 8	nps = 50700743				1tally 8
169	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
170	tally for	photons				tally for	photons				tally fo
171											
172	cell 2					cell 2					cell 2
173	energy					energy					energy
174	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
175	5.00E-02	1.72E-01	0.0003			5.00E-02	2.09E-01	0.0003			5.00E-02
176	1.00E-01	4.14E-02	0.0007			1.00E-01	3.52E-02	0.0007			1.00E-01
177	1.50E-01	2.71E-01	0.0002			1.50E-01	5.79E-02	0.0006			1.50E-01
178	2.00E-01	0.00E+00	0			2.00E-01	1.83E-01	0.0003			2.00E-01
179	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
180	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
181	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
182	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
183	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
184	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
185	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
186	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
187	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
188	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
189	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
190	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
191	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
192	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
193	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
194	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
195	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
196	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
197	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
198	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
199	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
200	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
201	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
202	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
203	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
204	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
205	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
206	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
207	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
208	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
209	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
210	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
211	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
212	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
213	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
214	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
215	total	4.85E-01	0.0001			total	4.85E-01	0.0001			total

	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY
1											
2											
3											
4											
5											
6											
7											
8											
9											
10	fid180a				**Filename**	fid200a				**Filename**	fid220a
11											
12	ps = 44266815				1tally 8	nps = 43394503				1tally 8	nps = 4311
13	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
14	photons				tally for photons					tally for photons	
15											
16					cell 2					cell 2	
17					energy					energy	
18	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
19	2.30E-01	0.0003			5.00E-02	2.55E-01	0.0003			5.00E-02	2.74E-01
20	3.59E-02	0.0008			1.00E-01	3.51E-02	0.0008			1.00E-01	3.41E-02
21	5.82E-02	0.0006			1.50E-01	5.07E-02	0.0007			1.50E-01	4.67E-02
22	1.26E-01	0.0004			2.00E-01	1.11E-01	0.0004			2.00E-01	2.33E-02
23	0.00E+00	0			2.50E-01	4.24E-05	0.0233			2.50E-01	7.34E-02
24	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
25	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
26	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
27	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
28	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
29	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
30	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
31	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
32	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
33	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
34	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
35	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
36	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
37	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
38	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
39	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
40	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
41	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
42	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
43	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
44	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
45	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
46	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
47	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
48	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
49	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
50	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
51	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
52	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
53	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
54	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
55	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
56	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
57	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
58	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
59	4.51E-01	0.0002			total	4.51E-01	0.0002			total	4.52E-01
60											

	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY
61											
62	fid180b				**Filename**	fid200b				**Filename**	fid220b
63											
64	ps = 46093043				1tally 8	nps = 45024097				1tally 8	nps = 4462
65	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
66	photons				tally for photons					tally for photons	
67											
68					cell 2					cell 2	
69					energy					energy	
70	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
71	2.37E-01	0.0003			5.00E-02	2.62E-01	0.0002			5.00E-02	2.83E-01
72	3.50E-02	0.0008			1.00E-01	3.54E-02	0.0008			1.00E-01	3.51E-02
73	5.48E-02	0.0006			1.50E-01	4.80E-02	0.0007			1.50E-01	4.48E-02
74	1.44E-01	0.0004			2.00E-01	1.26E-01	0.0004			2.00E-01	2.33E-02
75	0.00E+00	0			2.50E-01	5.08E-05	0.0209			2.50E-01	8.57E-02
76	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
77	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
78	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
79	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
80	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
81	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
82	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
83	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
84	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
85	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
86	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
87	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
88	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
89	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
90	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
91	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
92	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
93	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
94	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
95	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
96	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
97	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
98	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
99	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
100	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
101	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
102	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
103	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
104	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
105	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
106	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
107	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
108	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
109	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
110	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
111	4.71E-01	0.0002			total	4.71E-01	0.0002			total	4.72E-01
112											
113											
114	fid180c				**Filename**	fid200c				**Filename**	fid220c
115											
116	ps = 47593856				1tally 8	nps = 46502368				1tally 8	nps = 4580
117	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
118	photons				tally for photons					tally for photons	
119											
120					cell 2					cell 2	

	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY
121					energy					energy	
122	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
123	2.39E-01	0.0003			5.00E-02	2.65E-01	0.0002			5.00E-02	2.86E-01
124	3.43E-02	0.0008			1.00E-01	3.54E-02	0.0008			1.00E-01	3.57E-02
125	5.06E-02	0.0006			1.50E-01	4.47E-02	0.0007			1.50E-01	4.23E-02
126	1.56E-01	0.0003			2.00E-01	1.36E-01	0.0004			2.00E-01	2.27E-02
127	0.00E+00	0			2.50E-01	5.54E-05	0.0197			2.50E-01	9.44E-02
128	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
129	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
130	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
131	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
132	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
133	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
134	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
135	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
136	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
137	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
138	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
139	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
140	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
141	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
142	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
143	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
144	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
145	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
146	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
147	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
148	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
149	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
150	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
151	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
152	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
153	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
154	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
155	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
156	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
157	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
158	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
159	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
160	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
161	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
162	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
163	4.81E-01	0.0002			total	4.81E-01	0.0002			total	4.81E-01
164											
165											
166	fid180d				**Filename**	fid200d				**Filename**	fid220d
167											
168	ps = 48678819				1tally 8	nps = 47903061				1tally 8	nps = 4666
169	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
170	photons				tally for photons					tally for photons	
171											
172					cell 2					cell 2	
173					energy					energy	
174	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
175	2.40E-01	0.0003			5.00E-02	2.66E-01	0.0002			5.00E-02	2.87E-01
176	3.38E-02	0.0008			1.00E-01	3.55E-02	0.0008			1.00E-01	3.62E-02
177	4.63E-02	0.0007			1.50E-01	4.13E-02	0.0007			1.50E-01	3.98E-02
178	1.65E-01	0.0003			2.00E-01	1.43E-01	0.0004			2.00E-01	2.19E-02
179	0.00E+00	0			2.50E-01	5.56E-05	0.0194			2.50E-01	1.01E-01
180	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00

	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY
181	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
182	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
183	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
184	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
185	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
186	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
187	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
188	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
189	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
190	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
191	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
192	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
193	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
194	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
195	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
196	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
197	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
198	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
199	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
200	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
201	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
202	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
203	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
204	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
205	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
206	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
207	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
208	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
209	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
210	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
211	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
212	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
213	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
214	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
215	4.86E-01	0.0001			total	4.86E-01	0.0001			total	4.86E-01

	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ
1											
2											
3											
4											
5											
6											
7											
8											
9											
10				**Filename**	fid240a				**Filename**	fid260a	
11											
12	00			1tally 8	nps = 42543188				1tally 8	nps = 42214361	
13	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
14				tally for photons					tally for photons		
15											
16				cell 2					cell 2		
17				energy					energy		
18	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
19	0.0002			5.00E-02	2.90E-01	0.0002			5.00E-02	3.03E-01	0.0002
20	0.0008			1.00E-01	3.04E-02	0.0009			1.00E-01	2.76E-02	0.0009
21	0.0007			1.50E-01	4.60E-02	0.0007			1.50E-01	4.46E-02	0.0007
22	0.001			2.00E-01	1.59E-02	0.0012			2.00E-01	1.57E-02	0.0012
23	0.0005			2.50E-01	6.96E-02	0.0006			2.50E-01	1.22E-02	0.0014
24	0			3.00E-01	0.00E+00	0			3.00E-01	4.89E-02	0.0007
25	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
26	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
27	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
28	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
29	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
30	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
31	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
32	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
33	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
34	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
35	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
36	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
37	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
38	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
39	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
40	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
41	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
42	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
43	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
44	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
45	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
46	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
47	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
48	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
49	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
50	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
51	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
52	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
53	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
54	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
55	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
56	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
57	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
58	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
59	0.0002			total	4.52E-01	0.0002			total	4.52E-01	0.0002
60											

	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ
61											
62				**Filename**	fid240b				**Filename**	fid260b	
63											
64	30			1tally 8	nps = 43793979				1tally 8	nps = 43432998	
65	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
66				tally for photons					tally for photons		
67											
68				cell 2					cell 2		
69				energy					energy		
70	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
71	0.0002			5.00E-02	2.99E-01	0.0002			5.00E-02	3.13E-01	0.0002
72	0.0008			1.00E-01	3.14E-02	0.0008			1.00E-01	2.86E-02	0.0009
73	0.0007			1.50E-01	4.52E-02	0.0007			1.50E-01	4.47E-02	0.0007
74	0.001			2.00E-01	1.51E-02	0.0012			2.00E-01	1.51E-02	0.0012
75	0.0005			2.50E-01	8.08E-02	0.0005			2.50E-01	1.27E-02	0.0013
76	0			3.00E-01	0.00E+00	0			3.00E-01	5.80E-02	0.0006
77	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
78	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
79	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
80	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
81	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
82	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
83	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
84	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
85	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
86	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
87	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
88	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
89	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
90	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
91	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
92	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
93	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
94	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
95	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
96	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
97	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
98	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
99	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
100	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
101	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
102	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
103	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
104	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
105	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
106	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
107	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
108	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
109	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
110	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
111	0.0002			total	4.72E-01	0.0002			total	4.72E-01	0.0002
112											
113											
114				**Filename**	fid240c				**Filename**	fid260c	
115											
116	98			1tally 8	nps = 44982423				1tally 8	nps = 44575000	
117	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
118				tally for photons					tally for photons		
119											
120				cell 2					cell 2		

	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ
121				energy					energy		
122	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
123	0.0002			5.00E-02	3.03E-01	0.0002			5.00E-02	3.17E-01	0.0002
124	0.0008			1.00E-01	3.20E-02	0.0008			1.00E-01	2.92E-02	0.0009
125	0.0007			1.50E-01	4.38E-02	0.0007			1.50E-01	4.41E-02	0.0007
126	0.001			2.00E-01	1.39E-02	0.0013			2.00E-01	1.41E-02	0.0013
127	0.0005			2.50E-01	8.88E-02	0.0005			2.50E-01	1.26E-02	0.0013
128	0			3.00E-01	0.00E+00	0			3.00E-01	6.46E-02	0.0006
129	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
130	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
131	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
132	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
133	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
134	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
135	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
136	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
137	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
138	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
139	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
140	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
141	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
142	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
143	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
144	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
145	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
146	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
147	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
148	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
149	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
150	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
151	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
152	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
153	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
154	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
155	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
156	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
157	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
158	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
159	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
160	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
161	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
162	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
163	0.0002			total	4.81E-01	0.0002			total	4.81E-01	0.0002
164											
165											
166				**Filename**	fid240d				**Filename**	fid260d	
167											
168	51			1tally 8	nps = 46171680				1tally 8	nps = 45383705	
169	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
170				tally for photons					tally for photons		
171											
172				cell 2					cell 2		
173				energy					energy		
174	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
175	0.0002			5.00E-02	3.04E-01	0.0002			5.00E-02	3.18E-01	0.0002
176	0.0008			1.00E-01	3.25E-02	0.0008			1.00E-01	2.98E-02	0.0008
177	0.0007			1.50E-01	4.22E-02	0.0007			1.50E-01	4.32E-02	0.0007
178	0.001			2.00E-01	1.25E-02	0.0013			2.00E-01	1.30E-02	0.0013
179	0.0004			2.50E-01	9.52E-02	0.0005			2.50E-01	1.24E-02	0.0013
180	0			3.00E-01	0.00E+00	0			3.00E-01	7.02E-02	0.0005

	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ
181	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
182	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
183	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
184	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
185	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
186	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
187	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
188	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
189	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
190	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
191	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
192	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
193	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
194	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
195	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
196	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
197	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
198	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
199	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
200	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
201	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
202	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
203	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
204	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
205	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
206	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
207	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
208	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
209	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
210	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
211	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
212	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
213	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
214	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
215	0.0002			total	4.86E-01	0.0002			total	4.86E-01	0.0002

	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
1											
2											
3											
4											
5											
6											
7											
8											
9											
10			**Filename**	fid280a				**Filename**	fid300a		
11											
12			1tally 8	nps = 41783854				1tally 8	nps = 42117930		
13	bution.	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.			
14			tally for photons					tally for photons			
15											
16			cell 2					cell 2			
17			energy					energy			
18			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
19			5.00E-02	3.14E-01	0.0002			5.00E-02	3.22E-01	0.0002	
20			1.00E-01	2.58E-02	0.001			1.00E-01	2.43E-02	0.001	
21			1.50E-01	4.26E-02	0.0007			1.50E-01	3.78E-02	0.0008	
22			2.00E-01	1.61E-02	0.0012			2.00E-01	1.93E-02	0.0011	
23			2.50E-01	8.12E-03	0.0017			2.50E-01	6.69E-03	0.0019	
24			3.00E-01	4.61E-02	0.0007			3.00E-01	4.17E-02	0.0007	
25			3.50E-01	0.00E+00	0			3.50E-01	1.65E-05	0.0379	
26			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
27			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
28			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
29			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
30			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
31			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
32			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
33			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
34			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
35			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
36			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
37			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
38			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
39			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
40			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
41			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
42			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
43			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
44			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
45			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
46			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
47			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
48			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
49			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
50			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
51			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
52			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
53			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
54			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
55			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
56			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
57			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
58			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
59			total	4.52E-01	0.0002			total	4.52E-01	0.0002	
60											

	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
61											
62			**Filename**	fid280b				**Filename**	fid300b		
63											
64			1tally 8	nps = 43178529				1tally 8	nps = 43228791		
65	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
66			tally for	photons				tally for	photons		
67											
68			cell 2					cell 2			
69			energy					energy			
70			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
71			5.00E-02	3.24E-01	0.0002			5.00E-02	3.33E-01	0.0002	
72			1.00E-01	2.68E-02	0.0009			1.00E-01	2.54E-02	0.0009	
73			1.50E-01	4.33E-02	0.0007			1.50E-01	3.85E-02	0.0008	
74			2.00E-01	1.56E-02	0.0012			2.00E-01	1.94E-02	0.0011	
75			2.50E-01	8.00E-03	0.0017			2.50E-01	6.52E-03	0.0019	
76			3.00E-01	5.43E-02	0.0006			3.00E-01	4.89E-02	0.0007	
77			3.50E-01	0.00E+00	0			3.50E-01	1.99E-05	0.0341	
78			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
79			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
80			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
81			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
82			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
83			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
84			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
85			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
86			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
87			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
88			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
89			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
90			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
91			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
92			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
93			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
94			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
95			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
96			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
97			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
98			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
99			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
100			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
101			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
102			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
103			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
104			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
105			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
106			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
107			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
108			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
109			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
110			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
111			total	4.72E-01	0.0002			total	4.72E-01	0.0002	
112											
113											
114			**Filename**	fid280c				**Filename**	fid300c		
115											
116			1tally 8	nps = 43963300				1tally 8	nps = 44134813		
117	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
118			tally for	photons				tally for	photons		
119											
120			cell 2					cell 2			

	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
121			energy					energy			
122			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
123			5.00E-02	3.28E-01	0.0002			5.00E-02	3.37E-01	0.0002	
124			1.00E-01	2.75E-02	0.0009			1.00E-01	2.61E-02	0.0009	
125			1.50E-01	4.32E-02	0.0007			1.50E-01	3.86E-02	0.0008	
126			2.00E-01	1.47E-02	0.0012			2.00E-01	1.90E-02	0.0011	
127			2.50E-01	7.61E-03	0.0017			2.50E-01	6.13E-03	0.0019	
128			3.00E-01	6.03E-02	0.0006			3.00E-01	5.41E-02	0.0006	
129			3.50E-01	0.00E+00	0			3.50E-01	2.16E-05	0.0324	
130			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
131			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
132			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
133			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
134			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
135			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
136			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
137			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
138			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
139			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
140			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
141			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
142			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
143			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
144			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
145			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
146			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
147			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
148			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
149			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
150			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
151			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
152			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
153			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
154			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
155			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
156			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
157			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
158			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
159			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
160			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
161			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
162			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
163			total	4.81E-01	0.0002			total	4.81E-01	0.0002	
164											
165											
166			**Filename**	fid280d				**Filename**	fid300d		
167											
168			1tally 8	nps = 45219254				1tally 8	nps = 45009679		
169	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
170			tally for	photons				tally for	photons		
171											
172			cell 2					cell 2			
173			energy					energy			
174			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
175			5.00E-02	3.29E-01	0.0002			5.00E-02	3.39E-01	0.0002	
176			1.00E-01	2.80E-02	0.0009			1.00E-01	2.66E-02	0.0009	
177			1.50E-01	4.29E-02	0.0007			1.50E-01	3.84E-02	0.0007	
178			2.00E-01	1.38E-02	0.0013			2.00E-01	1.84E-02	0.0011	
179			2.50E-01	7.07E-03	0.0018			2.50E-01	5.64E-03	0.002	
180			3.00E-01	6.53E-02	0.0006			3.00E-01	5.85E-02	0.0006	

	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
181			3.50E-01	0.00E+00	0			3.50E-01	2.14E-05	0.0323	
182			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
183			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
184			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
185			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
186			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
187			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
188			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
189			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
190			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
191			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
192			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
193			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
194			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
195			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
196			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
197			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
198			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
199			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
200			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
201			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
202			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
203			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
204			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
205			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
206			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
207			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
208			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
209			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
210			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
211			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
212			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
213			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
214			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
215			total	4.86E-01	0.0002			total	4.86E-01	0.0002	

	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF
1											
2											
3											
4											
5											
6											
7											
8											
9											
10		**Filename**	fid320a				**Filename**	fid340a			
11											
12		1tally 8	nps = 41843278				1tally 8	nps = 41890720			
13	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni
14		tally for photons					tally for photons				
15											
16		cell 2					cell 2				
17		energy					energy				
18		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
19		5.00E-02	3.30E-01	0.0002			5.00E-02	3.36E-01	0.0002		
20		1.00E-01	2.30E-02	0.001			1.00E-01	2.18E-02	0.001		
21		1.50E-01	3.31E-02	0.0008			1.50E-01	2.90E-02	0.0009		
22		2.00E-01	2.25E-02	0.001			2.00E-01	2.52E-02	0.001		
23		2.50E-01	6.29E-03	0.0019			2.50E-01	6.11E-03	0.002		
24		3.00E-01	6.78E-03	0.0019			3.00E-01	3.80E-03	0.0025		
25		3.50E-01	3.09E-02	0.0009			3.50E-01	3.04E-02	0.0009		
26		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
27		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
28		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
29		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
30		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
31		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
32		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
33		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
34		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
35		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
36		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
37		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
38		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
39		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
40		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
41		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
42		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
43		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
44		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
45		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
46		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
47		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
48		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
49		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
50		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
51		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
52		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
53		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
54		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
55		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
56		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
57		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
58		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
59		total	4.52E-01	0.0002			total	4.52E-01	0.0002		
60											

	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF
61											
62		**Filename**	fid320b				**Filename**	fid340b			
63											
64		1tally 8	nps = 42902308				1tally 8	nps = 42420720			
65	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
66		tally for	photons				tally for	photons			
67											
68		cell 2					cell 2				
69		energy					energy				
70		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
71		5.00E-02	3.41E-01	0.0002			5.00E-02	3.48E-01	0.0002		
72		1.00E-01	2.41E-02	0.001			1.00E-01	2.29E-02	0.001		
73		1.50E-01	3.37E-02	0.0008			1.50E-01	2.95E-02	0.0009		
74		2.00E-01	2.32E-02	0.001			2.00E-01	2.63E-02	0.0009		
75		2.50E-01	6.18E-03	0.0019			2.50E-01	6.08E-03	0.002		
76		3.00E-01	7.25E-03	0.0018			3.00E-01	3.75E-03	0.0025		
77		3.50E-01	3.67E-02	0.0008			3.50E-01	3.59E-02	0.0008		
78		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
79		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
80		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
81		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
82		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
83		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
84		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
85		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
86		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
87		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
88		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
89		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
90		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
91		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
92		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
93		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
94		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
95		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
96		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
97		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
98		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
99		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
100		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
101		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
102		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
103		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
104		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
105		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
106		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
107		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
108		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
109		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
110		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
111		total	4.72E-01	0.0002			total	4.72E-01	0.0002		
112											
113											
114		**Filename**	fid320c				**Filename**	fid340c			
115											
116		1tally 8	nps = 43755190				1tally 8	nps = 43690404			
117	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
118		tally for	photons				tally for	photons			
119											
120		cell 2					cell 2				

	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF
121		energy					energy				
122		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
123		5.00E-02	3.45E-01	0.0002			5.00E-02	3.52E-01	0.0002		
124		1.00E-01	2.48E-02	0.0009			1.00E-01	2.36E-02	0.001		
125		1.50E-01	3.37E-02	0.0008			1.50E-01	2.96E-02	0.0009		
126		2.00E-01	2.32E-02	0.001			2.00E-01	2.67E-02	0.0009		
127		2.50E-01	5.89E-03	0.002			2.50E-01	5.85E-03	0.002		
128		3.00E-01	7.43E-03	0.0017			3.00E-01	3.55E-03	0.0025		
129		3.50E-01	4.10E-02	0.0007			3.50E-01	4.00E-02	0.0007		
130		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
131		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
132		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
133		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
134		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
135		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
136		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
137		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
138		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
139		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
140		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
141		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
142		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
143		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
144		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
145		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
146		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
147		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
148		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
149		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
150		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
151		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
152		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
153		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
154		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
155		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
156		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
157		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
158		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
159		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
160		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
161		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
162		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
163		total	4.81E-01	0.0002			total	4.81E-01	0.0002		
164											
165											
166		**Filename**	fid320d				**Filename**	fid340d			
167											
168		1tally 8	nps = 44494552				1tally 8	nps = 44227210			
169	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
170		tally for	photons				tally for	photons			
171											
172		cell 2					cell 2				
173		energy					energy				
174		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
175		5.00E-02	3.47E-01	0.0002			5.00E-02	3.54E-01	0.0002		
176		1.00E-01	2.54E-02	0.0009			1.00E-01	2.42E-02	0.001		
177		1.50E-01	3.36E-02	0.0008			1.50E-01	2.95E-02	0.0009		
178		2.00E-01	2.31E-02	0.001			2.00E-01	2.68E-02	0.0009		
179		2.50E-01	5.52E-03	0.002			2.50E-01	5.56E-03	0.002		
180		3.00E-01	7.45E-03	0.0017			3.00E-01	3.27E-03	0.0026		

	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF
181		3.50E-01	4.47E-02	0.0007			3.50E-01	4.35E-02	0.0007		
182		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
183		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
184		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
185		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
186		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
187		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
188		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
189		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
190		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
191		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
192		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
193		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
194		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
195		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
196		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
197		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
198		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
199		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
200		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
201		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
202		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
203		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
204		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
205		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
206		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
207		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
208		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
209		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
210		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
211		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
212		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
213		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
214		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
215		total	4.86E-01	0.0002			total	4.86E-01	0.0002		

	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ
1											
2											
3											
4											
5											
6											
7											
8											
9											
10	**Filename**	fid360a				**Filename**	fid380a				**Filename**
11											
12	1tally 8	nps = 41724742				1tally 8	nps = 41831350				1tally 8
13	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni	tally ty
14	tally for photons					tally for photons					tally fo
15											
16	cell 2					cell 2					cell 2
17	energy					energy					energy
18	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
19	5.00E-02	3.42E-01	0.0002			5.00E-02	3.46E-01	0.0002			5.00E-02
20	1.00E-01	2.08E-02	0.0011			1.00E-01	1.98E-02	0.0011			1.00E-01
21	1.50E-01	2.53E-02	0.001			1.50E-01	2.35E-02	0.001			1.50E-01
22	2.00E-01	2.56E-02	0.001			2.00E-01	2.39E-02	0.001			2.00E-01
23	2.50E-01	7.89E-03	0.0017			2.50E-01	1.01E-02	0.0015			2.50E-01
24	3.00E-01	3.56E-03	0.0026			3.00E-01	3.38E-03	0.0027			3.00E-01
25	3.50E-01	4.45E-03	0.0023			3.50E-01	2.79E-03	0.0029			3.50E-01
26	4.00E-01	2.32E-02	0.001			4.00E-01	2.26E-02	0.001			4.00E-01
27	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
28	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
29	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
30	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
31	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
32	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
33	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
34	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
35	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
36	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
37	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
38	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
39	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
40	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
41	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
42	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
43	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
44	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
45	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
46	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
47	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
48	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
49	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
50	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
51	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
52	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
53	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
54	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
55	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
56	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
57	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
58	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
59	total	4.52E-01	0.0002			total	4.52E-01	0.0002			total
60											

	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ
61											
62	**Filename**	fid360b				**Filename**	fid380b				**Filename**
63											
64	1tally 8	nps = 42715724				1tally 8	nps = 41677709				1tally 8
65	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
66	tally for	photons				tally for	photons				tally fo
67											
68	cell 2					cell 2					cell 2
69	energy					energy					energy
70	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
71	5.00E-02	3.53E-01	0.0002			5.00E-02	3.58E-01	0.0002			5.00E-02
72	1.00E-01	2.18E-02	0.001			1.00E-01	2.08E-02	0.0011			1.00E-01
73	1.50E-01	2.57E-02	0.0009			1.50E-01	2.39E-02	0.001			1.50E-01
74	2.00E-01	2.68E-02	0.0009			2.00E-01	2.49E-02	0.001			2.00E-01
75	2.50E-01	8.28E-03	0.0017			2.50E-01	1.10E-02	0.0015			2.50E-01
76	3.00E-01	3.56E-03	0.0026			3.00E-01	3.42E-03	0.0026			3.00E-01
77	3.50E-01	4.85E-03	0.0022			3.50E-01	2.87E-03	0.0029			3.50E-01
78	4.00E-01	2.77E-02	0.0009			4.00E-01	2.68E-02	0.0009			4.00E-01
79	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
80	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
81	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
82	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
83	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
84	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
85	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
86	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
87	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
88	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
89	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
90	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
91	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
92	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
93	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
94	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
95	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
96	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
97	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
98	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
99	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
100	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
101	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
102	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
103	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
104	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
105	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
106	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
107	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
108	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
109	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
110	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
111	total	4.72E-01	0.0002			total	4.72E-01	0.0002			total
112											
113											
114	**Filename**	fid360c				**Filename**	fid380c				**Filename**
115											
116	1tally 8	nps = 43509720				1tally 8	nps = 43535035				1tally 8
117	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
118	tally for	photons				tally for	photons				tally fo
119											
120	cell 2					cell 2					cell 2

	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ
121	energy					energy					energy
122	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
123	5.00E-02	3.58E-01	0.0002			5.00E-02	3.63E-01	0.0002			5.00E-02
124	1.00E-01	2.25E-02	0.001			1.00E-01	2.15E-02	0.001			1.00E-01
125	1.50E-01	2.58E-02	0.0009			1.50E-01	2.40E-02	0.001			1.50E-01
126	2.00E-01	2.72E-02	0.0009			2.00E-01	2.52E-02	0.0009			2.00E-01
127	2.50E-01	8.40E-03	0.0016			2.50E-01	1.15E-02	0.0014			2.50E-01
128	3.00E-01	3.43E-03	0.0026			3.00E-01	3.33E-03	0.0026			3.00E-01
129	3.50E-01	5.05E-03	0.0021			3.50E-01	2.85E-03	0.0028			3.50E-01
130	4.00E-01	3.11E-02	0.0008			4.00E-01	3.01E-02	0.0009			4.00E-01
131	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
132	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
133	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
134	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
135	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
136	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
137	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
138	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
139	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
140	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
141	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
142	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
143	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
144	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
145	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
146	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
147	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
148	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
149	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
150	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
151	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
152	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
153	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
154	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
155	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
156	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
157	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
158	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
159	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
160	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
161	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
162	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
163	total	4.81E-01	0.0002			total	4.81E-01	0.0002			total
164											
165											
166	**Filename**	fid360d				**Filename**	fid380d				**Filename**
167											
168	1tally 8 nps = 44108495					1tally 8 nps = 44134923					1tally 8
169	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni	tally ty
170	tally for photons					tally for photons					tally fo
171											
172	cell 2					cell 2					cell 2
173	energy					energy					energy
174	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
175	5.00E-02	3.60E-01	0.0002			5.00E-02	3.65E-01	0.0002			5.00E-02
176	1.00E-01	2.31E-02	0.001			1.00E-01	2.20E-02	0.001			1.00E-01
177	1.50E-01	2.59E-02	0.0009			1.50E-01	2.40E-02	0.001			1.50E-01
178	2.00E-01	2.73E-02	0.0009			2.00E-01	2.52E-02	0.0009			2.00E-01
179	2.50E-01	8.41E-03	0.0016			2.50E-01	1.19E-02	0.0014			2.50E-01
180	3.00E-01	3.23E-03	0.0026			3.00E-01	3.20E-03	0.0027			3.00E-01

	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ
181	3.50E-01	5.13E-03	0.0021			3.50E-01	2.73E-03	0.0029			3.50E-01
182	4.00E-01	3.40E-02	0.0008			4.00E-01	3.28E-02	0.0008			4.00E-01
183	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
184	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
185	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
186	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
187	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
188	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
189	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
190	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
191	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
192	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
193	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
194	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
195	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
196	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
197	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
198	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
199	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
200	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
201	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
202	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
203	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
204	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
205	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
206	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
207	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
208	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
209	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
210	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
211	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
212	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
213	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
214	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
215	total	4.87E-01	0.0002			total	4.87E-01	0.0002			total

	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB
1											
2											
3											
4											
5											
6											
7											
8											
9											
10	fid400a				**Filename**	fid420a				**Filename**	fid440a
11											
12	ps = 40721404				1tally 8	nps = 41938348				1tally 8	nps = 4195
13	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
14	photons				tally for photons					tally for photons	
15											
16					cell 2					cell 2	
17					energy					energy	
18	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
19	3.51E-01	0.0002			5.00E-02	3.54E-01	0.0002			5.00E-02	3.57E-01
20	1.89E-02	0.0011			1.00E-01	1.81E-02	0.0011			1.00E-01	1.73E-02
21	2.22E-02	0.001			1.50E-01	2.10E-02	0.0011			1.50E-01	2.00E-02
22	2.23E-02	0.001			2.00E-01	2.09E-02	0.0011			2.00E-01	1.97E-02
23	1.18E-02	0.0014			2.50E-01	1.14E-02	0.0014			2.50E-01	1.05E-02
24	3.32E-03	0.0027			3.00E-01	4.94E-03	0.0022			3.00E-01	6.90E-03
25	2.30E-03	0.0033			3.50E-01	2.21E-03	0.0033			3.50E-01	2.15E-03
26	2.11E-02	0.0011			4.00E-01	3.06E-03	0.0028			4.00E-01	1.57E-03
27	8.13E-06	0.055			4.50E-01	1.65E-02	0.0012			4.50E-01	1.67E-02
28	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
29	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
30	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
31	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
32	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
33	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
34	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
35	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
36	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
37	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
38	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
39	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
40	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
41	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
42	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
43	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
44	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
45	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
46	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
47	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
48	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
49	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
50	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
51	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
52	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
53	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
54	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
55	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
56	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
57	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
58	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
59	4.52E-01	0.0002			total	4.52E-01	0.0002			total	4.52E-01
60											

	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB
61											
62	fid400b				**Filename**	fid420b				**Filename**	fid440b
63											
64	ps = 42579931				1tally 8	nps = 42740350				1tally 8	nps = 4280
65	e 8 pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse
66	photons				tally for photons					tally for photons	
67											
68					cell 2					cell 2	
69					energy					energy	
70	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
71	3.63E-01	0.0002			5.00E-02	3.67E-01	0.0002			5.00E-02	3.70E-01
72	1.99E-02	0.0011			1.00E-01	1.90E-02	0.0011			1.00E-01	1.82E-02
73	2.26E-02	0.001			1.50E-01	2.14E-02	0.001			1.50E-01	2.03E-02
74	2.32E-02	0.001			2.00E-01	2.17E-02	0.001			2.00E-01	2.05E-02
75	1.30E-02	0.0013			2.50E-01	1.26E-02	0.0014			2.50E-01	1.15E-02
76	3.40E-03	0.0026			3.00E-01	5.38E-03	0.0021			3.00E-01	7.78E-03
77	2.32E-03	0.0032			3.50E-01	2.26E-03	0.0032			3.50E-01	2.24E-03
78	2.50E-02	0.001			4.00E-01	3.38E-03	0.0026			4.00E-01	1.60E-03
79	9.89E-06	0.0487			4.50E-01	1.97E-02	0.0011			4.50E-01	1.99E-02
80	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
81	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
82	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
83	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
84	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
85	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
86	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
87	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
88	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
89	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
90	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
91	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
92	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
93	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
94	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
95	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
96	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
97	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
98	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
99	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
100	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
101	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
102	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
103	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
104	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
105	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
106	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
107	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
108	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
109	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
110	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
111	4.72E-01	0.0002			total	4.72E-01	0.0002			total	4.72E-01
112											
113											
114	fid400c				**Filename**	fid420c				**Filename**	fid440c
115											
116	ps = 43458490				1tally 8	nps = 43381849				1tally 8	nps = 4305
117	e 8 pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse
118	photons				tally for photons					tally for photons	
119											
120					cell 2					cell 2	

	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB
121					energy					energy	
122	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
123	3.67E-01	0.0002			5.00E-02	3.71E-01	0.0002			5.00E-02	3.75E-01
124	2.05E-02	0.001			1.00E-01	1.96E-02	0.0011			1.00E-01	1.88E-02
125	2.27E-02	0.001			1.50E-01	2.15E-02	0.001			1.50E-01	2.04E-02
126	2.34E-02	0.001			2.00E-01	2.19E-02	0.001			2.00E-01	2.07E-02
127	1.38E-02	0.0013			2.50E-01	1.34E-02	0.0013			2.50E-01	1.21E-02
128	3.36E-03	0.0026			3.00E-01	5.62E-03	0.002			3.00E-01	8.38E-03
129	2.26E-03	0.0032			3.50E-01	2.23E-03	0.0032			3.50E-01	2.24E-03
130	2.79E-02	0.0009			4.00E-01	3.55E-03	0.0025			4.00E-01	1.55E-03
131	1.06E-05	0.0466			4.50E-01	2.22E-02	0.001			4.50E-01	2.23E-02
132	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
133	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
134	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
135	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
136	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
137	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
138	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
139	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
140	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
141	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
142	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
143	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
144	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
145	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
146	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
147	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
148	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
149	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
150	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
151	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
152	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
153	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
154	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
155	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
156	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
157	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
158	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
159	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
160	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
161	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
162	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
163	4.81E-01	0.0002			total	4.81E-01	0.0002			total	4.81E-01
164											
165											
166	fid400d				**Filename**	fid420d				**Filename**	fid440d
167											
168	ps = 44016029				1tally 8	nps = 43990034				1tally 8	nps = 4402
169	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8	pulse
170	photons				tally for photons					tally for photons	
171											
172					cell 2					cell 2	
173					energy					energy	
174	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
175	3.69E-01	0.0002			5.00E-02	3.73E-01	0.0002			5.00E-02	3.77E-01
176	2.10E-02	0.001			1.00E-01	2.01E-02	0.0011			1.00E-01	1.92E-02
177	2.27E-02	0.001			1.50E-01	2.15E-02	0.001			1.50E-01	2.05E-02
178	2.33E-02	0.001			2.00E-01	2.19E-02	0.001			2.00E-01	2.06E-02
179	1.44E-02	0.0012			2.50E-01	1.40E-02	0.0013			2.50E-01	1.26E-02
180	3.28E-03	0.0026			3.00E-01	5.79E-03	0.002			3.00E-01	8.85E-03

	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB
181	2.13E-03	0.0033			3.50E-01	2.16E-03	0.0032			3.50E-01	2.21E-03
182	3.04E-02	0.0009			4.00E-01	3.66E-03	0.0025			4.00E-01	1.46E-03
183	1.07E-05	0.046			4.50E-01	2.43E-02	0.001			4.50E-01	2.44E-02
184	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
185	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
186	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
187	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
188	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
189	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
190	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
191	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
192	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
193	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
194	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
195	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
196	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
197	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
198	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
199	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
200	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
201	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
202	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
203	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
204	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
205	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
206	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
207	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
208	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
209	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
210	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
211	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
212	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
213	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
214	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
215	4.87E-01	0.0002			total	4.87E-01	0.0002			total	4.87E-01

	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL	EM
1											
2											
3											
4											
5											
6											
7											
8											
9											
10				**Filename**	fid460a				**Filename**	fid480a	
11											
12	07			1tally 8	nps = 41962666				1tally 8	nps = 42226493	
13	height distribution.		uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height dist		
14				tally for photons					tally for photons		
15											
16				cell 2					cell 2		
17				energy					energy		
18	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
19	0.0002			5.00E-02	3.60E-01	0.0002			5.00E-02	3.63E-01	0.0002
20	0.0012			1.00E-01	1.66E-02	0.0012			1.00E-01	1.60E-02	0.0012
21	0.0011			1.50E-01	1.90E-02	0.0011			1.50E-01	1.81E-02	0.0011
22	0.0011			2.00E-01	1.86E-02	0.0011			2.00E-01	1.77E-02	0.0011
23	0.0015			2.50E-01	9.86E-03	0.0015			2.50E-01	9.42E-03	0.0016
24	0.0019			3.00E-01	8.38E-03	0.0017			3.00E-01	7.86E-03	0.0017
25	0.0033			3.50E-01	2.16E-03	0.0033			3.50E-01	3.85E-03	0.0025
26	0.0039			4.00E-01	1.57E-03	0.0039			4.00E-01	1.53E-03	0.0039
27	0.0012			4.50E-01	2.24E-03	0.0033			4.50E-01	1.37E-03	0.0042
28	0			5.00E-01	1.33E-02	0.0013			5.00E-01	1.33E-02	0.0013
29	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
30	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
31	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
32	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
33	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
34	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
35	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
36	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
37	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
38	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
39	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
40	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
41	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
42	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
43	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
44	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
45	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
46	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
47	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
48	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
49	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
50	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
51	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
52	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
53	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
54	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
55	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
56	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
57	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
58	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
59	0.0002			total	4.52E-01	0.0002			total	4.52E-01	0.0002
60											

	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL	EM
61											
62				**Filename**	fid460b				**Filename**	fid480b	
63											
64	73			1tally 8	nps = 42789915				1tally 8	nps = 42815173	
65	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
66				tally for photons					tally for photons		
67											
68				cell 2					cell 2		
69				energy					energy		
70	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
71	0.0002			5.00E-02	3.73E-01	0.0002			5.00E-02	3.76E-01	0.0002
72	0.0011			1.00E-01	1.75E-02	0.0011			1.00E-01	1.68E-02	0.0012
73	0.0011			1.50E-01	1.93E-02	0.0011			1.50E-01	1.84E-02	0.0011
74	0.0011			2.00E-01	1.94E-02	0.0011			2.00E-01	1.84E-02	0.0011
75	0.0014			2.50E-01	1.07E-02	0.0015			2.50E-01	1.02E-02	0.0015
76	0.0017			3.00E-01	9.60E-03	0.0016			3.00E-01	8.99E-03	0.0016
77	0.0032			3.50E-01	2.28E-03	0.0032			3.50E-01	4.33E-03	0.0023
78	0.0038			4.00E-01	1.62E-03	0.0038			4.00E-01	1.62E-03	0.0038
79	0.0011			4.50E-01	2.52E-03	0.003			4.50E-01	1.46E-03	0.004
80	0			5.00E-01	1.60E-02	0.0012			5.00E-01	1.59E-02	0.0012
81	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
82	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
83	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
84	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
85	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
86	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
87	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
88	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
89	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
90	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
91	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
92	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
93	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
94	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
95	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
96	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
97	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
98	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
99	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
100	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
101	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
102	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
103	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
104	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
105	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
106	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
107	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
108	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
109	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
110	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
111	0.0002			total	4.72E-01	0.0002			total	4.72E-01	0.0002
112											
113											
114				**Filename**	fid460c				**Filename**	fid480c	
115											
116	81			1tally 8	nps = 43369000				1tally 8	nps = 42274992	
117	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
118				tally for photons					tally for photons		
119											
120				cell 2					cell 2		

	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL	EM
121				energy					energy		
122	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
123	0.0002			5.00E-02	3.78E-01	0.0002			5.00E-02	3.81E-01	0.0002
124	0.0011			1.00E-01	1.80E-02	0.0011			1.00E-01	1.73E-02	0.0012
125	0.0011			1.50E-01	1.94E-02	0.0011			1.50E-01	1.85E-02	0.0011
126	0.001			2.00E-01	1.96E-02	0.0011			2.00E-01	1.86E-02	0.0011
127	0.0014			2.50E-01	1.12E-02	0.0014			2.50E-01	1.06E-02	0.0015
128	0.0017			3.00E-01	1.05E-02	0.0015			3.00E-01	9.80E-03	0.0015
129	0.0032			3.50E-01	2.31E-03	0.0032			3.50E-01	4.63E-03	0.0023
130	0.0039			4.00E-01	1.60E-03	0.0038			4.00E-01	1.63E-03	0.0038
131	0.001			4.50E-01	2.67E-03	0.0029			4.50E-01	1.46E-03	0.004
132	0			5.00E-01	1.80E-02	0.0011			5.00E-01	1.79E-02	0.0011
133	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
134	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
135	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
136	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
137	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
138	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
139	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
140	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
141	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
142	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
143	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
144	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
145	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
146	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
147	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
148	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
149	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
150	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
151	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
152	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
153	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
154	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
155	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
156	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
157	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
158	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
159	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
160	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
161	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
162	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
163	0.0002			total	4.81E-01	0.0002			total	4.81E-01	0.0002
164											
165											
166				**Filename**	fid460d				**Filename**	fid480d	
167											
168	77			1tally 8	nps = 44095084				1tally 8	nps = 44187332	
169	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
170				tally for	photons				tally for	photons	
171											
172				cell 2					cell 2		
173				energy					energy		
174	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
175	0.0002			5.00E-02	3.80E-01	0.0002			5.00E-02	3.83E-01	0.0002
176	0.0011			1.00E-01	1.84E-02	0.0011			1.00E-01	1.77E-02	0.0011
177	0.001			1.50E-01	1.95E-02	0.0011			1.50E-01	1.86E-02	0.0011
178	0.001			2.00E-01	1.96E-02	0.0011			2.00E-01	1.86E-02	0.0011
179	0.0013			2.50E-01	1.16E-02	0.0014			2.50E-01	1.09E-02	0.0014
180	0.0016			3.00E-01	1.12E-02	0.0014			3.00E-01	1.05E-02	0.0015

	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL	EM
181	0.0032			3.50E-01	2.31E-03	0.0031			3.50E-01	4.89E-03	0.0021
182	0.0039			4.00E-01	1.55E-03	0.0038			4.00E-01	1.61E-03	0.0037
183	0.001			4.50E-01	2.77E-03	0.0029			4.50E-01	1.43E-03	0.004
184	0			5.00E-01	1.98E-02	0.0011			5.00E-01	1.96E-02	0.0011
185	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
186	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
187	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
188	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
189	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
190	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
191	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
192	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
193	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
194	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
195	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
196	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
197	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
198	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
199	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
200	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
201	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
202	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
203	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
204	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
205	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
206	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
207	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
208	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
209	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
210	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
211	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
212	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
213	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
214	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
215	0.0002			total	4.87E-01	0.0002			total	4.87E-01	0.0002

	EN	EO	EP	EQ	ER	ES	ET	EU	EV
1									
2									
3									
4									
5									
6									
7									
8									
9									
10			**Filename**	fid500a					
11									
12			1tally 8	nps = 42359916					
13	bution.	uni	tally type 8 pulse height distribution.				units	number	
14			tally for photons						
15									
16			cell 2						
17			energy						
18			0.00E+00	0.00E+00	0				
19			5.00E-02	3.66E-01	0.0002				
20			1.00E-01	1.54E-02	0.0012				
21			1.50E-01	1.73E-02	0.0012				
22			2.00E-01	1.68E-02	0.0012				
23			2.50E-01	9.12E-03	0.0016				
24			3.00E-01	7.05E-03	0.0018				
25			3.50E-01	5.61E-03	0.002				
26			4.00E-01	1.54E-03	0.0039				
27			4.50E-01	1.16E-03	0.0045				
28			5.00E-01	1.27E-02	0.0014				
29			5.50E-01	5.10E-06	0.068				
30			6.00E-01	0.00E+00	0				
31			6.50E-01	0.00E+00	0				
32			7.00E-01	0.00E+00	0				
33			7.50E-01	0.00E+00	0				
34			8.00E-01	0.00E+00	0				
35			8.50E-01	0.00E+00	0				
36			9.00E-01	0.00E+00	0				
37			9.50E-01	0.00E+00	0				
38			1.00E+00	0.00E+00	0				
39			1.05E+00	0.00E+00	0				
40			1.10E+00	0.00E+00	0				
41			1.15E+00	0.00E+00	0				
42			1.20E+00	0.00E+00	0				
43			1.25E+00	0.00E+00	0				
44			1.30E+00	0.00E+00	0				
45			1.35E+00	0.00E+00	0				
46			1.40E+00	0.00E+00	0				
47			1.45E+00	0.00E+00	0				
48			1.50E+00	0.00E+00	0				
49			1.55E+00	0.00E+00	0				
50			1.60E+00	0.00E+00	0				
51			1.65E+00	0.00E+00	0				
52			1.70E+00	0.00E+00	0				
53			1.75E+00	0.00E+00	0				
54			1.80E+00	0.00E+00	0				
55			1.85E+00	0.00E+00	0				
56			1.90E+00	0.00E+00	0				
57			1.95E+00	0.00E+00	0				
58			2.00E+00	0.00E+00	0				
59			total	4.52E-01	0.0002				
60									

	EN	EO	EP	EQ	ER	ES	ET	EU	EV
61									
62			**Filename**	fid500b					
63									
64			1tally 8	nps = 42864480					
65	bution.	uni	tally type 8	pulse height distribution.			units	number	
66			tally for	photons					
67									
68			cell 2						
69			energy						
70			0.00E+00	0.00E+00	0				
71			5.00E-02	3.79E-01	0.0002				
72			1.00E-01	1.62E-02	0.0012				
73			1.50E-01	1.76E-02	0.0011				
74			2.00E-01	1.75E-02	0.0011				
75			2.50E-01	9.82E-03	0.0015				
76			3.00E-01	8.00E-03	0.0017				
77			3.50E-01	6.48E-03	0.0019				
78			4.00E-01	1.65E-03	0.0038				
79			4.50E-01	1.20E-03	0.0044				
80			5.00E-01	1.51E-02	0.0012				
81			5.50E-01	5.83E-06	0.0632				
82			6.00E-01	0.00E+00	0				
83			6.50E-01	0.00E+00	0				
84			7.00E-01	0.00E+00	0				
85			7.50E-01	0.00E+00	0				
86			8.00E-01	0.00E+00	0				
87			8.50E-01	0.00E+00	0				
88			9.00E-01	0.00E+00	0				
89			9.50E-01	0.00E+00	0				
90			1.00E+00	0.00E+00	0				
91			1.05E+00	0.00E+00	0				
92			1.10E+00	0.00E+00	0				
93			1.15E+00	0.00E+00	0				
94			1.20E+00	0.00E+00	0				
95			1.25E+00	0.00E+00	0				
96			1.30E+00	0.00E+00	0				
97			1.35E+00	0.00E+00	0				
98			1.40E+00	0.00E+00	0				
99			1.45E+00	0.00E+00	0				
100			1.50E+00	0.00E+00	0				
101			1.55E+00	0.00E+00	0				
102			1.60E+00	0.00E+00	0				
103			1.65E+00	0.00E+00	0				
104			1.70E+00	0.00E+00	0				
105			1.75E+00	0.00E+00	0				
106			1.80E+00	0.00E+00	0				
107			1.85E+00	0.00E+00	0				
108			1.90E+00	0.00E+00	0				
109			1.95E+00	0.00E+00	0				
110			2.00E+00	0.00E+00	0				
111			total	4.72E-01	0.0002				
112									
113									
114			**Filename**	fid500c					
115									
116			1tally 8	nps = 43458490					
117	bution.	uni	tally type 8	pulse height distribution.			units	number	
118			tally for	photons					
119									
120			cell 2						

	EN	EO	EP	EQ	ER	ES	ET	EU	EV
121			energy						
122			0.00E+00	0.00E+00	0				
123			5.00E-02	3.84E-01	0.0002				
124			1.00E-01	1.67E-02	0.0012				
125			1.50E-01	1.77E-02	0.0011				
126			2.00E-01	1.77E-02	0.0011				
127			2.50E-01	1.02E-02	0.0015				
128			3.00E-01	8.68E-03	0.0016				
129			3.50E-01	7.08E-03	0.0018				
130			4.00E-01	1.69E-03	0.0037				
131			4.50E-01	1.18E-03	0.0044				
132			5.00E-01	1.70E-02	0.0012				
133			5.50E-01	6.67E-06	0.0587				
134			6.00E-01	0.00E+00	0				
135			6.50E-01	0.00E+00	0				
136			7.00E-01	0.00E+00	0				
137			7.50E-01	0.00E+00	0				
138			8.00E-01	0.00E+00	0				
139			8.50E-01	0.00E+00	0				
140			9.00E-01	0.00E+00	0				
141			9.50E-01	0.00E+00	0				
142			1.00E+00	0.00E+00	0				
143			1.05E+00	0.00E+00	0				
144			1.10E+00	0.00E+00	0				
145			1.15E+00	0.00E+00	0				
146			1.20E+00	0.00E+00	0				
147			1.25E+00	0.00E+00	0				
148			1.30E+00	0.00E+00	0				
149			1.35E+00	0.00E+00	0				
150			1.40E+00	0.00E+00	0				
151			1.45E+00	0.00E+00	0				
152			1.50E+00	0.00E+00	0				
153			1.55E+00	0.00E+00	0				
154			1.60E+00	0.00E+00	0				
155			1.65E+00	0.00E+00	0				
156			1.70E+00	0.00E+00	0				
157			1.75E+00	0.00E+00	0				
158			1.80E+00	0.00E+00	0				
159			1.85E+00	0.00E+00	0				
160			1.90E+00	0.00E+00	0				
161			1.95E+00	0.00E+00	0				
162			2.00E+00	0.00E+00	0				
163			total	4.81E-01	0.0002				
164									
165									
166			**Filename**	fid500d					
167									
168			1tally 8 nps = 44107757						
169	bution.	uni	tally type 8 pulse height distribution.				units	number	
170			tally for photons						
171									
172			cell 2						
173			energy						
174			0.00E+00	0.00E+00	0				
175			5.00E-02	3.86E-01	0.0002				
176			1.00E-01	1.70E-02	0.0011				
177			1.50E-01	1.77E-02	0.0011				
178			2.00E-01	1.77E-02	0.0011				
179			2.50E-01	1.05E-02	0.0015				
180			3.00E-01	9.22E-03	0.0016				

	EN	EO	EP	EQ	ER	ES	ET	EU	EV
181			3.50E-01	7.60E-03	0.0017				
182			4.00E-01	1.71E-03	0.0036				
183			4.50E-01	1.13E-03	0.0045				
184			5.00E-01	1.85E-02	0.0011				
185			5.50E-01	6.85E-06	0.0575				
186			6.00E-01	0.00E+00	0				
187			6.50E-01	0.00E+00	0				
188			7.00E-01	0.00E+00	0				
189			7.50E-01	0.00E+00	0				
190			8.00E-01	0.00E+00	0				
191			8.50E-01	0.00E+00	0				
192			9.00E-01	0.00E+00	0				
193			9.50E-01	0.00E+00	0				
194			1.00E+00	0.00E+00	0				
195			1.05E+00	0.00E+00	0				
196			1.10E+00	0.00E+00	0				
197			1.15E+00	0.00E+00	0				
198			1.20E+00	0.00E+00	0				
199			1.25E+00	0.00E+00	0				
200			1.30E+00	0.00E+00	0				
201			1.35E+00	0.00E+00	0				
202			1.40E+00	0.00E+00	0				
203			1.45E+00	0.00E+00	0				
204			1.50E+00	0.00E+00	0				
205			1.55E+00	0.00E+00	0				
206			1.60E+00	0.00E+00	0				
207			1.65E+00	0.00E+00	0				
208			1.70E+00	0.00E+00	0				
209			1.75E+00	0.00E+00	0				
210			1.80E+00	0.00E+00	0				
211			1.85E+00	0.00E+00	0				
212			1.90E+00	0.00E+00	0				
213			1.95E+00	0.00E+00	0				
214			2.00E+00	0.00E+00	0				
215			total	4.87E-01	0.0002				

	A	B	C	D	E	F	G	H	I	J	K
1	This is the MCNP data for the Seneca Army Depot volume contamination study.										
2	The goal is to determine the affect that volume contamination would have on the FIDLER istrument used for gamma spectroscopy.										
3	Filenames use the following format:				fid	energy (keV)	depth				
4		where depth is indicated by: 1) a = 1 cm: 2) b = 0.5 cm; 3) c = 0.25 cm; 4) d = 0.1 cm									
5		as an example fid100c is the 100 keV source that is 0.25 cm thick									
6	An air shield exists between the source and detector that is 0.265 cm (0.1 inch) thick and should not effect the results.										
7	All runs were completed in 60 minutes of run time.										
8	**These run are with the 2.35 g/cc density.**										
9											
10	**Filename**	fid10a				**Filename**	fid20a				**Filename**
11											
12	1tally 8	nps = 54135083				1tally 8	nps = 46811064				1tally 8
13	tally type 8 pulse height distribution.				un	tally type 8 pulse height distribution.				unit,	tally ty
14	tally for photons					tally for photons					tally fo
15											
16	cell 2					cell 2					cell 2
17	energy					energy					energy
18	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
19	5.00E-02	1.93E-03	0.0031			5.00E-02	3.58E-02	0.0008			5.00E-02
20	1.00E-01	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01
21	1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01
22	2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01
23	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
24	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
25	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
26	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
27	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
28	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
29	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
30	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
31	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
32	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
33	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
34	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
35	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
36	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
37	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
38	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
39	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
40	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
41	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
42	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
43	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
44	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
45	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
46	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
47	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
48	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
49	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
50	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
51	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
52	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
53	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
54	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
55	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
56	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
57	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
58	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
59	total	1.93E-03	0.0031			total	3.58E-02	0.0008			total
60											

	A	B	C	D	E	F	G	H	I	J	K
61											
62	**Filename**	fid10b				**Filename**	fid20b				**Filename**
63											
64	1tally 8	nps = 53861331				1tally 8	nps = 44818681				1tally 8
65	tally type 8	pulse height distribution.			un	tally type 8	pulse height distribution.			unit	tally ty
66	tally for	photons				tally for	photons				tally fo
67											
68	cell 2					cell 2					cell 2
69	energy					energy					energy
70	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
71	5.00E-02	3.55E-03	0.0023			5.00E-02	6.45E-02	0.0006			5.00E-02
72	1.00E-01	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01
73	1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01
74	2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01
75	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
76	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
77	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
78	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
79	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
80	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
81	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
82	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
83	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
84	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
85	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
86	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
87	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
88	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
89	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
90	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
91	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
92	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
93	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
94	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
95	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
96	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
97	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
98	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
99	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
100	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
101	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
102	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
103	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
104	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
105	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
106	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
107	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
108	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
109	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
110	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
111	total	3.55E-03	0.0023			total	6.45E-02	0.0006			total
112											
113											
114	**Filename**	fid10c				**Filename**	fid20c				**Filename**
115											
116	1tally 8	nps = 52772288				1tally 8	nps = 40709495				1tally 8
117	tally type 8	pulse height distribution.			un	tally type 8	pulse height distribution.			unit	tally ty
118	tally for	photons				tally for	photons				tally fo
119											
120	cell 2					cell 2					cell 2

	A	B	C	D	E	F	G	H	I	J	K
121	energy					energy					energy
122	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
123	5.00E-02	6.92E-03	0.0016			5.00E-02	1.17E-01	0.0004			5.00E-02
124	1.00E-01	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01
125	1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01
126	2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01
127	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
128	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
129	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
130	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
131	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
132	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
133	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
134	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
135	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
136	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
137	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
138	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
139	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
140	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
141	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
142	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
143	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
144	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
145	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
146	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
147	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
148	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
149	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
150	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
151	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
152	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
153	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
154	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
155	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
156	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
157	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
158	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
159	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
160	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
161	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
162	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
163	total	6.92E-03	0.0016			total	1.17E-01	0.0004			total
164											
165											
166	**Filename**	fid10d				**Filename**	fid20d				**Filename**
167											
168	1tally 8	nps = 51482285				1tally 8	nps = 35841362				1tally 8
169	tally type 8 pulse height distribution.				un	tally type 8 pulse height distribution.				unit	tally ty
170	tally for photons					tally for photons					tally fo
171											
172	cell 2					cell 2					cell 2
173	energy					energy					energy
174	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
175	5.00E-02	1.89E-02	0.001			5.00E-02	2.18E-01	0.0003			5.00E-02
176	1.00E-01	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01
177	1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01
178	2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01
179	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
180	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01

	A	B	C	D	E	F	G	H	I	J	K
181	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
182	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
183	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
184	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
185	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
186	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
187	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
188	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
189	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
190	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
191	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
192	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
193	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
194	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
195	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
196	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
197	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
198	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
199	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
200	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
201	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
202	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
203	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
204	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
205	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
206	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
207	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
208	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
209	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
210	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
211	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
212	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
213	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
214	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
215	total	1.89E-02	0.001			total	2.18E-01	0.0003			total

	L	M	N	O	P	Q	R	S	T	U	V
1											
2											
3											
4											
5											
6											
7											
8											
9											
10	fid30a				**Filename**	fid40a				**Filename**	fid50a
11											
12	ps = 36297615				1tally 8	nps = 25651719				1tally 8	nps = 2202
13	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				un	tally type 8	pulse
14	photons				tally for photons					tally for photons	
15											
16					cell 2					cell 2	
17					energy					energy	
18	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
19	1.20E-01	0.0004			5.00E-02	2.21E-01	0.0004			5.00E-02	2.99E-01
20	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01	1.91E-04
21	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00
22	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00
23	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00
24	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
25	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
26	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
27	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
28	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
29	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
30	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
31	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
32	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
33	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
34	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
35	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
36	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
37	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
38	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
39	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
40	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
41	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
42	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
43	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
44	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
45	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
46	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
47	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
48	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
49	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
50	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
51	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
52	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
53	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
54	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
55	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
56	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
57	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
58	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
59	1.20E-01	0.0004			total	2.21E-01	0.0004			total	2.99E-01
60											

	L	M	N	O	P	Q	R	S	T	U	V
61											
62	fid30b				**Filename**	fid40b				**Filename**	fid50b
63											
64	ps = 34142905				1tally 8	nps = 24065109				1tally 8	nps = 2178
65	e 8 pulse height distribution.			uni	tally type 8	pulse height distribution.			un	tally type 8	pulse
66	photons				tally for photons					tally for photons	
67											
68					cell 2					cell 2	
69					energy					energy	
70	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
71	1.90E-01	0.0004			5.00E-02	2.99E-01	0.0003			5.00E-02	3.66E-01
72	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01	2.63E-04
73	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00
74	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00
75	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00
76	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
77	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
78	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
79	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
80	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
81	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
82	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
83	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
84	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
85	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
86	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
87	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
88	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
89	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
90	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
91	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
92	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
93	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
94	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
95	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
96	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
97	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
98	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
99	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
100	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
101	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
102	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
103	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
104	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
105	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
106	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
107	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
108	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
109	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
110	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
111	1.90E-01	0.0004			total	2.99E-01	0.0003			total	3.67E-01
112											
113											
114	fid30c				**Filename**	fid40c				**Filename**	fid50c
115											
116	ps = 31328998				1tally 8	nps = 22565602				1tally 8	nps = 2114
117	e 8 pulse height distribution.			uni	tally type 8	pulse height distribution.			un	tally type 8	pulse
118	photons				tally for photons					tally for photons	
119											
120					cell 2					cell 2	

	L	M	N	O	P	Q	R	S	T	U	V
121					energy					energy	
122	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
123	2.70E-01	0.0003			5.00E-02	3.64E-01	0.0003			5.00E-02	4.14E-01
124	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01	3.20E-04
125	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00
126	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00
127	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00
128	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
129	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
130	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
131	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
132	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
133	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
134	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
135	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
136	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
137	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
138	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
139	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
140	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
141	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
142	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
143	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
144	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
145	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
146	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
147	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
148	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
149	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
150	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
151	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
152	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
153	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
154	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
155	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
156	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
157	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
158	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
159	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
160	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
161	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
162	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
163	2.70E-01	0.0003			total	3.64E-01	0.0003			total	4.14E-01
164											
165											
166	fid30d				**Filename**	fid40d				**Filename**	fid50d
167											
168	ps = 29381852				1tally 8	nps = 21608132				1tally 8	nps = 2104
169	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				un	tally type 8	pulse
170	photons				tally for photons					tally for photons	
171											
172					cell 2					cell 2	
173					energy					energy	
174	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
175	3.60E-01	0.0002			5.00E-02	4.24E-01	0.0003			5.00E-02	4.52E-01
176	0.00E+00	0			1.00E-01	0.00E+00	0			1.00E-01	3.14E-04
177	0.00E+00	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00
178	0.00E+00	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00
179	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00
180	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00

	L	M	N	O	P	Q	R	S	T	U	V
181	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
182	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
183	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
184	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
185	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
186	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
187	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
188	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
189	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
190	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
191	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
192	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
193	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
194	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
195	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
196	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
197	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
198	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
199	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
200	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
201	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
202	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
203	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
204	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
205	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
206	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
207	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
208	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
209	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
210	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
211	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
212	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
213	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
214	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
215	3.60E-01	0.0002			total	4.24E-01	0.0003			total	4.52E-01

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1											
2											
3											
4											
5											
6											
7											
8											
9											
10				**Filename**	fid60a				**Filename**	fid70a	
11											
12	03			1tally 8	nps = 20219640				1tally 8	nps = 19277774	
13	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
14				tally for	photons				tally for	photons	
15											
16				cell 2					cell 2		
17				energy					energy		
18	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
19	0.0003			5.00E-02	7.34E-02	0.0008			5.00E-02	6.48E-02	0.0009
20	0.0154			1.00E-01	2.78E-01	0.0004			1.00E-01	3.19E-01	0.0003
21	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0
22	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0
23	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0
24	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0
25	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
26	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
27	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
28	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
29	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
30	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
31	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
32	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
33	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
34	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
35	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
36	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
37	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
38	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
39	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
40	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
41	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
42	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
43	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
44	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
45	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
46	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
47	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
48	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
49	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
50	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
51	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
52	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
53	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
54	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
55	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
56	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
57	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
58	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
59	0.0003			total	3.51E-01	0.0003			total	3.84E-01	0.0003
60											

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
61											
62				**Filename**	fid60b				**Filename**	fid70b	
63											
64	03			1tally 8	nps = 20617424				1tally 8	nps = 20028908	
65	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
66				tally for	photons				tally for	photons	
67											
68				cell 2					cell 2		
69				energy					energy		
70	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
71	0.0003			5.00E-02	8.07E-02	0.0007			5.00E-02	7.14E-02	0.0008
72	0.0132			1.00E-01	3.25E-01	0.0003			1.00E-01	3.58E-01	0.0003
73	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0
74	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0
75	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0
76	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0
77	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
78	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
79	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
80	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
81	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
82	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
83	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
84	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
85	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
86	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
87	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
88	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
89	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
90	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
91	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
92	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
93	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
94	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
95	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
96	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
97	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
98	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
99	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
100	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
101	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
102	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
103	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
104	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
105	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
106	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
107	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
108	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
109	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
110	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
111	0.0003			total	4.06E-01	0.0003			total	4.29E-01	0.0003
112											
113											
114				**Filename**	fid60c				**Filename**	fid70c	
115											
116	36			1tally 8	nps = 20497076				1tally 8	nps = 20219776	
117	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
118				tally for	photons				tally for	photons	
119											
120				cell 2					cell 2		

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
121				energy					energy		
122	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
123	0.0003			5.00E-02	8.43E-02	0.0007			5.00E-02	7.55E-02	0.0008
124	0.0122			1.00E-01	3.57E-01	0.0003			1.00E-01	3.80E-01	0.0003
125	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0
126	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0
127	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0
128	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0
129	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
130	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
131	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
132	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
133	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
134	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
135	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
136	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
137	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
138	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
139	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
140	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
141	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
142	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
143	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
144	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
145	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
146	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
147	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
148	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
149	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
150	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
151	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
152	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
153	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
154	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
155	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
156	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
157	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
158	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
159	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
160	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
161	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
162	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
163	0.0003			total	4.41E-01	0.0002			total	4.56E-01	0.0002
164											
165											
166				**Filename**	fid60d				**Filename**	fid70d	
167											
168	43			1tally 8	nps = 20832943				1tally 8	nps = 20803508	
169	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
170				tally for	photons				tally for	photons	
171											
172				cell 2					cell 2		
173				energy					energy		
174	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
175	0.0002			5.00E-02	8.69E-02	0.0007			5.00E-02	7.94E-02	0.0007
176	0.0123			1.00E-01	3.80E-01	0.0003			1.00E-01	3.95E-01	0.0003
177	0			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0
178	0			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0
179	0			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0
180	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
181	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
182	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
183	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
184	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
185	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
186	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
187	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
188	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
189	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
190	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
191	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
192	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
193	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
194	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
195	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
196	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
197	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
198	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
199	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
200	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
201	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
202	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
203	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
204	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
205	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
206	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
207	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
208	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
209	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
210	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
211	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
212	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
213	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
214	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
215	0.0002			total	4.67E-01	0.0002			total	4.74E-01	0.0002

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1											
2											
3											
4											
5											
6											
7											
8											
9											
10			**Filename**	fid80a				**Filename**	fid90a		
11											
12			1tally 8	nps = 18691550				1tally 8	nps = 18222799		
13	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
14			tally for photons					tally for photons			
15											
16			cell 2					cell 2			
17			energy					energy			
18			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
19			5.00E-02	4.50E-02	0.0011			5.00E-02	5.24E-02	0.001	
20			1.00E-01	3.60E-01	0.0003			1.00E-01	3.66E-01	0.0003	
21			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0	
22			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0	
23			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0	
24			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0	
25			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0	
26			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
27			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
28			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
29			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
30			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
31			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
32			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
33			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
34			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
35			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
36			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
37			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
38			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
39			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
40			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
41			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
42			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
43			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
44			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
45			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
46			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
47			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
48			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
49			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
50			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
51			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
52			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
53			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
54			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
55			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
56			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
57			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
58			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
59			total	4.05E-01	0.0003			total	4.19E-01	0.0003	
60											

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
61											
62			**Filename**	fid80b				**Filename**	fid90b		
63											
64			1tally 8	nps = 19575592				1tally 8	nps = 19238791		
65	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
66			tally for	photons				tally for	photons		
67											
68			cell 2					cell 2			
69			energy					energy			
70			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
71			5.00E-02	4.57E-02	0.001			5.00E-02	5.34E-02	0.001	
72			1.00E-01	3.98E-01	0.0003			1.00E-01	3.99E-01	0.0003	
73			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0	
74			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0	
75			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0	
76			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0	
77			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0	
78			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
79			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
80			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
81			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
82			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
83			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
84			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
85			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
86			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
87			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
88			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
89			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
90			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
91			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
92			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
93			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
94			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
95			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
96			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
97			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
98			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
99			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
100			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
101			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
102			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
103			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
104			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
105			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
106			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
107			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
108			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
109			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
110			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
111			total	4.44E-01	0.0003			total	4.53E-01	0.0003	
112											
113											
114			**Filename**	fid80c				**Filename**	fid90c		
115											
116			1tally 8	nps = 19920658				1tally 8	nps = 19663480		
117	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
118			tally for	photons				tally for	photons		
119											
120			cell 2					cell 2			

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
121			energy					energy			
122			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
123			5.00E-02	4.51E-02	0.001			5.00E-02	5.31E-02	0.001	
124			1.00E-01	4.20E-01	0.0003			1.00E-01	4.17E-01	0.0003	
125			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0	
126			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0	
127			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0	
128			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0	
129			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0	
130			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
131			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
132			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
133			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
134			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
135			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
136			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
137			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
138			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
139			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
140			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
141			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
142			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
143			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
144			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
145			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
146			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
147			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
148			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
149			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
150			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
151			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
152			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
153			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
154			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
155			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
156			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
157			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
158			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
159			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
160			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
161			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
162			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
163			total	4.65E-01	0.0002			total	4.70E-01	0.0002	
164											
165											
166			**Filename**	fid80d				**Filename**	fid90d		
167											
168			1tally 8	nps = 20611652				1tally 8	nps = 20425912		
169	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
170			tally for	photons				tally for	photons		
171											
172			cell 2					cell 2			
173			energy					energy			
174			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
175			5.00E-02	4.41E-02	0.001			5.00E-02	5.23E-02	0.0009	
176			1.00E-01	4.34E-01	0.0003			1.00E-01	4.29E-01	0.0003	
177			1.50E-01	0.00E+00	0			1.50E-01	0.00E+00	0	
178			2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0	
179			2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0	
180			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0	

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
181			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0	
182			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
183			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
184			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
185			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
186			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
187			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
188			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
189			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
190			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
191			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
192			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
193			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
194			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
195			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
196			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
197			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
198			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
199			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
200			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
201			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
202			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
203			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
204			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
205			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
206			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
207			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
208			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
209			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
210			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
211			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
212			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
213			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
214			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
215			total	4.79E-01	0.0002			total	4.81E-01	0.0002	

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC
1											
2											
3											
4											
5											
6											
7											
8											
9											
10		**Filename**	fid100a				**Filename**	fid120a			
11											
12		1tally 8	nps = 17838998				1tally 8	nps = 17155768			
13	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni
14		tally for photons					tally for photons				
15											
16		cell 2					cell 2				
17		energy					energy				
18		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
19		5.00E-02	7.19E-02	0.0009			5.00E-02	1.16E-01	0.0007		
20		1.00E-01	3.56E-01	0.0003			1.00E-01	1.04E-01	0.0007		
21		1.50E-01	1.22E-04	0.0214			1.50E-01	2.20E-01	0.0005		
22		2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0		
23		2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0		
24		3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0		
25		3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0		
26		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
27		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
28		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
29		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
30		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
31		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
32		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
33		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
34		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
35		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
36		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
37		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
38		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
39		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
40		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
41		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
42		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
43		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
44		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
45		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
46		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
47		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
48		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
49		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
50		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
51		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
52		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
53		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
54		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
55		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
56		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
57		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
58		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
59		total	4.28E-01	0.0003			total	4.39E-01	0.0003		
60											

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC
61											
62		**Filename**	fid100b				**Filename**	fid120b			
63											
64		1tally 8	nps = 18893736				1tally 8	nps = 18159259			
65	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
66		tally for	photons				tally for	photons			
67											
68		cell 2					cell 2				
69		energy					energy				
70		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
71		5.00E-02	7.46E-02	0.0008			5.00E-02	1.21E-01	0.0006		
72		1.00E-01	3.84E-01	0.0003			1.00E-01	9.51E-02	0.0007		
73		1.50E-01	1.55E-04	0.0185			1.50E-01	2.49E-01	0.0004		
74		2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0		
75		2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0		
76		3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0		
77		3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0		
78		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
79		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
80		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
81		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
82		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
83		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
84		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
85		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
86		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
87		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
88		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
89		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
90		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
91		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
92		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
93		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
94		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
95		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
96		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
97		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
98		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
99		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
100		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
101		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
102		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
103		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
104		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
105		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
106		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
107		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
108		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
109		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
110		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
111		total	4.59E-01	0.0003			total	4.65E-01	0.0003		
112											
113											
114		**Filename**	fid100c				**Filename**	fid120c			
115											
116		1tally 8	nps = 19334160				1tally 8	nps = 18576478			
117	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
118		tally for	photons				tally for	photons			
119											
120		cell 2					cell 2				

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC
121		energy					energy				
122		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
123		5.00E-02	7.55E-02	0.0008			5.00E-02	1.23E-01	0.0006		
124		1.00E-01	3.98E-01	0.0003			1.00E-01	8.60E-02	0.0008		
125		1.50E-01	1.73E-04	0.0173			1.50E-01	2.68E-01	0.0004		
126		2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0		
127		2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0		
128		3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0		
129		3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0		
130		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
131		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
132		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
133		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
134		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
135		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
136		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
137		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
138		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
139		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
140		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
141		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
142		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
143		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
144		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
145		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
146		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
147		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
148		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
149		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
150		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
151		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
152		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
153		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
154		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
155		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
156		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
157		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
158		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
159		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
160		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
161		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
162		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
163		total	4.74E-01	0.0002			total	4.78E-01	0.0002		
164											
165											
166		**Filename**	fid100d				**Filename**	fid120d			
167											
168		1tally 8	nps = 20115266				1tally 8	nps = 19333990			
169	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni
170		tally for	photons				tally for	photons			
171											
172		cell 2					cell 2				
173		energy					energy				
174		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
175		5.00E-02	7.56E-02	0.0008			5.00E-02	1.25E-01	0.0006		
176		1.00E-01	4.07E-01	0.0003			1.00E-01	7.75E-02	0.0008		
177		1.50E-01	1.68E-04	0.0172			1.50E-01	2.83E-01	0.0004		
178		2.00E-01	0.00E+00	0			2.00E-01	0.00E+00	0		
179		2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0		
180		3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0		

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC
181		3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0		
182		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
183		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
184		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
185		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
186		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
187		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
188		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
189		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
190		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
191		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
192		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
193		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
194		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
195		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
196		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
197		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
198		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
199		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
200		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
201		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
202		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
203		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
204		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
205		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
206		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
207		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
208		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
209		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
210		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
211		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
212		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
213		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
214		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
215		total	4.83E-01	0.0002			total	4.85E-01	0.0002		

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
1											
2											
3											
4											
5											
6											
7											
8											
9											
10	**Filename**	fid140a				**Filename**	fid160a				**Filename**
11											
12	1tally 8	nps = 16595968				1tally 8	nps = 16083654				1tally 8
13	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
14	tally for	photons				tally for	photons				tally fo
15											
16	cell 2					cell 2					cell 2
17	energy					energy					energy
18	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
19	5.00E-02	1.60E-01	0.0006			5.00E-02	1.95E-01	0.0005			5.00E-02
20	1.00E-01	6.74E-02	0.0009			1.00E-01	4.86E-02	0.0011			1.00E-01
21	1.50E-01	2.18E-01	0.0005			1.50E-01	7.89E-02	0.0009			1.50E-01
22	2.00E-01	0.00E+00	0			2.00E-01	1.26E-01	0.0007			2.00E-01
23	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
24	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
25	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
26	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
27	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
28	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
29	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
30	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
31	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
32	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
33	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
34	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
35	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
36	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
37	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
38	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
39	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
40	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
41	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
42	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
43	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
44	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
45	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
46	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
47	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
48	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
49	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
50	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
51	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
52	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
53	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
54	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
55	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
56	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
57	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
58	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
59	total	4.45E-01	0.0003			total	4.49E-01	0.0003			total
60											

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
61											
62	**Filename**	fid140b				**Filename**	fid160b				**Filename**
63											
64	1tally 8	nps = 17524808				1tally 8	nps = 16914761				1tally 8
65	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
66	tally for photons					tally for photons					tally fo
67											
68	cell 2					cell 2					cell 2
69	energy					energy					energy
70	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
71	5.00E-02	1.67E-01	0.0005			5.00E-02	2.04E-01	0.0005			5.00E-02
72	1.00E-01	5.88E-02	0.001			1.00E-01	4.33E-02	0.0011			1.00E-01
73	1.50E-01	2.43E-01	0.0004			1.50E-01	7.48E-02	0.0009			1.50E-01
74	2.00E-01	0.00E+00	0			2.00E-01	1.49E-01	0.0006			2.00E-01
75	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
76	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
77	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
78	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
79	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
80	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
81	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
82	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
83	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
84	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
85	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
86	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
87	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
88	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
89	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
90	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
91	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
92	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
93	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
94	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
95	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
96	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
97	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
98	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
99	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
100	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
101	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
102	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
103	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
104	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
105	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
106	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
107	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
108	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
109	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
110	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
111	total	4.69E-01	0.0003			total	4.71E-01	0.0003			total
112											
113											
114	**Filename**	fid140c				**Filename**	fid160c				**Filename**
115											
116	1tally 8	nps = 17900129				1tally 8	nps = 17220850				1tally 8
117	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
118	tally for photons					tally for photons					tally fo
119											
120	cell 2					cell 2					cell 2

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
121	energy					energy					energy
122	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
123	5.00E-02	1.70E-01	0.0005			5.00E-02	2.07E-01	0.0005			5.00E-02
124	1.00E-01	5.09E-02	0.001			1.00E-01	3.93E-02	0.0012			1.00E-01
125	1.50E-01	2.58E-01	0.0004			1.50E-01	6.84E-02	0.0009			1.50E-01
126	2.00E-01	0.00E+00	0			2.00E-01	1.66E-01	0.0005			2.00E-01
127	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
128	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01
129	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
130	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
131	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
132	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
133	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
134	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
135	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
136	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
137	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
138	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
139	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
140	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
141	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
142	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
143	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
144	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
145	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
146	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
147	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
148	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
149	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
150	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
151	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
152	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
153	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
154	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
155	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
156	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
157	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
158	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
159	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
160	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
161	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
162	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
163	total	4.80E-01	0.0002			total	4.81E-01	0.0003			total
164											
165											
166	**Filename**	fid140d				**Filename**	fid160d				**Filename**
167											
168	1tally 8	nps = 52304431				1tally 8	nps = 50098082				1tally 8
169	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.			uni	tally ty
170	tally for	photons				tally for	photons				tally fo
171											
172	cell 2					cell 2					cell 2
173	energy					energy					energy
174	0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00
175	5.00E-02	1.72E-01	0.0003			5.00E-02	2.09E-01	0.0003			5.00E-02
176	1.00E-01	4.41E-02	0.0006			1.00E-01	3.63E-02	0.0007			1.00E-01
177	1.50E-01	2.70E-01	0.0002			1.50E-01	6.13E-02	0.0006			1.50E-01
178	2.00E-01	0.00E+00	0			2.00E-01	1.80E-01	0.0003			2.00E-01
179	2.50E-01	0.00E+00	0			2.50E-01	0.00E+00	0			2.50E-01
180	3.00E-01	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
181	3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01
182	4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01
183	4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01
184	5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01
185	5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01
186	6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01
187	6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01
188	7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01
189	7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01
190	8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01
191	8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01
192	9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01
193	9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01
194	1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00
195	1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00
196	1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00
197	1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00
198	1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00
199	1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00
200	1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00
201	1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00
202	1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00
203	1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00
204	1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00
205	1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00
206	1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00
207	1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00
208	1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00
209	1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00
210	1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00
211	1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00
212	1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00
213	1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00
214	2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00
215	total	4.86E-01	0.0001			total	4.86E-01	0.0001			total

	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY
1											
2											
3											
4											
5											
6											
7											
8											
9											
10	fid180a				**Filename**	fid200a				**Filename**	fid220a
11											
12	ps = 15731365				1tally 8	nps = 15458739				1tally 8	nps = 1527
13	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
14	photons				tally for photons					tally for photons	
15											
16					cell 2					cell 2	
17					energy					energy	
18	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
19	2.25E-01	0.0005			5.00E-02	2.49E-01	0.0004			5.00E-02	2.69E-01
20	4.13E-02	0.0012			1.00E-01	3.93E-02	0.0013			1.00E-01	3.75E-02
21	6.62E-02	0.0009			1.50E-01	5.79E-02	0.001			1.50E-01	5.30E-02
22	1.18E-01	0.0007			2.00E-01	1.05E-01	0.0007			2.00E-01	2.57E-02
23	0.00E+00	0			2.50E-01	3.83E-05	0.0411			2.50E-01	6.77E-02
24	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
25	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
26	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
27	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
28	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
29	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
30	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
31	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
32	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
33	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
34	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
35	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
36	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
37	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
38	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
39	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
40	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
41	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
42	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
43	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
44	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
45	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
46	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
47	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
48	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
49	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
50	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
51	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
52	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
53	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
54	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
55	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
56	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
57	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
58	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
59	4.51E-01	0.0003			total	4.52E-01	0.0003			total	4.53E-01
60											

	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY
61											
62	fid180b				**Filename**	fid200b				**Filename**	fid220b
63											
64	ps = 16493944				1tally 8	nps = 16163430				1tally 8	nps = 1592
65	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
66	photons				tally for photons					tally for photons	
67											
68					cell 2					cell 2	
69					energy					energy	
70	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
71	2.34E-01	0.0004			5.00E-02	2.60E-01	0.0004			5.00E-02	2.80E-01
72	3.81E-02	0.0012			1.00E-01	3.76E-02	0.0013			1.00E-01	3.67E-02
73	6.17E-02	0.001			1.50E-01	5.38E-02	0.001			1.50E-01	4.96E-02
74	1.38E-01	0.0006			2.00E-01	1.22E-01	0.0007			2.00E-01	2.55E-02
75	0.00E+00	0			2.50E-01	4.79E-05	0.0359			2.50E-01	8.10E-02
76	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
77	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
78	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
79	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
80	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
81	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
82	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
83	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
84	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
85	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
86	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
87	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
88	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
89	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
90	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
91	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
92	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
93	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
94	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
95	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
96	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
97	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
98	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
99	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
100	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
101	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
102	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
103	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
104	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
105	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
106	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
107	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
108	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
109	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
110	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
111	4.72E-01	0.0003			total	4.73E-01	0.0003			total	4.73E-01
112											
113											
114	fid180c				**Filename**	fid200c				**Filename**	fid220c
115											
116	ps = 16765874				1tally 8	nps = 16393106				1tally 8	nps = 1615
117	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
118	photons				tally for photons					tally for photons	
119											
120					cell 2					cell 2	

	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY
121					energy					energy	
122	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
123	2.39E-01	0.0004			5.00E-02	2.64E-01	0.0004			5.00E-02	2.85E-01
124	3.59E-02	0.0013			1.00E-01	3.65E-02	0.0013			1.00E-01	3.64E-02
125	5.56E-02	0.001			1.50E-01	4.89E-02	0.0011			1.50E-01	4.57E-02
126	1.52E-01	0.0006			2.00E-01	1.33E-01	0.0006			2.00E-01	2.43E-02
127	0.00E+00	0			2.50E-01	5.51E-05	0.0333			2.50E-01	9.09E-02
128	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00
129	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
130	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
131	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
132	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
133	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
134	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
135	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
136	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
137	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
138	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
139	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
140	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
141	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
142	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
143	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
144	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
145	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
146	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
147	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
148	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
149	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
150	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
151	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
152	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
153	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
154	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
155	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
156	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
157	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
158	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
159	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
160	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
161	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
162	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
163	4.82E-01	0.0003			total	4.82E-01	0.0003			total	4.82E-01
164											
165											
166	fid180d				**Filename**	fid200d				**Filename**	fid220d
167											
168	ps = 48562650				1tally 8	nps = 47123945				1tally 8	nps = 4640
169	e 8 pulse height distribution.			uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse	
170	photons				tally for photons					tally for photons	
171											
172					cell 2					cell 2	
173					energy					energy	
174	0.00E+00	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00
175	2.40E-01	0.0003			5.00E-02	2.66E-01	0.0002			5.00E-02	2.87E-01
176	3.44E-02	0.0008			1.00E-01	3.59E-02	0.0008			1.00E-01	3.64E-02
177	4.92E-02	0.0006			1.50E-01	4.37E-02	0.0007			1.50E-01	4.16E-02
178	1.63E-01	0.0003			2.00E-01	1.41E-01	0.0004			2.00E-01	2.28E-02
179	0.00E+00	0			2.50E-01	5.83E-05	0.0191			2.50E-01	9.95E-02
180	0.00E+00	0			3.00E-01	0.00E+00	0			3.00E-01	0.00E+00

	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY
181	0.00E+00	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00
182	0.00E+00	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00
183	0.00E+00	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00
184	0.00E+00	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00
185	0.00E+00	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00
186	0.00E+00	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00
187	0.00E+00	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00
188	0.00E+00	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00
189	0.00E+00	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00
190	0.00E+00	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00
191	0.00E+00	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00
192	0.00E+00	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00
193	0.00E+00	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00
194	0.00E+00	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00
195	0.00E+00	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00
196	0.00E+00	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00
197	0.00E+00	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00
198	0.00E+00	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00
199	0.00E+00	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00
200	0.00E+00	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00
201	0.00E+00	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00
202	0.00E+00	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00
203	0.00E+00	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00
204	0.00E+00	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00
205	0.00E+00	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00
206	0.00E+00	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00
207	0.00E+00	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00
208	0.00E+00	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00
209	0.00E+00	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00
210	0.00E+00	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00
211	0.00E+00	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00
212	0.00E+00	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00
213	0.00E+00	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00
214	0.00E+00	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00
215	4.87E-01	0.0001			total	4.87E-01	0.0001			total	4.87E-01

	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ
1											
2											
3											
4											
5											
6											
7											
8											
9											
10				**Filename**	fid240a				**Filename**	fid260a	
11											
12	24			1tally 8	nps = 15156581				1tally 8	nps = 15059499	
13	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
14				tally for	photons				tally for	photons	
15											
16				cell 2					cell 2		
17				energy					energy		
18	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
19	0.0004			5.00E-02	2.85E-01	0.0004			5.00E-02	2.98E-01	0.0004
20	0.0013			1.00E-01	3.34E-02	0.0014			1.00E-01	3.03E-02	0.0015
21	0.0011			1.50E-01	5.12E-02	0.0011			1.50E-01	4.92E-02	0.0011
22	0.0016			2.00E-01	1.86E-02	0.0019			2.00E-01	1.82E-02	0.0019
23	0.0009			2.50E-01	6.51E-02	0.001			2.50E-01	1.32E-02	0.0022
24	0			3.00E-01	0.00E+00	0			3.00E-01	4.47E-02	0.0012
25	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
26	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
27	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
28	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
29	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
30	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
31	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
32	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
33	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
34	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
35	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
36	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
37	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
38	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
39	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
40	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
41	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
42	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
43	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
44	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
45	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
46	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
47	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
48	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
49	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
50	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
51	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
52	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
53	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
54	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
55	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
56	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
57	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
58	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
59	0.0003			total	4.54E-01	0.0003			total	4.54E-01	0.0003
60											

	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ
61											
62				**Filename**	fid240b				**Filename**	fid260b	
63											
64	89			1tally 8	nps = 15771720				1tally 8	nps = 14932828	
65	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
66				tally for photons					tally for photons		
67											
68				cell 2					cell 2		
69				energy					energy		
70	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
71	0.0004			5.00E-02	2.97E-01	0.0004			5.00E-02	3.11E-01	0.0004
72	0.0013			1.00E-01	3.28E-02	0.0014			1.00E-01	2.98E-02	0.0015
73	0.0011			1.50E-01	4.92E-02	0.0011			1.50E-01	4.80E-02	0.0012
74	0.0015			2.00E-01	1.74E-02	0.0019			2.00E-01	1.71E-02	0.002
75	0.0008			2.50E-01	7.71E-02	0.0009			2.50E-01	1.36E-02	0.0022
76	0			3.00E-01	0.00E+00	0			3.00E-01	5.44E-02	0.0011
77	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
78	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
79	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
80	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
81	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
82	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
83	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
84	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
85	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
86	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
87	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
88	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
89	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
90	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
91	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
92	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
93	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
94	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
95	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
96	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
97	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
98	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
99	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
100	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
101	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
102	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
103	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
104	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
105	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
106	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
107	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
108	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
109	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
110	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
111	0.0003			total	4.74E-01	0.0003			total	4.74E-01	0.0003
112											
113											
114				**Filename**	fid240c				**Filename**	fid260c	
115											
116	22			1tally 8	nps = 15949188				1tally 8	nps = 15821370	
117	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
118				tally for photons					tally for photons		
119											
120				cell 2					cell 2		

	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ
121				energy					energy		
122	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
123	0.0004			5.00E-02	3.02E-01	0.0004			5.00E-02	3.16E-01	0.0004
124	0.0013			1.00E-01	3.26E-02	0.0014			1.00E-01	2.98E-02	0.0014
125	0.0011			1.50E-01	4.64E-02	0.0011			1.50E-01	4.62E-02	0.0011
126	0.0016			2.00E-01	1.55E-02	0.002			2.00E-01	1.55E-02	0.002
127	0.0008			2.50E-01	8.60E-02	0.0008			2.50E-01	1.34E-02	0.0022
128	0			3.00E-01	0.00E+00	0			3.00E-01	6.19E-02	0.001
129	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
130	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
131	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
132	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
133	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
134	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
135	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
136	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
137	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
138	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
139	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
140	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
141	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
142	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
143	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
144	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
145	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
146	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
147	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
148	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
149	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
150	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
151	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
152	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
153	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
154	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
155	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
156	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
157	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
158	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
159	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
160	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
161	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
162	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
163	0.0003			total	4.83E-01	0.0003			total	4.83E-01	0.0003
164											
165											
166				**Filename**	fid240d				**Filename**	fid260d	
167											
168	13			1tally 8	nps = 45806593				1tally 8	nps = 44574773	
169	height distribution.		uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height dist	
170				tally for photons					tally for photons		
171											
172				cell 2					cell 2		
173				energy					energy		
174	0			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0
175	0.0002			5.00E-02	3.04E-01	0.0002			5.00E-02	3.18E-01	0.0002
176	0.0008			1.00E-01	3.27E-02	0.0008			1.00E-01	3.00E-02	0.0009
177	0.0007			1.50E-01	4.36E-02	0.0007			1.50E-01	4.43E-02	0.0007
178	0.001			2.00E-01	1.35E-02	0.0013			2.00E-01	1.38E-02	0.0013
179	0.0004			2.50E-01	9.36E-02	0.0005			2.50E-01	1.28E-02	0.0013
180	0			3.00E-01	0.00E+00	0			3.00E-01	6.86E-02	0.0006

	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ
181	0			3.50E-01	0.00E+00	0			3.50E-01	0.00E+00	0
182	0			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0
183	0			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0
184	0			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0
185	0			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0
186	0			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0
187	0			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0
188	0			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0
189	0			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0
190	0			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0
191	0			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0
192	0			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0
193	0			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0
194	0			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0
195	0			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0
196	0			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0
197	0			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0
198	0			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0
199	0			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0
200	0			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0
201	0			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0
202	0			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0
203	0			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0
204	0			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0
205	0			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0
206	0			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0
207	0			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0
208	0			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0
209	0			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0
210	0			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0
211	0			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0
212	0			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0
213	0			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0
214	0			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0
215	0.0002			total	4.87E-01	0.0002			total	4.87E-01	0.0002

	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
1											
2											
3											
4											
5											
6											
7											
8											
9											
10			**Filename**	fid280a				**Filename**	fid300a		
11											
12			1tally 8	nps = 14998195				1tally 8	nps = 14941813		
13	bution.	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.			
14			tally for photons					tally for photons			
15											
16			cell 2					cell 2			
17			energy					energy			
18			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
19			5.00E-02	3.09E-01	0.0004			5.00E-02	3.18E-01	0.0004	
20			1.00E-01	2.82E-02	0.0015			1.00E-01	2.65E-02	0.0016	
21			1.50E-01	4.64E-02	0.0012			1.50E-01	4.14E-02	0.0012	
22			2.00E-01	1.84E-02	0.0019			2.00E-01	2.12E-02	0.0018	
23			2.50E-01	9.33E-03	0.0027			2.50E-01	7.83E-03	0.0029	
24			3.00E-01	4.27E-02	0.0012			3.00E-01	3.92E-02	0.0013	
25			3.50E-01	0.00E+00	0			3.50E-01	1.65E-05	0.0638	
26			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
27			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
28			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
29			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
30			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
31			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
32			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
33			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
34			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
35			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
36			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
37			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
38			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
39			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
40			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
41			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
42			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
43			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
44			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
45			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
46			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
47			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
48			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
49			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
50			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
51			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
52			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
53			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
54			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
55			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
56			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
57			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
58			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
59			total	4.54E-01	0.0003			total	4.54E-01	0.0003	
60											

	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
61											
62			**Filename**	fid280b				**Filename**	fid300b		
63											
64			1tally 8	nps = 15259884				1tally 8	nps = 15147829		
65	bution.	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.			
66			tally for photons					tally for photons			
67											
68			cell 2					cell 2			
69			energy					energy			
70			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
71			5.00E-02	3.22E-01	0.0004			5.00E-02	3.31E-01	0.0004	
72			1.00E-01	2.79E-02	0.0015			1.00E-01	2.64E-02	0.0016	
73			1.50E-01	4.59E-02	0.0012			1.50E-01	4.09E-02	0.0012	
74			2.00E-01	1.75E-02	0.0019			2.00E-01	2.09E-02	0.0018	
75			2.50E-01	9.07E-03	0.0027			2.50E-01	7.47E-03	0.003	
76			3.00E-01	5.14E-02	0.0011			3.00E-01	4.68E-02	0.0012	
77			3.50E-01	0.00E+00	0			3.50E-01	2.03E-05	0.0571	
78			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
79			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
80			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
81			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
82			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
83			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
84			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
85			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
86			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
87			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
88			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
89			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
90			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
91			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
92			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
93			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
94			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
95			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
96			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
97			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
98			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
99			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
100			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
101			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
102			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
103			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
104			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
105			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
106			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
107			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
108			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
109			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
110			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
111			total	4.74E-01	0.0003			total	4.74E-01	0.0003	
112											
113											
114			**Filename**	fid280c				**Filename**	fid300c		
115											
116			1tally 8	nps = 15704519				1tally 8	nps = 15624679		
117	bution.	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.			
118			tally for photons					tally for photons			
119											
120			cell 2					cell 2			

	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
121			energy					energy			
122			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
123			5.00E-02	3.27E-01	0.0004			5.00E-02	3.37E-01	0.0004	
124			1.00E-01	2.80E-02	0.0015			1.00E-01	2.65E-02	0.0015	
125			1.50E-01	4.49E-02	0.0012			1.50E-01	4.00E-02	0.0012	
126			2.00E-01	1.61E-02	0.002			2.00E-01	2.01E-02	0.0018	
127			2.50E-01	8.40E-03	0.0027			2.50E-01	6.83E-03	0.0031	
128			3.00E-01	5.81E-02	0.001			3.00E-01	5.25E-02	0.0011	
129			3.50E-01	0.00E+00	0			3.50E-01	2.20E-05	0.0539	
130			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
131			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
132			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
133			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
134			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
135			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
136			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
137			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
138			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
139			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
140			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
141			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
142			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
143			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
144			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
145			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
146			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
147			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
148			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
149			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
150			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
151			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
152			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
153			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
154			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
155			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
156			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
157			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
158			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
159			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
160			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
161			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
162			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
163			total	4.83E-01	0.0003			total	4.83E-01	0.0003	
164											
165											
166			**Filename**	fid280d				**Filename**	fid300d		
167											
168			1tally 8	nps = 44968646				1tally 8	nps = 44818172		
169	bution.	uni	tally type 8	pulse height distribution.			uni	tally type 8	pulse height distribution.		
170			tally for	photons				tally for	photons		
171											
172			cell 2					cell 2			
173			energy					energy			
174			0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0	
175			5.00E-02	3.29E-01	0.0002			5.00E-02	3.39E-01	0.0002	
176			1.00E-01	2.82E-02	0.0009			1.00E-01	2.68E-02	0.0009	
177			1.50E-01	4.38E-02	0.0007			1.50E-01	3.91E-02	0.0007	
178			2.00E-01	1.45E-02	0.0012			2.00E-01	1.91E-02	0.0011	
179			2.50E-01	7.55E-03	0.0017			2.50E-01	6.05E-03	0.0019	
180			3.00E-01	6.41E-02	0.0006			3.00E-01	5.75E-02	0.0006	

	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
181			3.50E-01	0.00E+00	0			3.50E-01	2.23E-05	0.0316	
182			4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0	
183			4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0	
184			5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0	
185			5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0	
186			6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0	
187			6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0	
188			7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0	
189			7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0	
190			8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0	
191			8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0	
192			9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0	
193			9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0	
194			1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0	
195			1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0	
196			1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0	
197			1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0	
198			1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0	
199			1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0	
200			1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0	
201			1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0	
202			1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0	
203			1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0	
204			1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0	
205			1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0	
206			1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0	
207			1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0	
208			1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0	
209			1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0	
210			1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0	
211			1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0	
212			1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0	
213			1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0	
214			2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0	
215			total	4.88E-01	0.0002			total	4.88E-01	0.0002	

	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF
1											
2											
3											
4											
5											
6											
7											
8											
9											
10		**Filename**	fid320a				**Filename**	fid340a			
11											
12		1tally 8 nps = 14924560					1tally 8 nps = 14881429				
13	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni
14		tally for photons					tally for photons				
15											
16		cell 2					cell 2				
17		energy					energy				
18		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
19		5.00E-02	3.26E-01	0.0004			5.00E-02	3.32E-01	0.0004		
20		1.00E-01	2.50E-02	0.0016			1.00E-01	2.37E-02	0.0017		
21		1.50E-01	3.65E-02	0.0013			1.50E-01	3.22E-02	0.0014		
22		2.00E-01	2.41E-02	0.0016			2.00E-01	2.66E-02	0.0016		
23		2.50E-01	7.24E-03	0.003			2.50E-01	6.98E-03	0.0031		
24		3.00E-01	7.28E-03	0.003			3.00E-01	4.44E-03	0.0039		
25		3.50E-01	2.85E-02	0.0015			3.50E-01	2.83E-02	0.0015		
26		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
27		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
28		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
29		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
30		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
31		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
32		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
33		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
34		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
35		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
36		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
37		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
38		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
39		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
40		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
41		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
42		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
43		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
44		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
45		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
46		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
47		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
48		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
49		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
50		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
51		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
52		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
53		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
54		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
55		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
56		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
57		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
58		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
59		total	4.54E-01	0.0003			total	4.55E-01	0.0003		
60											

	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF
61											
62		**Filename**	fid320b				**Filename**	fid340b			
63											
64		1tally 8	nps = 15147951				1tally 8	nps = 15130177			
65	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni
66		tally for photons					tally for photons				
67											
68		cell 2					cell 2				
69		energy					energy				
70		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
71		5.00E-02	3.39E-01	0.0004			5.00E-02	3.46E-01	0.0004		
72		1.00E-01	2.51E-02	0.0016			1.00E-01	2.38E-02	0.0016		
73		1.50E-01	3.59E-02	0.0013			1.50E-01	3.15E-02	0.0014		
74		2.00E-01	2.45E-02	0.0016			2.00E-01	2.75E-02	0.0015		
75		2.50E-01	6.97E-03	0.0031			2.50E-01	6.77E-03	0.0031		
76		3.00E-01	7.71E-03	0.0029			3.00E-01	4.31E-03	0.0039		
77		3.50E-01	3.46E-02	0.0014			3.50E-01	3.41E-02	0.0014		
78		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
79		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
80		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
81		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
82		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
83		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
84		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
85		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
86		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
87		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
88		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
89		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
90		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
91		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
92		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
93		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
94		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
95		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
96		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
97		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
98		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
99		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
100		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
101		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
102		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
103		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
104		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
105		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
106		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
107		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
108		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
109		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
110		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
111		total	4.74E-01	0.0003			total	4.74E-01	0.0003		
112											
113											
114		**Filename**	fid320c				**Filename**	fid340c			
115											
116		1tally 8	nps = 15532533				1tally 8	nps = 15567504			
117	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni
118		tally for photons					tally for photons				
119											
120		cell 2					cell 2				

	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF
121		energy					energy				
122		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
123		5.00E-02	3.45E-01	0.0003			5.00E-02	3.52E-01	0.0003		
124		1.00E-01	2.52E-02	0.0016			1.00E-01	2.40E-02	0.0016		
125		1.50E-01	3.50E-02	0.0013			1.50E-01	3.07E-02	0.0014		
126		2.00E-01	2.42E-02	0.0016			2.00E-01	2.75E-02	0.0015		
127		2.50E-01	6.45E-03	0.0031			2.50E-01	6.34E-03	0.0032		
128		3.00E-01	7.77E-03	0.0029			3.00E-01	3.97E-03	0.004		
129		3.50E-01	3.94E-02	0.0013			3.50E-01	3.87E-02	0.0013		
130		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
131		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
132		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
133		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
134		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
135		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
136		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
137		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
138		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
139		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
140		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
141		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
142		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
143		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
144		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
145		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
146		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
147		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
148		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
149		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
150		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
151		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
152		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
153		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
154		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
155		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
156		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
157		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
158		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
159		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
160		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
161		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
162		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
163		total	4.83E-01	0.0003			total	4.83E-01	0.0003		
164											
165											
166		**Filename**	fid320d				**Filename**	fid340d			
167											
168		1tally 8 nps = 44534616					1tally 8 nps = 44334024				
169	uni	tally type 8 pulse height distribution.				uni	tally type 8 pulse height distribution.				uni
170		tally for photons					tally for photons				
171											
172		cell 2					cell 2				
173		energy					energy				
174		0.00E+00	0.00E+00	0			0.00E+00	0.00E+00	0		
175		5.00E-02	3.47E-01	0.0002			5.00E-02	3.54E-01	0.0002		
176		1.00E-01	2.55E-02	0.0009			1.00E-01	2.43E-02	0.001		
177		1.50E-01	3.42E-02	0.0008			1.50E-01	3.01E-02	0.0009		
178		2.00E-01	2.36E-02	0.001			2.00E-01	2.72E-02	0.0009		
179		2.50E-01	5.85E-03	0.002			2.50E-01	5.85E-03	0.002		
180		3.00E-01	7.65E-03	0.0017			3.00E-01	3.53E-03	0.0025		

	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF
181		3.50E-01	4.37E-02	0.0007			3.50E-01	4.27E-02	0.0007		
182		4.00E-01	0.00E+00	0			4.00E-01	0.00E+00	0		
183		4.50E-01	0.00E+00	0			4.50E-01	0.00E+00	0		
184		5.00E-01	0.00E+00	0			5.00E-01	0.00E+00	0		
185		5.50E-01	0.00E+00	0			5.50E-01	0.00E+00	0		
186		6.00E-01	0.00E+00	0			6.00E-01	0.00E+00	0		
187		6.50E-01	0.00E+00	0			6.50E-01	0.00E+00	0		
188		7.00E-01	0.00E+00	0			7.00E-01	0.00E+00	0		
189		7.50E-01	0.00E+00	0			7.50E-01	0.00E+00	0		
190		8.00E-01	0.00E+00	0			8.00E-01	0.00E+00	0		
191		8.50E-01	0.00E+00	0			8.50E-01	0.00E+00	0		
192		9.00E-01	0.00E+00	0			9.00E-01	0.00E+00	0		
193		9.50E-01	0.00E+00	0			9.50E-01	0.00E+00	0		
194		1.00E+00	0.00E+00	0			1.00E+00	0.00E+00	0		
195		1.05E+00	0.00E+00	0			1.05E+00	0.00E+00	0		
196		1.10E+00	0.00E+00	0			1.10E+00	0.00E+00	0		
197		1.15E+00	0.00E+00	0			1.15E+00	0.00E+00	0		
198		1.20E+00	0.00E+00	0			1.20E+00	0.00E+00	0		
199		1.25E+00	0.00E+00	0			1.25E+00	0.00E+00	0		
200		1.30E+00	0.00E+00	0			1.30E+00	0.00E+00	0		
201		1.35E+00	0.00E+00	0			1.35E+00	0.00E+00	0		
202		1.40E+00	0.00E+00	0			1.40E+00	0.00E+00	0		
203		1.45E+00	0.00E+00	0			1.45E+00	0.00E+00	0		
204		1.50E+00	0.00E+00	0			1.50E+00	0.00E+00	0		
205		1.55E+00	0.00E+00	0			1.55E+00	0.00E+00	0		
206		1.60E+00	0.00E+00	0			1.60E+00	0.00E+00	0		
207		1.65E+00	0.00E+00	0			1.65E+00	0.00E+00	0		
208		1.70E+00	0.00E+00	0			1.70E+00	0.00E+00	0		
209		1.75E+00	0.00E+00	0			1.75E+00	0.00E+00	0		
210		1.80E+00	0.00E+00	0			1.80E+00	0.00E+00	0		
211		1.85E+00	0.00E+00	0			1.85E+00	0.00E+00	0		
212		1.90E+00	0.00E+00	0			1.90E+00	0.00E+00	0		
213		1.95E+00	0.00E+00	0			1.95E+00	0.00E+00	0		
214		2.00E+00	0.00E+00	0			2.00E+00	0.00E+00	0		
215		total	4.88E-01	0.0002			total	4.88E-01	0.0002		

	DG	DH	DI	DJ	DK	DL	DM
1							
2							
3							
4							
5							
6							
7							
8							
9							
10	**Filename**	fid360a					
11							
12	Itally 8	nps = 14915907					
13	tally type 8	pulse height distribution.			units	number	
14	tally for	photons					
15							
16	cell 2						
17	energy						
18	0.00E+00	0.00E+00	0				
19	5.00E-02	3.38E-01	0.0004				
20	1.00E-01	2.25E-02	0.0017				
21	1.50E-01	2.84E-02	0.0015				
22	2.00E-01	2.71E-02	0.0016				
23	2.50E-01	8.49E-03	0.0028				
24	3.00E-01	4.11E-03	0.004				
25	3.50E-01	4.70E-03	0.0038				
26	4.00E-01	2.13E-02	0.0018				
27	4.50E-01	0.00E+00	0				
28	5.00E-01	0.00E+00	0				
29	5.50E-01	0.00E+00	0				
30	6.00E-01	0.00E+00	0				
31	6.50E-01	0.00E+00	0				
32	7.00E-01	0.00E+00	0				
33	7.50E-01	0.00E+00	0				
34	8.00E-01	0.00E+00	0				
35	8.50E-01	0.00E+00	0				
36	9.00E-01	0.00E+00	0				
37	9.50E-01	0.00E+00	0				
38	1.00E+00	0.00E+00	0				
39	1.05E+00	0.00E+00	0				
40	1.10E+00	0.00E+00	0				
41	1.15E+00	0.00E+00	0				
42	1.20E+00	0.00E+00	0				
43	1.25E+00	0.00E+00	0				
44	1.30E+00	0.00E+00	0				
45	1.35E+00	0.00E+00	0				
46	1.40E+00	0.00E+00	0				
47	1.45E+00	0.00E+00	0				
48	1.50E+00	0.00E+00	0				
49	1.55E+00	0.00E+00	0				
50	1.60E+00	0.00E+00	0				
51	1.65E+00	0.00E+00	0				
52	1.70E+00	0.00E+00	0				
53	1.75E+00	0.00E+00	0				
54	1.80E+00	0.00E+00	0				
55	1.85E+00	0.00E+00	0				
56	1.90E+00	0.00E+00	0				
57	1.95E+00	0.00E+00	0				
58	2.00E+00	0.00E+00	0				
59	total	4.55E-01	0.0003				
60							

	DG	DH	DI	DJ	DK	DL	DM
61							
62	**Filename**	fid360b					
63							
64	1tally 8	nps = 15116807					
65	tally type 8	pulse height distribution.			units	number	
66	tally for	photons					
67							
68	cell 2						
69	energy						
70	0.00E+00	0.00E+00	0				
71	5.00E-02	3.52E-01	0.0003				
72	1.00E-01	2.26E-02	0.0017				
73	1.50E-01	2.76E-02	0.0015				
74	2.00E-01	2.80E-02	0.0015				
75	2.50E-01	8.74E-03	0.0027				
76	3.00E-01	4.03E-03	0.004				
77	3.50E-01	5.09E-03	0.0036				
78	4.00E-01	2.60E-02	0.0016				
79	4.50E-01	0.00E+00	0				
80	5.00E-01	0.00E+00	0				
81	5.50E-01	0.00E+00	0				
82	6.00E-01	0.00E+00	0				
83	6.50E-01	0.00E+00	0				
84	7.00E-01	0.00E+00	0				
85	7.50E-01	0.00E+00	0				
86	8.00E-01	0.00E+00	0				
87	8.50E-01	0.00E+00	0				
88	9.00E-01	0.00E+00	0				
89	9.50E-01	0.00E+00	0				
90	1.00E+00	0.00E+00	0				
91	1.05E+00	0.00E+00	0				
92	1.10E+00	0.00E+00	0				
93	1.15E+00	0.00E+00	0				
94	1.20E+00	0.00E+00	0				
95	1.25E+00	0.00E+00	0				
96	1.30E+00	0.00E+00	0				
97	1.35E+00	0.00E+00	0				
98	1.40E+00	0.00E+00	0				
99	1.45E+00	0.00E+00	0				
100	1.50E+00	0.00E+00	0				
101	1.55E+00	0.00E+00	0				
102	1.60E+00	0.00E+00	0				
103	1.65E+00	0.00E+00	0				
104	1.70E+00	0.00E+00	0				
105	1.75E+00	0.00E+00	0				
106	1.80E+00	0.00E+00	0				
107	1.85E+00	0.00E+00	0				
108	1.90E+00	0.00E+00	0				
109	1.95E+00	0.00E+00	0				
110	2.00E+00	0.00E+00	0				
111	total	4.74E-01	0.0003				
112							
113							
114	**Filename**	fid360c					
115							
116	1tally 8	nps = 15541272					
117	tally type 8	pulse height distribution.			units	number	
118	tally for	photons					
119							
120	cell 2						

	DG	DH	DI	DJ	DK	DL	DM
121	energy						
122	0.00E+00	0.00E+00	0				
123	5.00E-02	3.58E-01	0.0003				
124	1.00E-01	2.29E-02	0.0017				
125	1.50E-01	2.69E-02	0.0015				
126	2.00E-01	2.81E-02	0.0015				
127	2.50E-01	8.73E-03	0.0027				
128	3.00E-01	3.77E-03	0.0041				
129	3.50E-01	5.24E-03	0.0035				
130	4.00E-01	2.98E-02	0.0014				
131	4.50E-01	0.00E+00	0				
132	5.00E-01	0.00E+00	0				
133	5.50E-01	0.00E+00	0				
134	6.00E-01	0.00E+00	0				
135	6.50E-01	0.00E+00	0				
136	7.00E-01	0.00E+00	0				
137	7.50E-01	0.00E+00	0				
138	8.00E-01	0.00E+00	0				
139	8.50E-01	0.00E+00	0				
140	9.00E-01	0.00E+00	0				
141	9.50E-01	0.00E+00	0				
142	1.00E+00	0.00E+00	0				
143	1.05E+00	0.00E+00	0				
144	1.10E+00	0.00E+00	0				
145	1.15E+00	0.00E+00	0				
146	1.20E+00	0.00E+00	0				
147	1.25E+00	0.00E+00	0				
148	1.30E+00	0.00E+00	0				
149	1.35E+00	0.00E+00	0				
150	1.40E+00	0.00E+00	0				
151	1.45E+00	0.00E+00	0				
152	1.50E+00	0.00E+00	0				
153	1.55E+00	0.00E+00	0				
154	1.60E+00	0.00E+00	0				
155	1.65E+00	0.00E+00	0				
156	1.70E+00	0.00E+00	0				
157	1.75E+00	0.00E+00	0				
158	1.80E+00	0.00E+00	0				
159	1.85E+00	0.00E+00	0				
160	1.90E+00	0.00E+00	0				
161	1.95E+00	0.00E+00	0				
162	2.00E+00	0.00E+00	0				
163	total	4.83E-01	0.0003				
164							
165							
166	**Filename**	fid360d					
167							
168	1tally 8	nps = 44253988					
169	tally type 8	pulse height distribution.				units number	
170	tally for	photons					
171							
172	cell 2						
173	energy						
174	0.00E+00	0.00E+00	0				
175	5.00E-02	3.60E-01	0.0002				
176	1.00E-01	2.32E-02	0.001				
177	1.50E-01	2.63E-02	0.0009				
178	2.00E-01	2.78E-02	0.0009				
179	2.50E-01	8.59E-03	0.0016				
180	3.00E-01	3.44E-03	0.0026				

	DG	DH	DI	DJ	DK	DL	DM
181	3.50E-01	5.25E-03	0.0021				
182	4.00E-01	3.33E-02	0.0008				
183	4.50E-01	0.00E+00	0				
184	5.00E-01	0.00E+00	0				
185	5.50E-01	0.00E+00	0				
186	6.00E-01	0.00E+00	0				
187	6.50E-01	0.00E+00	0				
188	7.00E-01	0.00E+00	0				
189	7.50E-01	0.00E+00	0				
190	8.00E-01	0.00E+00	0				
191	8.50E-01	0.00E+00	0				
192	9.00E-01	0.00E+00	0				
193	9.50E-01	0.00E+00	0				
194	1.00E+00	0.00E+00	0				
195	1.05E+00	0.00E+00	0				
196	1.10E+00	0.00E+00	0				
197	1.15E+00	0.00E+00	0				
198	1.20E+00	0.00E+00	0				
199	1.25E+00	0.00E+00	0				
200	1.30E+00	0.00E+00	0				
201	1.35E+00	0.00E+00	0				
202	1.40E+00	0.00E+00	0				
203	1.45E+00	0.00E+00	0				
204	1.50E+00	0.00E+00	0				
205	1.55E+00	0.00E+00	0				
206	1.60E+00	0.00E+00	0				
207	1.65E+00	0.00E+00	0				
208	1.70E+00	0.00E+00	0				
209	1.75E+00	0.00E+00	0				
210	1.80E+00	0.00E+00	0				
211	1.85E+00	0.00E+00	0				
212	1.90E+00	0.00E+00	0				
213	1.95E+00	0.00E+00	0				
214	2.00E+00	0.00E+00	0				
215	total	4.88E-01	0.0002				

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	This is the manipulation of the data to complete the initial plot of the data.													
2	All energy values are in keV													
3														
4	**This set is for the 1.5 g/cc density case**													
5	**1 cm Thick Source**													
6	energy	10	20	30	40	50	60	70	80	90	100	120	140	160
7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	5.00E-02	4.22E-03	5.78E-02	1.71E-01	2.77E-01	3.45E-01	7.65E-02	6.76E-02	4.41E-02	5.22E-02	7.32E-02	1.19E-01	1.64E-01	2.00E-01
9	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E-04	3.08E-01	3.41E-01	3.78E-01	3.79E-01	3.64E-01	9.05E-02	5.63E-02	4.12E-02
10	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-04	2.34E-01	2.27E-01	7.03E-02
11	2.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-01
12	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	4.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	5.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	5.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	1 cm total	4.2E-03	5.8E-02	1.7E-01	2.8E-01	3.5E-01	3.8E-01	4.1E-01	4.2E-01	4.3E-01	4.4E-01	4.4E-01	4.5E-01	4.5E-01
20														
21	**0.5 cm thick Source**													
22	energy	10	20	30	40	50	60	70	80	90	100	120	140	160
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	5.00E-02	7.73E-03	1.02E-01	2.48E-01	3.46E-01	3.99E-01	8.20E-02	7.33E-02	4.45E-02	5.26E-02	7.48E-02	1.22E-01	1.69E-01	2.06E-01
25	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.97E-04	3.46E-01	3.71E-01	4.09E-01	4.06E-01	3.88E-01	8.48E-02	5.07E-02	3.87E-02
26	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-04	2.60E-01	2.49E-01	6.71E-02
27	2.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.58E-01
28	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
31	4.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
32	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
33	5.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
34	5.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	0.5 cm total	7.7E-03	1.0E-01	2.5E-01	3.5E-01	4.0E-01	4.3E-01	4.4E-01	4.5E-01	4.6E-01	4.6E-01	4.7E-01	4.7E-01	4.7E-01
36														
37	**0.25 cm Thick Source**													
38	energy	10	20	30	40	50	60	70	80	90	100	120	140	160
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	5.00E-02	1.50E-02	1.69E-01	3.21E-01	3.99E-01	4.35E-01	8.50E-02	7.71E-02	4.41E-02	5.23E-02	7.53E-02	1.24E-01	1.71E-01	2.08E-01
41	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E-04	3.69E-01	3.87E-01	4.26E-01	4.21E-01	4.00E-01	7.91E-02	4.58E-02	3.68E-02
42	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-04	2.75E-01	2.62E-01	6.26E-02
43	2.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-01
44	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
46	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47	4.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	5.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	5.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	0.25 cm total	1.5E-02	1.7E-01	3.2E-01	4.0E-01	4.4E-01	4.5E-01	4.6E-01	4.7E-01	4.7E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01
52														
53	**0.1 cm Thick Source**													
54	energy	10	20	30	40	50	60	70	80	90	100	120	140	160
55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
56	5.00E-02	4.04E-02	2.74E-01	3.95E-01	4.43E-01	4.63E-01	8.74E-02	8.05E-02	4.34E-02	5.18E-02	7.54E-02	1.25E-01	1.72E-01	2.09E-01
57	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.81E-04	3.85E-01	3.97E-01	4.37E-01	4.30E-01	4.08E-01	7.38E-02	4.14E-02	3.52E-02
58	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-04	2.86E-01	2.71E-01	5.79E-02
59	2.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E-01
60	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
62	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
63	4.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
64	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	5.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
66	5.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67	0.1 cm total	4.0E-02	2.7E-01	4.0E-01	4.4E-01	4.6E-01	4.7E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.9E-01	4.9E-01
68														
69	Ratio Calculation													
70	0.1 to 1	9.6	4.7	2.3	1.6	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
71	0.1 to 0.5	5.2	2.7	1.6	1.3	1.2	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0
72	0.1 to 0.25	2.7	1.6	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
73														
74														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
75														
76	**This set is for the 2.35 g/cc density case**													
77	**1 cm Thick Source**													
78	energy	10	20	30	40	50	60	70	80	90	100	120	140	160
79	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	5.00E-02	1.93E-03	3.58E-02	1.20E-01	2.21E-01	2.99E-01	7.34E-02	6.48E-02	4.50E-02	5.24E-02	7.19E-02	1.16E-01	1.60E-01	1.95E-01
81	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-04	2.78E-01	3.19E-01	3.60E-01	3.66E-01	3.56E-01	1.04E-01	6.74E-02	4.86E-02
82	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-04	2.20E-01	2.18E-01	7.89E-02
83	2.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-01
84	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
86	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
87	4.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
88	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
89	5.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90	5.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
91	1 cm total	1.93E-03	3.58E-02	1.20E-01	2.21E-01	2.99E-01	3.51E-01	3.84E-01	4.05E-01	4.19E-01	4.28E-01	4.39E-01	4.45E-01	4.49E-01
92														
93	**0.5 cm thick Source**													
94	energy	10	20	30	40	50	60	70	80	90	100	120	140	160
95	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
96	5.00E-02	3.55E-03	6.45E-02	1.90E-01	2.99E-01	3.66E-01	8.07E-02	7.14E-02	4.57E-02	5.34E-02	7.46E-02	1.21E-01	1.67E-01	2.04E-01
97	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E-04	3.25E-01	3.58E-01	3.98E-01	3.99E-01	3.84E-01	9.51E-02	5.88E-02	4.33E-02
98	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-04	2.49E-01	2.43E-01	7.48E-02
99	2.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-01
100	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
101	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
102	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
103	4.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
104	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
105	5.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
106	5.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
107	0.5 cm total	3.55E-03	6.45E-02	1.90E-01	2.99E-01	3.67E-01	4.06E-01	4.29E-01	4.44E-01	4.53E-01	4.59E-01	4.65E-01	4.69E-01	4.71E-01
108														
109	**0.25 cm Thick Source**													
110	energy	10	20	30	40	50	60	70	80	90	100	120	140	160
111	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
112	5.00E-02	6.92E-03	1.17E-01	2.70E-01	3.64E-01	4.14E-01	8.43E-02	7.55E-02	4.51E-02	5.31E-02	7.55E-02	1.23E-01	1.70E-01	2.07E-01
113	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-04	3.57E-01	3.80E-01	4.20E-01	4.17E-01	3.98E-01	8.60E-02	5.09E-02	3.93E-02
114	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-04	2.68E-01	2.58E-01	6.84E-02
115	2.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E-01
116	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
117	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
118	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
119	4.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
121	5.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
122	5.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
123	0.25 cm total	6.92E-03	1.17E-01	2.70E-01	3.64E-01	4.14E-01	4.41E-01	4.56E-01	4.65E-01	4.70E-01	4.74E-01	4.78E-01	4.80E-01	4.81E-01
124														
125	**0.1 cm Thick Source**													
126	energy	10	20	30	40	50	60	70	80	90	100	120	140	160
127	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
128	5.00E-02	1.89E-02	2.18E-01	3.60E-01	4.24E-01	4.52E-01	8.69E-02	7.94E-02	4.41E-02	5.23E-02	7.56E-02	1.25E-01	1.72E-01	2.09E-01
129	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-04	3.80E-01	3.95E-01	4.34E-01	4.29E-01	4.07E-01	7.75E-02	4.41E-02	3.63E-02
130	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E-04	2.83E-01	2.70E-01	6.13E-02
131	2.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-01
132	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
133	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
134	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
135	4.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
136	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
137	5.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
138	5.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
139	0.1 cm total	1.89E-02	2.18E-01	3.60E-01	4.24E-01	4.52E-01	4.67E-01	4.74E-01	4.79E-01	4.81E-01	4.83E-01	4.85E-01	4.86E-01	4.86E-01
140														
141	Ratio Calculation													
142	0.1 to 1	9.8	6.1	3.0	1.9	1.5	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1
143	0.1 to 0.5	5.3	3.4	1.9	1.4	1.2	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0
144	0.1 to 0.25	2.7	1.9	1.3	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0

	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1															
2															
3															
4															
5															
6	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460
7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	2.30E-01	2.55E-01	2.74E-01	2.90E-01	3.03E-01	3.14E-01	3.22E-01	3.30E-01	3.36E-01	3.42E-01	3.46E-01	3.51E-01	3.54E-01	3.57E-01	3.60E-01
9	3.59E-02	3.51E-02	3.41E-02	3.04E-02	2.76E-02	2.58E-02	2.43E-02	2.30E-02	2.18E-02	2.08E-02	1.98E-02	1.89E-02	1.81E-02	1.73E-02	1.66E-02
10	5.82E-02	5.07E-02	4.67E-02	4.60E-02	4.46E-02	4.26E-02	3.78E-02	3.31E-02	2.90E-02	2.53E-02	2.35E-02	2.22E-02	2.10E-02	2.00E-02	1.90E-02
11	1.26E-01	1.11E-01	2.33E-02	1.59E-02	1.57E-02	1.61E-02	1.93E-02	2.25E-02	2.52E-02	2.56E-02	2.39E-02	2.23E-02	2.09E-02	1.97E-02	1.86E-02
12	0.00E+00	4.24E-05	7.34E-02	6.96E-02	1.22E-02	8.12E-03	6.69E-03	6.29E-03	6.11E-03	7.89E-03	1.01E-02	1.18E-02	1.14E-02	1.05E-02	9.86E-03
13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.89E-02	4.61E-02	4.17E-02	6.78E-03	3.80E-03	3.56E-03	3.38E-03	3.32E-03	4.94E-03	6.90E-03	8.38E-03
14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.65E-05	3.09E-02	3.04E-02	4.45E-03	2.79E-03	2.30E-03	2.21E-03	2.15E-03	2.16E-03
15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.32E-02	2.26E-02	2.11E-02	3.06E-03	1.57E-03	1.57E-03
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.13E-06	1.65E-02	1.67E-02	2.24E-03
17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-02
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01	4.5E-01
20															
21															
22	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	2.37E-01	2.62E-01	2.83E-01	2.99E-01	3.13E-01	3.24E-01	3.33E-01	3.41E-01	3.48E-01	3.53E-01	3.58E-01	3.63E-01	3.67E-01	3.70E-01	3.73E-01
25	3.50E-02	3.54E-02	3.51E-02	3.14E-02	2.86E-02	2.68E-02	2.54E-02	2.41E-02	2.29E-02	2.18E-02	2.08E-02	1.99E-02	1.90E-02	1.82E-02	1.75E-02
26	5.48E-02	4.80E-02	4.48E-02	4.52E-02	4.47E-02	4.33E-02	3.85E-02	3.37E-02	2.95E-02	2.57E-02	2.39E-02	2.26E-02	2.14E-02	2.03E-02	1.93E-02
27	1.44E-01	1.26E-01	2.33E-02	1.51E-02	1.51E-02	1.56E-02	1.94E-02	2.32E-02	2.63E-02	2.68E-02	2.49E-02	2.32E-02	2.17E-02	2.05E-02	1.94E-02
28	0.00E+00	5.08E-05	8.57E-02	8.08E-02	1.27E-02	8.00E-03	6.52E-03	6.18E-03	6.08E-03	8.28E-03	1.10E-02	1.30E-02	1.26E-02	1.15E-02	1.07E-02
29	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.80E-02	5.43E-02	4.89E-02	7.25E-03	3.75E-03	3.56E-03	3.42E-03	3.40E-03	5.38E-03	7.78E-03	9.60E-03
30	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-05	3.67E-02	3.59E-02	4.85E-03	2.87E-03	2.32E-03	2.26E-03	2.24E-03	2.28E-03
31	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E-02	2.68E-02	2.50E-02	3.38E-03	1.60E-03	1.62E-03
32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.89E-06	1.97E-02	1.99E-02	2.52E-03
33	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-02
34	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01
36															
37															
38	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	2.39E-01	2.65E-01	2.86E-01	3.03E-01	3.17E-01	3.28E-01	3.37E-01	3.45E-01	3.52E-01	3.58E-01	3.63E-01	3.67E-01	3.71E-01	3.75E-01	3.78E-01
41	3.43E-02	3.54E-02	3.57E-02	3.20E-02	2.92E-02	2.75E-02	2.61E-02	2.48E-02	2.36E-02	2.25E-02	2.15E-02	2.05E-02	1.96E-02	1.88E-02	1.80E-02
42	5.06E-02	4.47E-02	4.23E-02	4.38E-02	4.41E-02	4.32E-02	3.86E-02	3.37E-02	2.96E-02	2.58E-02	2.40E-02	2.27E-02	2.15E-02	2.04E-02	1.94E-02
43	1.56E-01	1.36E-01	2.27E-02	1.39E-02	1.41E-02	1.47E-02	1.90E-02	2.32E-02	2.67E-02	2.72E-02	2.52E-02	2.34E-02	2.19E-02	2.07E-02	1.96E-02
44	0.00E+00	5.54E-05	9.44E-02	8.88E-02	1.26E-02	7.61E-03	6.13E-03	5.89E-03	5.85E-03	8.40E-03	1.15E-02	1.38E-02	1.34E-02	1.21E-02	1.12E-02
45	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.46E-02	6.03E-02	5.41E-02	7.43E-03	3.55E-03	3.43E-03	3.33E-03	3.36E-03	5.62E-03	8.38E-03	1.05E-02
46	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.16E-05	4.10E-02	4.00E-02	5.05E-03	2.85E-03	2.26E-03	2.23E-03	2.24E-03	2.31E-03
47	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E-02	3.01E-02	2.79E-02	3.55E-03	1.55E-03	1.60E-03
48	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-05	2.22E-02	2.23E-02	2.67E-03
49	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-02
50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01
52															
53															
54	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460
55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
56	2.40E-01	2.66E-01	2.87E-01	3.04E-01	3.18E-01	3.29E-01	3.39E-01	3.47E-01	3.54E-01	3.60E-01	3.65E-01	3.69E-01	3.73E-01	3.77E-01	3.80E-01
57	3.38E-02	3.55E-02	3.62E-02	3.25E-02	2.98E-02	2.80E-02	2.66E-02	2.54E-02	2.42E-02	2.31E-02	2.20E-02	2.10E-02	2.01E-02	1.92E-02	1.84E-02
58	4.63E-02	4.13E-02	3.98E-02	4.22E-02	4.32E-02	4.29E-02	3.84E-02	3.36E-02	2.95E-02	2.59E-02	2.40E-02	2.27E-02	2.15E-02	2.05E-02	1.95E-02
59	1.65E-01	1.43E-01	2.19E-02	1.25E-02	1.30E-02	1.38E-02	1.84E-02	2.31E-02	2.68E-02	2.73E-02	2.52E-02	2.33E-02	2.19E-02	2.06E-02	1.96E-02
60	0.00E+00	5.56E-05	1.01E-01	9.52E-02	1.24E-02	7.07E-03	5.64E-03	5.52E-03	5.56E-03	8.41E-03	1.19E-02	1.44E-02	1.40E-02	1.26E-02	1.16E-02
61	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.02E-02	6.53E-02	5.85E-02	7.45E-03	3.27E-03	3.23E-03	3.20E-03	3.28E-03	5.79E-03	8.85E-03	1.12E-02
62	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.14E-05	4.47E-02	4.35E-02	5.13E-03	2.73E-03	2.13E-03	2.16E-03	2.21E-03	2.31E-03
63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-02	3.28E-02	3.04E-02	3.66E-03	1.46E-03	1.55E-03
64	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-05	2.43E-02	2.44E-02	2.77E-03
65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E-02
66	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01	4.9E-01
68															
69															
70	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
71	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
72	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
73															
74															

	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
75															
76															
77															
78	180	200	220	240	260	280	300	320	340	360					
79	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
80	2.25E-01	2.49E-01	2.69E-01	2.85E-01	2.98E-01	3.09E-01	3.18E-01	3.26E-01	3.32E-01	3.38E-01					
81	4.13E-02	3.93E-02	3.75E-02	3.34E-02	3.03E-02	2.82E-02	2.65E-02	2.50E-02	2.37E-02	2.25E-02					
82	6.62E-02	5.79E-02	5.30E-02	5.12E-02	4.92E-02	4.64E-02	4.14E-02	3.65E-02	3.22E-02	2.84E-02					
83	1.18E-01	1.05E-01	2.57E-02	1.86E-02	1.82E-02	1.84E-02	2.12E-02	2.41E-02	2.66E-02	2.71E-02					
84	0.00E+00	3.83E-05	6.77E-02	6.51E-02	1.32E-02	9.33E-03	7.83E-03	7.24E-03	6.98E-03	8.49E-03					
85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.47E-02	4.27E-02	3.92E-02	7.28E-03	4.44E-03	4.11E-03					
86	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.65E-05	2.85E-02	2.83E-02	4.70E-03					
87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E-02					
88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
91	4.51E-01	4.52E-01	4.53E-01	4.54E-01	4.54E-01	4.54E-01	4.54E-01	4.54E-01	4.55E-01	4.55E-01					
92															
93															
94	180	200	220	240	260	280	300	320	340	360					
95	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
96	2.34E-01	2.60E-01	2.80E-01	2.97E-01	3.11E-01	3.22E-01	3.31E-01	3.39E-01	3.46E-01	3.52E-01					
97	3.81E-02	3.76E-02	3.67E-02	3.28E-02	2.98E-02	2.79E-02	2.64E-02	2.51E-02	2.38E-02	2.26E-02					
98	6.17E-02	5.38E-02	4.96E-02	4.92E-02	4.80E-02	4.59E-02	4.09E-02	3.59E-02	3.15E-02	2.76E-02					
99	1.38E-01	1.22E-01	2.55E-02	1.74E-02	1.71E-02	1.75E-02	2.09E-02	2.45E-02	2.75E-02	2.80E-02					
100	0.00E+00	4.79E-05	8.10E-02	7.71E-02	1.36E-02	9.07E-03	7.47E-03	6.97E-03	6.77E-03	8.74E-03					
101	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.44E-02	5.14E-02	4.68E-02	7.71E-03	4.31E-03	4.03E-03					
102	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-05	3.46E-02	3.41E-02	5.09E-03					
103	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-02					
104	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
105	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
107	4.72E-01	4.73E-01	4.73E-01	4.74E-01	4.74E-01	4.74E-01	4.74E-01	4.74E-01	4.74E-01	4.74E-01					
108															
109															
110	180	200	220	240	260	280	300	320	340	360					
111	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
112	2.39E-01	2.64E-01	2.85E-01	3.02E-01	3.16E-01	3.27E-01	3.37E-01	3.45E-01	3.52E-01	3.58E-01					
113	3.59E-02	3.65E-02	3.64E-02	3.26E-02	2.98E-02	2.80E-02	2.65E-02	2.52E-02	2.40E-02	2.29E-02					
114	5.56E-02	4.89E-02	4.57E-02	4.64E-02	4.62E-02	4.49E-02	4.00E-02	3.50E-02	3.07E-02	2.69E-02					
115	1.52E-01	1.33E-01	2.43E-02	1.55E-02	1.55E-02	1.61E-02	2.01E-02	2.42E-02	2.75E-02	2.81E-02					
116	0.00E+00	5.51E-05	9.09E-02	8.60E-02	1.34E-02	8.40E-03	6.83E-03	6.45E-03	6.34E-03	8.73E-03					
117	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.19E-02	5.81E-02	5.25E-02	7.77E-03	3.97E-03	3.77E-03					
118	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-05	3.94E-02	3.87E-02	5.24E-03					
119	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E-02					
120	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
121	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
123	4.82E-01	4.82E-01	4.82E-01	4.83E-01	4.83E-01	4.83E-01	4.83E-01	4.83E-01	4.83E-01	4.83E-01					
124															
125															
126	180	200	220	240	260	280	300	320	340	360					
127	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
128	2.40E-01	2.66E-01	2.87E-01	3.04E-01	3.18E-01	3.29E-01	3.39E-01	3.47E-01	3.54E-01	3.60E-01					
129	3.44E-02	3.59E-02	3.64E-02	3.27E-02	3.00E-02	2.82E-02	2.68E-02	2.55E-02	2.43E-02	2.32E-02					
130	4.92E-02	4.37E-02	4.16E-02	4.36E-02	4.43E-02	4.38E-02	3.91E-02	3.42E-02	3.01E-02	2.63E-02					
131	1.63E-01	1.41E-01	2.28E-02	1.35E-02	1.38E-02	1.45E-02	1.91E-02	2.36E-02	2.72E-02	2.78E-02					
132	0.00E+00	5.83E-05	9.95E-02	9.36E-02	1.28E-02	7.55E-03	6.05E-03	5.85E-03	5.85E-03	8.59E-03					
133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.86E-02	6.41E-02	5.75E-02	7.65E-03	3.53E-03	3.44E-03					
134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-05	4.37E-02	4.27E-02	5.25E-03					
135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-02					
136	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00					
139	4.87E-01	4.87E-01	4.87E-01	4.87E-01	4.87E-01	4.88E-01	4.88E-01	4.88E-01	4.88E-01	4.88E-01					
140															
141															
142	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1					
143	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0					
144	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0					

	AD	AE	AF	AG	AH	AI
1						
2						
3						
4						
5						
6	480	500				
7	0.00E+00	0.00E+00				
8	3.63E-01	3.66E-01				
9	1.60E-02	1.54E-02				
10	1.81E-02	1.73E-02				
11	1.77E-02	1.68E-02				
12	9.42E-03	9.12E-03				
13	7.86E-03	7.05E-03				
14	3.85E-03	5.61E-03				
15	1.53E-03	1.54E-03				
16	1.37E-03	1.16E-03				
17	1.33E-02	1.27E-02				
18	0.00E+00	5.10E-06				
19	4.5E-01	4.5E-01				
20						
21						
22	480	500				
23	0.00E+00	0.00E+00				
24	3.76E-01	3.79E-01				
25	1.68E-02	1.62E-02				
26	1.84E-02	1.76E-02				
27	1.84E-02	1.75E-02				
28	1.02E-02	9.82E-03				
29	8.99E-03	8.00E-03				
30	4.33E-03	6.48E-03				
31	1.62E-03	1.65E-03				
32	1.46E-03	1.20E-03				
33	1.59E-02	1.51E-02				
34	0.00E+00	5.83E-06				
35	4.7E-01	4.7E-01				
36						
37						
38	480	500				
39	0.00E+00	0.00E+00				
40	3.81E-01	3.84E-01				
41	1.73E-02	1.67E-02				
42	1.85E-02	1.77E-02				
43	1.86E-02	1.77E-02				
44	1.06E-02	1.02E-02				
45	9.80E-03	8.68E-03				
46	4.63E-03	7.08E-03				
47	1.63E-03	1.69E-03				
48	1.46E-03	1.18E-03				
49	1.79E-02	1.70E-02				
50	0.00E+00	6.67E-06				
51	4.8E-01	4.8E-01				
52						
53						
54	480	500				
55	0.00E+00	0.00E+00				
56	3.83E-01	3.86E-01				
57	1.77E-02	1.70E-02				
58	1.86E-02	1.77E-02				
59	1.86E-02	1.77E-02				
60	1.09E-02	1.05E-02				
61	1.05E-02	9.22E-03				
62	4.89E-03	7.60E-03				
63	1.61E-03	1.71E-03				
64	1.43E-03	1.13E-03				
65	1.96E-02	1.85E-02				
66	0.00E+00	6.85E-06				
67	4.9E-01	4.9E-01				
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70	1.1	1.1				
71	1.0	1.0				
72	1.0	1.0				
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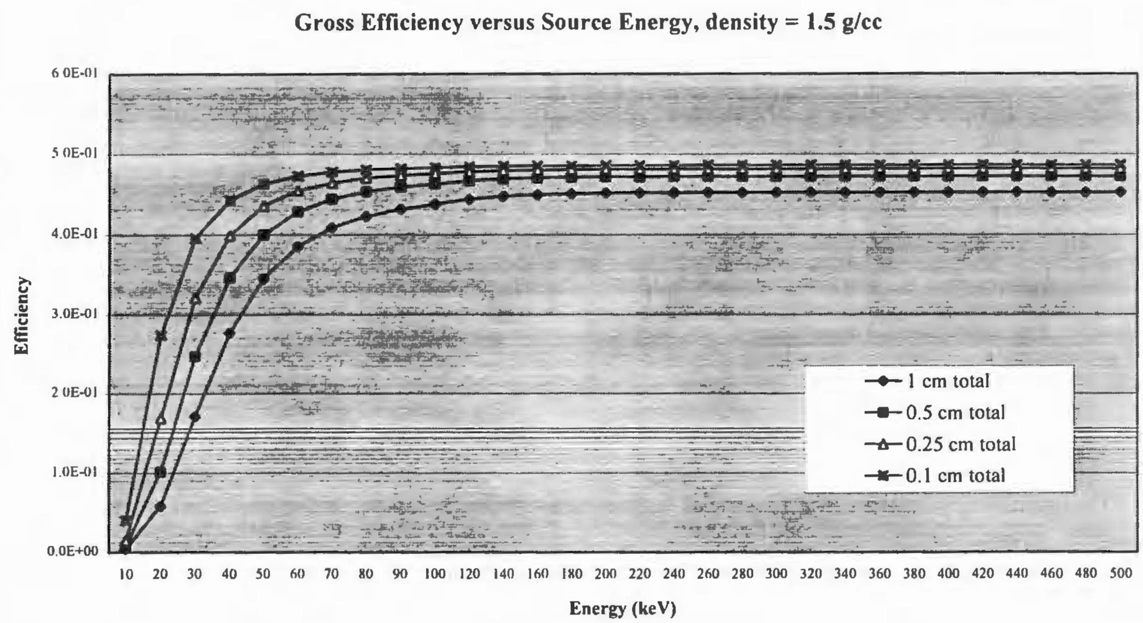
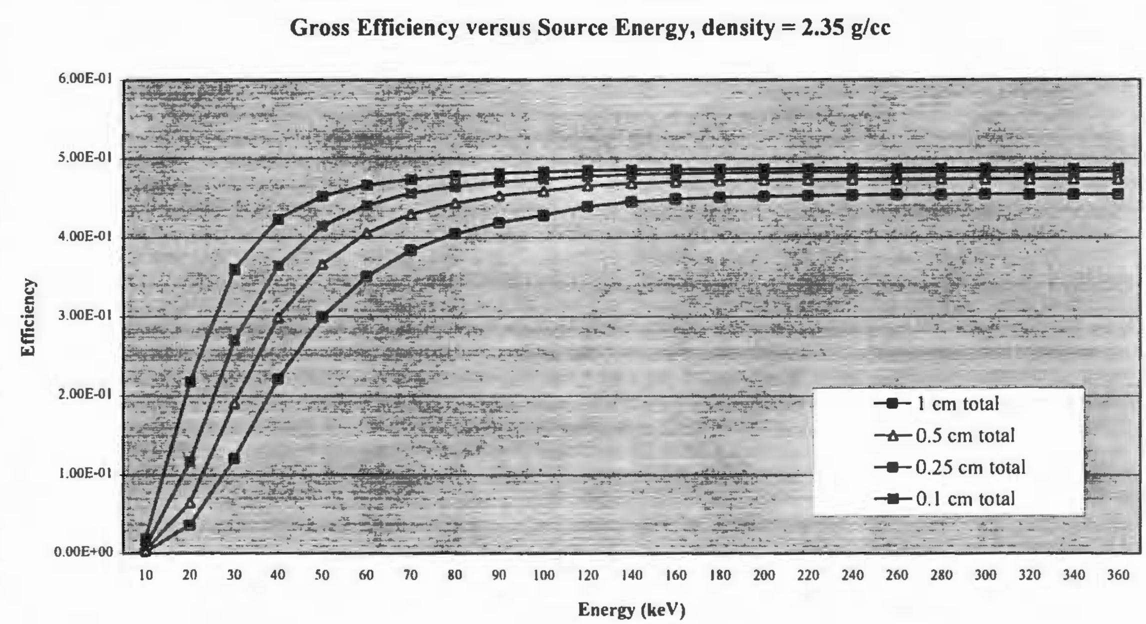

Gross Efficiency versus Source Energy, density = 1.5 g/cc
Efficiency
Energy (keV)
1 cm total
0.5 cm total
0.25 cm total
0.1 cm total


Gross Efficiency versus Source Energy, density = 2.35 g/cc
Efficiency
Energy (keV)
1 cm total
0.5 cm total
0.25 cm total
0.1 cm total

	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
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ATTACHMENT C

Assessment of the Potential Migration of Pu/Am Into Concrete, Parsons, 2002

Author: **Steven W. Woolfolk**
Checker: **Ron McConn**

Parsons Calculation No.: 730047-01001-01

Appendix C, pusol.xls Results Worksheet (Abbreviated copy of "Buildup Cal." worksheet attached to all copies except the record copy to minimized paper generation.)

1. PURPOSE

This calculation is intended to provide an assessment of the potential for the migration of Plutonium or Americium into concrete at the Seneca Army Depot. This assessment is based on the solubility of Plutonium or Americium and porosity of concrete.

2. REFERENCES, INPUTS, AND ASSUMPTIONS

2.1 References

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2.2 Assumptions

1. The Am or Pu present would be contamination from the handling of Pu metal so the Pu would be in oxide form typically (see Chapter 9, Section II of Hodge, 1973). It is also assumed that Am and Pu may be present as hydroxides. The presence of Pu/Am dissolve in acids is not credible situation since this is not a processing area and there is not evidence to acid damage of the concrete in the areas being addressed.

2. The concrete is assumed to be typical construction grade concrete with no significant cracking or pitting. The absence of cracking or pitting was observed during the survey activity, but was not specifically documented.

3. The only source of liquid in the area would be water (i.e., condensate, groundwater, or runoff water). It is assumed that the surface of the concrete can be wet for an extended period of time (i.e., 90 days). The water present on the surface is assumed to flow through the concrete based on current data on the porosity of concrete.

4. Other analysis specific assumptions will be detailed in the description of the analysis.

5. The material of concern is weapons grade plutonium as described by Shefelbine, 1978. Further, the Pu isotopes of interest are Pu-239 and to a lesser extent Pu-240. Pu-241 is of less importance since it is a beta emitter and has a half-life of about 13 years. The concern associated with Pu-241 is its progeny Am-241.

6. Am is present as a progeny of the Pu-241 in the plutonium.

3. DISCUSSION

This calculation models the movement of Pu/Am into concrete by considering the porosity of the concrete for transport of water, solubility of Pu/Am, and the chemical retardation of the transfer of Pu/Am dissolved in water. This calculation is done using an EXCEL spreadsheet (i.e., "pusol.xls" in Appendix C) with the following worksheets:

- "Pu solubility,"
- "Concrete,"
- "Concentrations," and
- "Buildup Cal."

The data is referenced in the spreadsheet in abbreviated form. These references are identified specifically in Section 2.1

3.1 Transport

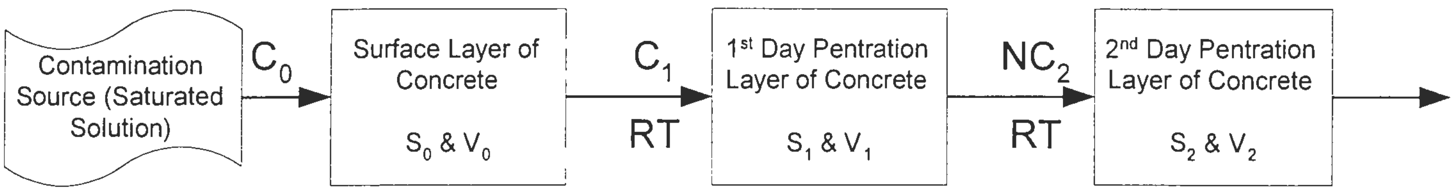
The process model assumed that the initial penetration of Pu/Am into concrete is as shown in Figure 1 for time t=0. The "Transportation Of A Chemical Through Concrete" chapter in the Material Science of Concrete III (Skalny, 1989) provides a 1 dimensional model for the movement of chemicals through concrete. It indicates that this movement can be modeled as a 1-dimenstion flow using:

$$x(t) = B * t^{1/2}$$

where the value of B (i.e., B=56.7 mm/day) for water can be found in Table I of this chapter. The Pu/Am is assumed to be transported as a dissolved species by the water. However, as is the case in soils, the chemical actions of the media can reduce the flow velocity of the chemical to less than the flow velocity of water by reacting with the dissolve material or precipitating it due to chemical changes. This can be modeled using a retardation factor for the material similar to the retardation factor used in water transport model for soils in the RESRAD software. The retardation factor (RT) is the ratio of the average water velocity to radionuclide transport velocity as discussed in Appendix E of Yu, 1993. When addressing the transport of Pu/Am through this media, it is important to limit the concentration being transported to less than or equal to the saturation concentration. For this simplified model it is assumed that any Pu/Am, which can't be transported due to the saturation limit or the retardation factor remains at the originating location.

The development of the concrete specific data, based on the Pu solubility data (see Section 3.1.5) is done in the "Concrete" worksheet of pusol.xls. The time dependent calculations and supporting information is addressed in the "Buildup Cal." worksheet of "pusol.xls" (see Appendix C).

Figure 1
Process For Chemical Transport (for time = 0)



$$S_0=C_0{*}V_0{*}wf/V_0 \qquad S_1=0 \qquad S_2=0$$

3.1.1 Time = 0 days

Where the conditions and parameters at time t=0 are as summarized below and in Figure 1:

- Contamination Source is the pool of liquid on the surface of the concrete, which is assumed to contain a saturated solution of Pu/Am. This pool is assumed to be at pH 7 and have a concentration of C_0.

- The surface layer of concrete is assumed to be a 0.2 cm layer of concrete. The CO_2 in the air is assumed to have modified the concrete in this surface layer so that the pH in the pore spaces is less than the pH of 12.5 normally found in concrete(see Section 2.16 of Troxell, 1968). Specifically the pH is assumed to 7 for this layer for conservatism . The parameters at t=0 days are:

  - $S_0(0)$ is the radioactivity per unit volume in the surface layer (μCi/ml).
  - C_0 is the incoming activity concentration of the liquid (μCi/ml).
  - V_0 is the volume (ml) of the section assuming a 1 cm^2 section.
  - wf is the fraction of V_0 that may contain water (ml).
  - C_1 is the outgoing activity concentration of the liquid (μCi/ml).

The activity concentration (μCi/ml) in the surface layer, cell i=0 is $S_0(0)$ a(i.e., t=0) is shown in Figure 1. Note, S_i (i) = 0 for i > 0 since the Pu/Am has not reached these cells yet, since penetration is modeled as occuring in 1 day steps and each layer below the surface layer is defined by the penetration boundary for the this additional day. Thus the value of "i" can be treated as both the time in days and the cell boundary with the break between cell "i=0" and "i=1" being a special case.

3.1.2 Time = 1 day

- The 1st Day Penetration Layer of Concrete is area that is penetrated during the 1 day of in flow into the concrete for 1 cm^2 section area minus the S_0 layer. The liquid pH is assumed to be about 12.5 consistent with the characteristics of concrete. Specifically for this assessment of activity concentration:

  - $S_1(t)$ is the average radioactivity per unit volume in the surface layer (µCi/ml) at time "t".
  - C_1 is the incoming activity concentration of the liquid (µCi/ml).
  - V_1 is the volume (ml) of the section assuming a 1 cm^2 section.
  - wf is the fraction of V_1 that may contain water (ml).
  - FV1 is the volume of fluid that can flow in to layer "i=1" thus FV1 = wf * V_1.
  - NC_i is the ingoing activity concentration of the liquid, and is assumed to be $NC_i = S_{i-1}*V_{i-1}/FVi$ if this concentration exceeds the saturation concentration then it is set to the saturation concentration. Essentially this is the activity in the source cell (i.e., $S_{i-1}*V_{i-1}$) divided by the volume of liquid that flows through that cell in a day (i.e., FV1) to determine the average concentration.
  - RT is the retardation factor for the material (i.e., Pu or Am) for transport by water, assumed to be similar to the retardation factor used in modeling water transport in soils in the RESRAD model. This is the ratio of average water velocity to radionuclide transport velocity (see RESRAD 6 and Yu, 1993). However, to ensure conservatism this value has be set to 0.1.

To assess the concentration at the end of the first day it is necessary to model the penetration of the concrete by the carrier media water and any retardation of the transfer of Pu/AM by the chemistry of the media through which the water is passing. The parameters for modeling this flow were defined above for t=1.

The activity concentration (µCi/ml) in each cell i is $S_i(1)$ (i.e., values at t=1) is summarized below for i < 2, and is zero for i ≥ 2, since the Pu/Am will not have reached these cells.

$$S_0(1) = [S_0(0) * V_0 + (C_0 - C_1) * FV1 + RT * C_1 * FV1] / V_0$$

$$S_1(1) = (S_1(1) * V_1 + RT * C_1 * FV1) / V_1$$

$$S_i(1) = 0, \ i > 1.$$

3.1.3 Time ≥ 2 days

- For time greater than or equal to two days the Penetration Layer of Concrete is that area that is penetrated beyond that penetrated the previous day for 1 cm^2 section area. The liquid pH is assumed to be about 12.5 consistent with the characteristics of concrete for all volume except V_0, which is assumed to have a pH of 7. Specifically for this assessment of activity concentration:

  - $S_i(t)$ is the radioactivity per unit volume in the surface layer (μCi/ml) for cell "i" at time "t".
  - NC_i is the incoming/outgoing (based on "i") activity concentration of the liquid and is assumed to be $NC_i = S_{i-1}(t)*V_{i-1}/FVi$ if this concentration exceeds the saturation concentration then it is set to the saturation concentration.
  - V_i is the volume (ml) of the section assuming a 1 cm^2 section.
  - wf is the fraction of V_0 that may contain water (ml).
  - FVi is the volume of water that can flow in layer "i".

  RT is the retardation factor for the material (i.e., Pu or Am) for transport by water and this value is assumed to be similar to the retardation factor used in model water transport in soils in the RESRAD model. This is the ratio of average water velocity to radionuclide transport velocity (see RESRAD 6 and Yu, 1993). However, to ensure conservatism this value has be set to 0.1.

3.1.4 Time t days

To assess the concentration at the end of each day (i.e., subsequent days ≥2 days) it is necessary to model the penetration of the concrete by the carrier media water and any retardation of the transfer by the chemistry of the media through which the water is passing. The parameters are defined above in the discussion for t=0 and t=1 days.

The activity concentration (μCi/ml) in each cell i is $S_i(t)$ (i.e., t=2, 3, 4, ...) is summarized below: The equations are interrelated to that cell, which the flow has not penetrated will have zero values.

$$S_0(t\geq 2) = [\ S_0(t-1) * V_0 + (C_0 - C_1) * FV1 + RT * C_1 * FV1\ ] / V_0$$

$$S_1(t\geq 2) = (S_1(t-1) * V_1 + RT * C_1 * FV1 - RT * NC2 * FV2) / V_1$$

$$S_i(t\geq 2) = [S_i(t-1) * V_1 + RT * NCi * FVi - RT * NC(i+1) * FVi] / V_i$$

with the following boundary condition:

$$NCi = \text{if}\ [\ S_{i-1}(t-1)*V_{i-1}/FVi > C_{i-1},\ C_{i-1},\ S_{i-1}(t-1)*V_{i-1}/FVi\ ]$$

3.1.5 Assessment of Saturation Concentration

Plutonium and americium are essentially insoluable materials unless the solution is highly acidic. The solubility is pH dependent and the behavior of a Pu/Am solution passing through concrete should be similar to a Pu/Am solution passing through soils, which was investigated and quantified as described in Rai, 1980 and Rai, 1981. For purposes of conservatism it is assumed that concentration flowing into the concrete is saturated with Pu and Am, even though this is unlikely. When the potential concentration in an area exceeds the saturation concentration, the excess Pu and/or Am is assumed to precipitate and drop out of solution and remain in the cell and would be included as a potential future source for future flows and existing concentration.

In the model discussed in Section 3.1 the concentration in a cell (i.e., C_i) is modeled based on the pH in the cell and the concentration of the entering solution. Above the top cell there is assumed to be a saturated solution of Pu and Am for the 90 days/year period that the concrete is assumed to be covered by this saturated solution of water. The Pu/Am source in this saturated water solution is assumed to be unlimited and have a pH of 7. Cell zero (i.e., the top cell) is the top layer of the concrete where the pH has been affected by the CO_2 in the air (i.e., the top 2 mm), and is assumed to have a pH of about 7 (i.e., below 12.5 pH for typical concrete based on Troxell,, 1968 , pg 48; Skalny, Jan, 1989, pg 287; & Skalny, Jan and Sidney Miness, 1991, pg 202) . Note, water has a pH of 7 with no contaminates. The concentration in a cell is controlled by the pH of the cell (i.e., below the top cell the pH is assumed to 12.5 based on Troxell, 1968 , pg 48; Skalny, Jan, 1989, pg 287; & Skalny, Jan and Sidney Miness, 1991, pg 202) that is being entered and any precipitating Pu and/or Am is assumed to be deposited in the cell above. The flow out of a cell is always controlled by the pH of the cell below and the flow into a cell is controlled by the pH of the cell. The concentration (i.e., C_i) in the solution flowing from a cell is equal to the radioactivity in the cell divided by the water volume in the cell unless this concentration exceeds the saturation concentration for the cell that solution is flowing into, in such a case the concentration is reduced to the saturation concentration.

The saturation concentration for Pu and Am can be characterized by the equations listed below:

$\log(Pu_{total}) = (-3.90 \pm 0.10) - (0.64 \pm 0.02) * pH$ (Rai, 1980) for PuO_2 in moles per liter of solution.

$\log(Pu_{total}) = (-1.19 \pm 0.08) - (0.80 \pm 0.01) * pH$ (Rai, 1980) for $Pu(OH)_4$ in moles per liter of solution.

$\log(Am_{total}) = (-3.76 \pm 0.24) - (1.07 \pm 0.04) * pH$ (Rai, 1981) for Am in moles per liter of solution.

Moles per liter are converted to g/liter by multiplying by the atomic weight of the compound for Pu (i.e., Pu-239) and by multiplying by the atomic weight of Am-241. The concentration was then multiplied by the specific activity of the radionuclide(s) to calculate the activity concentration, which is C_i.

Based on the chemistry of Pu and the assumed source of the Pu, which is metallic, the Pu in the solution above the top cell and in the top cell are assumed to be PuO_2. (Hodge, 1973). In subsequent cells because of the abundance of the $(OH)^-$ ion the source is assumed to be $Pu(OH)_4$, to ensure conservatism. Based on Rai, 1981 the Am is assumed to be in ionic form, typically associated with hydroxides of this chemical.

The solubility as a function of pH is summarized in Figure 1 for Pu/Am. Note, these values are described based on activity and include the specific activity of the material. For Pu we consider both Pu-239 and mixture of Pu-239/Pu-240 since both are of concern as discussed in Section 3.1.8.

The assessment of Pu/Am concentration at saturation is calculated in the "Pu solubility" worksheet of pusol.xls (see Appendix C).

3.1.6 Retardation Factor

The retardation factor (i.e., RT) for the material (i.e., Pu or Am) transport by water through concrete is assumed to be similar to the retardation factor used to model water transport of these chemicals in soils in the RESRAD software. R_d is the ratio of the average water velocity to radionuclide velocity and can be calculated using (see RESRAD 6 and Yu, 1993):

$$RT = 1/R_d = 1 + \rho_b * K_d / Th$$

Where:

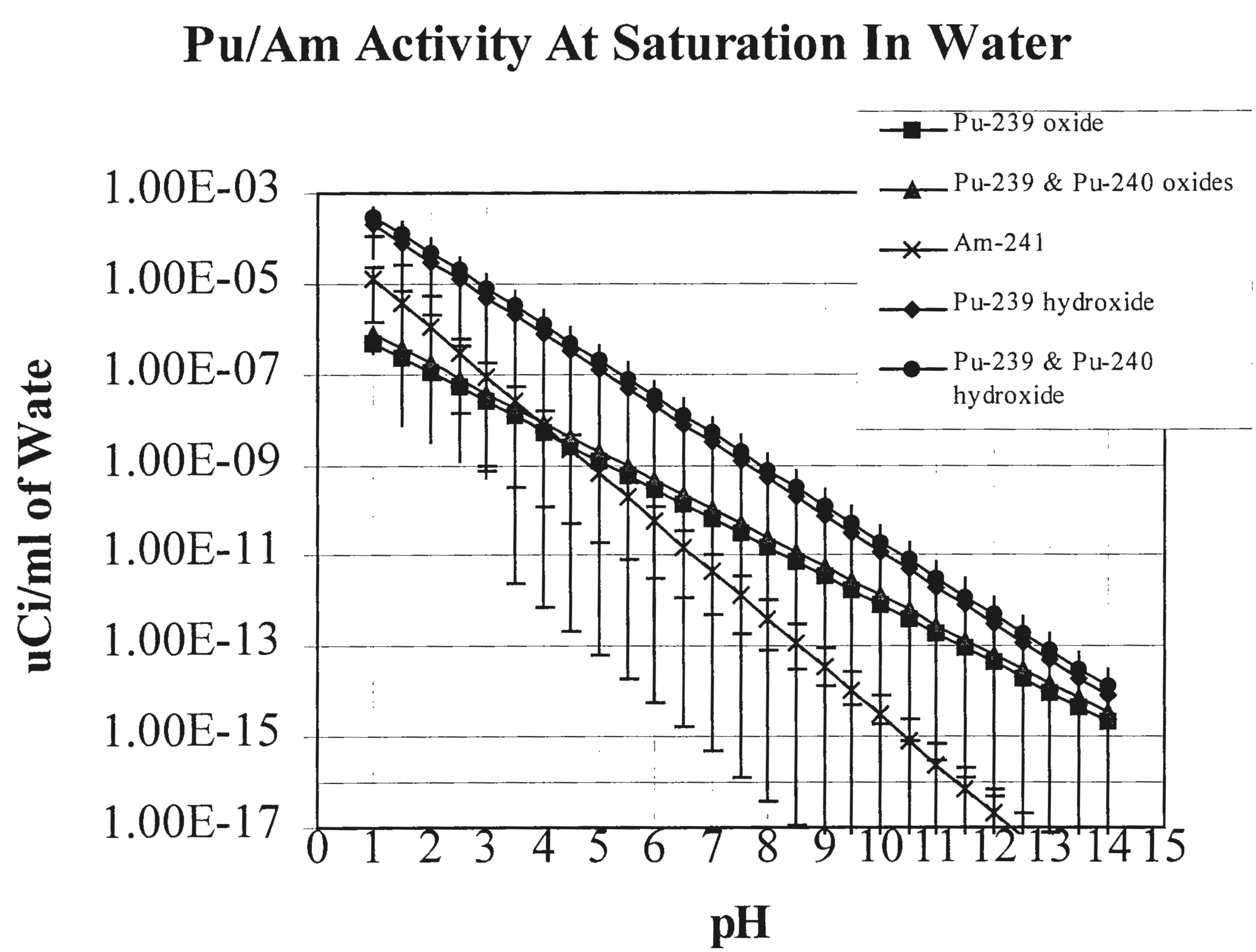
p_b	bulk density (g/cm^3)
K_d	distriubtion coefficent for radionuclide (cm^3/g)
Th	volumetric water content
R_d	ratio of average water velocity to radionuclide velocity

The value of K_d can vary based on the material for soils RESRAD uses:

Element	K_d	pH	Element	K_d	pH	
Pu	1000	at pH 11	Pu	8500	at pH 7	Table E.6 of Yu, 1993
Pu	2000	not specified	Am	20	not specified	RESRAD 6

These values are large and significantly reduce the movement of Pu/Am, which is consistent with what is seen in nature. However, $1/R_d$ (i.e., RT) was assumed to be 10 for both Pu and Am to ensure conservatism. The retardation factor is calculated and used in the "Buildup Cal." worksheet of the "pusol.xls" spreadsheet in Appendix C.

Figure 1 Pu/Am Solubility As a Function of pH



3.1.7 Description of Time Dependent Flow

The model assumes that the various cells (i.e., i=0 to 90) represent the amount of concrete that water would penetrate concrete in "i" days minus the amount of water that would penetrate concrete in "i-1" days. The time dependent calculation is found in the "Buildup Cal." worksheet of the "pusol.xls" spreadsheet.

The "i=0" cell is the layer on top of the concrete which is treated separately since it has different pH characteristics. The "i=1" cell begins at the bottom of the "i=0" cell and ends at the distance water would penetrate from the top of the concrete in one day. Thus the cells can be considered to be a time/distance dependent variable. The distance dependent variable begins with x=0 at the top of the concrete and the water layer above is not considered as part of the cells. The boundaries of these layers are summarized in Table 1. The liquid layer above cell "i=0" is assumed to be an unchanging saturated Pu/Am solution, which is present for 90 days/yr and absent for the balance of that period. It is only necessary to address a period of 180 days in each year since the water will have flowed beyond the bottom cell at the end of this period.

At time zero water is assumed to have penetrated cell "i=0" and for each day thereafter the penetration is summarized in Table 1. Thus the cell number and the lapse time in days is equivalent with cell "i=0" and "i=1" being special cases. The depth boundaries are also shown in Table 1. Below cell "i=90" there is assumed to be continuing concrete or soils, which would have concentrations less than those for the cells above this volume.

It is assumed that for the first 90 days there is liquid setting on the surface and the water proceeds down through the concrete for 90 days. It is then assumed that the saturated water source has dried out and is no longer providing Pu/Am saturated liquid input to cell "i=0". Thus after 90 days, each day the water input to the next cell ends, (e.g., on day 91 cell "i=1" receives no additional Pu/Am saturated water and then on day 92 cell "i=2" Pu/Am saturated water) until no water is present in the cells. The Pu/Am in the cell on the last day it has water is assumed to remain in the cell it starts in and is also assumed to flow with the water into the next cell. This results in the activity in the solution on the last day a cell has water being double counted to ensure conservatism. This conservatism was used since it is unclear if the flow will actually continue after the water head above the cell is eliminated and thus keeping the activity in the cell above. The spreadsheet in Appendix C, particularly worksheet "Buildup Cal." of the pusol.xls spreadsheet provides a model of 90 days of filling and then 90 days of empting out (i.e., drying), which is assumed to happen each year. This cycle is assumed to have occurred for 40 years, so this 180 day cycle is repeated 40 times. Assuming the 90 days is continuous maximizes the penetration of the Pu/Am solution.

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0, draft B	1/4/2002	SWW	RJM	**Assessment of the Potential Migration of Pu/Am Into Concrete**

Table 1 Cell Boundaries (Distance and Elapsed Time)

Depth (cm)		Elapsed Time (days)	Depth (cm)		Elapsed Time (days)	Depth (cm)		Elapsed Time (days)
Begin	End		Begin	End		Begin	End	
0	0.2	0 ($<2X10^{-5}$)			N/A			
0.2	5.7	1	31.1	31.6	31	43.9	44.3	61
5.7	8.0	2	31.6	32.1	32	44.3	44.6	62
8.0	9.8	3	32.1	32.6	33	44.6	45.0	63
9.8	11.3	4	32.6	33.1	34	45.0	45.4	64
11.3	12.7	5	33.1	33.5	35	45.4	45.7	65
12.7	13.9	6	33.5	34.0	36	45.7	46.1	66
13.9	15.0	7	34.0	34.5	37	46.1	46.4	67
15.0	16.0	8	34.5	35.0	38	46.4	46.8	68
16.0	17.0	9	35.0	35.4	39	46.8	47.1	69
17.0	17.9	10	35.4	35.9	40	47.1	47.4	70
17.9	18.8	11	35.9	36.3	41	47.4	47.8	71
18.8	19.6	12	36.3	36.7	42	47.8	48.1	72
19.6	20.4	13	36.7	37.2	43	48.1	48.4	73
20.4	21.2	14	37.2	37.6	44	48.4	48.8	74
21.2	22.0	15	37.6	38.0	45	48.8	49.1	75
22.0	22.7	16	38.0	38.5	46	49.1	49.4	76
22.7	23.4	17	38.5	38.9	47	49.4	49.8	77
23.4	24.1	18	38.9	39.3	48	49.8	50.1	78
24.1	24.7	19	39.3	39.7	49	50.1	50.4	79
24.7	25.4	20	39.7	40.1	50	50.4	50.7	80
25.4	26.0	21	40.1	40.5	51	50.7	51.0	81
26.0	26.6	22	40.5	40.9	52	51.0	51.3	82
26.6	27.2	23	40.9	41.3	53	51.3	51.7	83
27.2	27.8	24	41.3	41.7	54	51.7	52.0	84
27.8	28.4	25	41.7	42.0	55	52.0	52.3	85
28.4	28.9	26	42.0	42.4	56	52.3	52.6	86
28.9	29.5	27	42.4	42.8	57	52.6	52.9	87
29.5	30.0	28	42.8	43.2	58	52.9	53.2	88
30.0	30.5	29	43.2	43.6	59	53.2	53.5	89
30.5	31.1	30	43.6	43.9	60	53.5	53.8	90

3.1.8 Radionuclide Groups

The primary radionuclide of concern associated with contamination from weapons grade Pu is Pu-239, so it was specifically addressed. In addition, the Pu-239/Pu-240 mixture consistent with Shefelbine, 1968 was also addressed due to the increase in specific activity of Pu-240. The Pu-240/Pu-239 ratio based on the Shefelbine data is 0.223 and is reflected in the calculation of the specific activity of the two radionuclides mixture. Am-241 was also considered since it is a decay product of the short-lived Pu isotope Pu-241 (i.e., halflife of 13.2 years). As part of the survey activity the Pu-239 activity was extrapolated based on the Am-241 activity. For these analyses based on the projected age of material it was estimated that there are about 4 Pu-239 µCi for every single Am-241 µCi. This determination is documented in the survey and workplan documentation.

The specific activity of the various radionuclides were calculated based on the following equation from the Radiological Health Handbook:

$$SpAct_i(Ci/g) = 3.578 \times 10^5 / T_{1/2}\,(yr) / ATW$$

Where:

$T_{1/2}$ is the half-life in years, and
ATW is the atomic weight of the element.

The results for specific activity used in this analysis are summarized in Table 2 Specific Activity.

Table 2 Specific Activity

Radionuclide	At Wt	Half-life (yr) (ICRP-38)	SpA (Ci/g)
Pu-239	239	24065	0.0622095
Pu-240	240	6537	0.2280608
Am-241	241	432.2	3.4350933

This data is calculated in the "Pu Solubility" worksheet of the "pusol.xls" spreadsheet.

4. CONCLUSION

The projected activity range from 1.5 X 10^{-6} pCi/g to 4.66 X 10^{-23} pCi/g for the various layers after 40 years of exposure, as summarized in Table 3. The pCi/g values were calculated by multiplying the pCi/ml values by the density of concrete in g/ml (i.e., 2 g/cm^3). The data for the various layer is summarized in detail in Appendix A (i.e., Table 4, Table 5, and Table 6) and were calculated by the spreadsheet document in Appendix C, specifically in the "Concentrations" worksheet of "pusol.xls" spreadsheet. The values for the various radionuclide groups specific solubility were put in the "Activity (uCi/ml) Inflow Concentration Used" line in the ""Buildup Cal." worksheet and then the resulting table (i.e., the "Calculation Table") in the "Concentrations" worksheet was copied and then the values were "special pasted" into the appropriate radionuclide group table to document the calculation.

Table 3 Summary of Pu/Am Concentrations

Radionuclide(s)	**Concentration After 40 Years In**					
	0 to 0.02 cm Layer		**0.02 to 2.08 cm Layer**		**18.6 to 19.6 cm Layer**	
	pCi/ml	**pCi/g**	**pCi/ml**	**pCi/g**	**pCi/ml**	**pCi/g**
Pu-239/Pu-240	1.38E-06	6.89E-07	2.36E-13	1.18E-13	3.61E-50	1.81E-50
Pu-239	2.20E-06	1.10E-06	3.76E-13	1.88E-13	5.76E-50	2.88E-50
Am-241	9.16E-09	4.58E-09	8.90E-12	4.45E-12	1.36E-48	6.82E-49

The uncertainty in this calculation is only addressed semi-quantitatively since the results are so small that a detailed assessment of uncertainty is not justified. The saturation uncertainty data (see worksheet "Pu solubbility" of the pusol.xls spreadsheet in Appendix C) is clearly within an order magnitude. Further based on concrete porosity data uncertainties, the calculations of the flow through the concrete (see worksheets "Concrete" and "Buildup Cal." of the pusol.xls spreadsheet in Appendix C) are within an order of magnitude. The retardation factor is conservative by at least a factor of 2 for Am and orders of magnitude for Pu. Thus 100 times values in Table 3 and APPENDIX A bound the activity that could be in the cells and the values in reality are probably less than the values in Table 3 and APPENDIX A.

APPENDIX A

Pu/Am Concentrations

(Contains 5 pages)

PARSONS Calculation Page	Job/Cal. Number 730047-01001-01	Discipline Health Physics	Appendices

Rev	Date	By	Ck	Subject: **Assessment of the Potential Migration of Pu/Am Into Concrete**
0, draft B	1/4/2002	SWW	RJM	

Table 4 Pu-239/Pu-240 Concentration In Concrete (pCi/ml)

Layer	1	2	3	4	5	6	7	8	9	10
Thickness of the Layer (cm)	2.00E-01	5.67E+00	8.02E+00	9.82E+00	1.13E+01	1.27E+01	1.39E+01	1.50E+01	1.60E+01	1.70E+01
Day 1	3.65E-09	2.18E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.38E-06	2.36E-13	2.33E-13	2.20E-13	2.02E-13	1.81E-13	1.63E-13	1.48E-13	1.35E-13	1.24E-13
Layer	11	12	13	14	15	16	17	18	19	20
Thickness of the Layer (cm)	1.79E+01	1.88E+01	1.96E+01	2.04E+01	2.12E+01	2.20E+01	2.27E+01	2.34E+01	2.41E+01	2.47E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.15E-13	1.07E-13	1.00E-13	9.40E-14	8.86E-14	8.37E-14	7.92E-14	7.50E-14	7.11E-14	6.70E-14
Layer	21	22	23	24	25	26	27	28	29	30
Thickness of the Layer (cm)	2.54E+01	2.60E+01	2.66E+01	2.72E+01	2.78E+01	2.84E+01	2.89E+01	2.95E+01	3.00E+01	3.05E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	6.14E-14	5.41E-14	4.58E-14	3.71E-14	2.87E-14	2.12E-14	1.49E-14	1.00E-14	6.44E-15	3.95E-15
Layer	31	32	33	34	35	36	37	38	39	40
Thickness of the Layer (cm)	3.11E+01	3.16E+01	3.21E+01	3.26E+01	3.31E+01	3.35E+01	3.40E+01	3.45E+01	3.50E+01	3.54E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.32E-15	1.30E-15	7.00E-16	3.61E-16	1.79E-16	8.57E-17	3.94E-17	1.75E-17	7.48E-18	3.09E-18
Layer	41	42	43	44	45	46	47	48	49	50
Thickness of the Layer (cm)	3.59E+01	3.63E+01	3.67E+01	3.72E+01	3.76E+01	3.80E+01	3.85E+01	3.89E+01	3.93E+01	3.97E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.24E-18	4.80E-19	1.80E-19	6.55E-20	2.32E-20	7.95E-21	2.65E-21	8.62E-22	2.73E-22	8.40E-23
Layer	51	52	53	54	55	56	57	58	59	60
Thickness of the Layer (cm)	4.01E+01	4.05E+01	4.09E+01	4.13E+01	4.17E+01	4.20E+01	4.24E+01	4.28E+01	4.32E+01	4.36E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.52E-23	7.40E-24	2.12E-24	5.92E-25	1.62E-25	4.32E-26	1.13E-26	2.88E-27	7.22E-28	1.77E-28
Layer	61	62	63	64	65	66	67	68	69	70
Thickness of the Layer (cm)	4.39E+01	4.43E+01	4.46E+01	4.50E+01	4.54E+01	4.57E+01	4.61E+01	4.64E+01	4.68E+01	4.71E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.26E-29	1.00E-29	2.32E-30	5.28E-31	1.18E-31	2.57E-32	5.53E-33	1.17E-33	2.43E-34	4.96E-35
Layer	71	72	73	74	75	76	77	78	79	80

Table 4 Pu-239/Pu-240 Concentration In Concrete (pCi/ml)

Thickness of the Layer (cm)	4.74E+01	4.78E+01	4.81E+01	4.84E+01	4.88E+01	4.91E+01	4.94E+01	4.98E+01	5.01E+01	5.04E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.98E-36	1.97E-36	3.84E-37	7.36E-38	1.39E-38	2.58E-39	4.74E-40	8.55E-41	1.52E-41	2.67E-42
Layer	81	82	83	84	85	86	87	88	89	90
Thickness of the Layer (cm)	5.07E+01	5.10E+01	5.13E+01	5.17E+01	5.20E+01	5.23E+01	5.26E+01	5.29E+01	5.32E+01	5.35E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.63E-43	7.91E-44	1.33E-44	2.22E-45	3.64E-46	5.91E-47	9.46E-48	1.50E-48	2.34E-49	3.61E-50

Table 5 Pu-239 Concentration in Concrete (pCi/ml)

Layer	1	2	3	4	5	6	7	8	9	10
Thickness of the Layer (cm)	2.00E-01	5.67E+00	8.02E+00	9.82E+00	1.13E+01	1.27E+01	1.39E+01	1.50E+01	1.60E+01	1.70E+01
Day 1	5.81E-09	3.47E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.20E-06	3.76E-13	3.71E-13	3.51E-13	3.21E-13	2.89E-13	2.60E-13	2.35E-13	2.15E-13	1.98E-13
Layer	11	12	13	14	15	16	17	18	19	20
Thickness of the Layer (cm)	1.79E+01	1.88E+01	1.96E+01	2.04E+01	2.12E+01	2.20E+01	2.27E+01	2.34E+01	2.41E+01	2.47E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.83E-13	1.70E-13	1.59E-13	1.50E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13
Layer	21	22	23	24	25	26	27	28	29	30
Thickness of the Layer (cm)	2.54E+01	2.60E+01	2.66E+01	2.72E+01	2.78E+01	2.84E+01	2.89E+01	2.95E+01	3.00E+01	3.05E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.78E-14	8.63E-14	7.30E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14	1.60E-14	1.03E-14	6.29E-15
Layer	31	32	33	34	35	36	37	38	39	40
Thickness of the Layer (cm)	3.11E+01	3.16E+01	3.21E+01	3.26E+01	3.31E+01	3.35E+01	3.40E+01	3.45E+01	3.50E+01	3.54E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	3.69E-15	2.07E-15	1.11E-15	5.76E-16	2.86E-16	1.37E-16	6.28E-17	2.78E-17	1.19E-17	4.93E-18
Layer	41	42	43	44	45	46	47	48	49	50
Thickness of the Layer (cm)	3.59E+01	3.63E+01	3.67E+01	3.72E+01	3.76E+01	3.80E+01	3.85E+01	3.89E+01	3.93E+01	3.97E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.97E-18	7.64E-19	2.87E-19	1.04E-19	3.69E-20	1.27E-20	4.23E-21	1.37E-21	4.34E-22	1.34E-22
Layer	51	52	53	54	55	56	57	58	59	60

Table 5 Pu-239 Concentration in Concrete (pCi/ml)

Thickness of the Layer (cm)	4.01E+01	4.05E+01	4.09E+01	4.13E+01	4.17E+01	4.20E+01	4.24E+01	4.28E+01	4.32E+01	4.36E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.02E-23	1.18E-23	3.37E-24	9.43E-25	2.57E-25	6.88E-26	1.80E-26	4.59E-27	1.15E-27	2.82E-28
Layer	61	62	63	64	65	66	67	68	69	70
Thickness of the Layer (cm)	4.39E+01	4.43E+01	4.46E+01	4.50E+01	4.54E+01	4.57E+01	4.61E+01	4.64E+01	4.68E+01	4.71E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	6.79E-29	1.60E-29	3.70E-30	8.41E-31	1.87E-31	4.10E-32	8.82E-33	1.86E-33	3.87E-34	7.91E-35
Layer	71	72	73	74	75	76	77	78	79	80
Thickness of the Layer (cm)	4.74E+01	4.78E+01	4.81E+01	4.84E+01	4.88E+01	4.91E+01	4.94E+01	4.98E+01	5.01E+01	5.04E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.59E-35	3.14E-36	6.12E-37	1.17E-37	2.21E-38	4.12E-39	7.55E-40	1.36E-40	2.43E-41	4.26E-42
Layer	81	82	83	84	85	86	87	88	89	90
Thickness of the Layer (cm)	5.07E+01	5.10E+01	5.13E+01	5.17E+01	5.20E+01	5.23E+01	5.26E+01	5.29E+01	5.32E+01	5.35E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	7.38E-43	1.26E-43	2.12E-44	3.54E-45	5.81E-46	9.42E-47	1.51E-47	2.39E-48	3.73E-49	5.76E-50

Table 6 Am-241 Concentration in Concrete (pCi/ml)

Layer	1	2	3	4	5	6	7	8	9	10
Thickness of the Layer (cm)	2.00E-01	5.67E+00	8.02E+00	9.82E+00	1.13E+01	1.27E+01	1.39E+01	1.50E+01	1.60E+01	1.70E+01
Day 1	3.19E-11	8.23E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.16E-09	8.90E-12	8.78E-12	8.32E-12	7.61E-12	6.85E-12	6.16E-12	5.58E-12	5.09E-12	4.68E-12
Layer	11	12	13	14	15	16	17	18	19	20
Thickness of the Layer (cm)	1.79E+01	1.88E+01	1.96E+01	2.04E+01	2.12E+01	2.20E+01	2.27E+01	2.34E+01	2.41E+01	2.47E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.33E-12	4.04E-12	3.78E-12	3.55E-12	3.34E-12	3.16E-12	2.99E-12	2.83E-12	2.68E-12	2.53E-12
Layer	21	22	23	24	25	26	27	28	29	30
Thickness of the Layer (cm)	2.54E+01	2.60E+01	2.66E+01	2.72E+01	2.78E+01	2.84E+01	2.89E+01	2.95E+01	3.00E+01	3.05E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.32E-12	2.04E-12	1.73E-12	1.40E-12	1.09E-12	8.01E-13	5.64E-13	3.79E-13	2.43E-13	1.49E-13
Layer	31	32	33	34	35	36	37	38	39	40

Table 6 Am-241 Concentration in Concrete (pCi/ml)

Thickness of the Layer (cm)	3.11E+01	3.16E+01	3.21E+01	3.26E+01	3.31E+01	3.35E+01	3.40E+01	3.45E+01	3.50E+01	3.54E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	8.74E-14	4.91E-14	2.64E-14	1.36E-14	6.77E-15	3.24E-15	1.49E-15	6.60E-16	2.82E-16	1.17E-16
Layer	41	42	43	44	45	46	47	48	49	50
Thickness of the Layer (cm)	3.59E+01	3.63E+01	3.67E+01	3.72E+01	3.76E+01	3.80E+01	3.85E+01	3.89E+01	3.93E+01	3.97E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.67E-17	1.81E-17	6.80E-18	2.47E-18	8.74E-19	3.00E-19	1.00E-19	3.26E-20	1.03E-20	3.17E-21
Layer	51	52	53	54	55	56	57	58	59	60
Thickness of the Layer (cm)	4.01E+01	4.05E+01	4.09E+01	4.13E+01	4.17E+01	4.20E+01	4.24E+01	4.28E+01	4.32E+01	4.36E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.53E-22	2.79E-22	7.99E-23	2.23E-23	6.10E-24	1.63E-24	4.26E-25	1.09E-25	2.73E-26	6.69E-27
Layer	61	62	63	64	65	66	67	68	69	70
Thickness of the Layer (cm)	4.39E+01	4.43E+01	4.46E+01	4.50E+01	4.54E+01	4.57E+01	4.61E+01	4.64E+01	4.68E+01	4.71E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.61E-27	3.79E-28	8.78E-29	1.99E-29	4.44E-30	9.72E-31	2.09E-31	4.42E-32	9.17E-33	1.87E-33
Layer	71	72	73	74	75	76	77	78	79	80
Thickness of the Layer (cm)	4.74E+01	4.78E+01	4.81E+01	4.84E+01	4.88E+01	4.91E+01	4.94E+01	4.98E+01	5.01E+01	5.04E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	3.77E-34	7.45E-35	1.45E-35	2.78E-36	5.25E-37	9.76E-38	1.79E-38	3.23E-39	5.75E-40	1.01E-40
Layer	81	82	83	84	85	86	87	88	89	90
Thickness of the Layer (cm)	5.07E+01	5.10E+01	5.13E+01	5.17E+01	5.20E+01	5.23E+01	5.26E+01	5.29E+01	5.32E+01	5.35E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.75E-41	2.99E-42	5.04E-43	8.38E-44	1.38E-44	2.23E-45	3.57E-46	5.65E-47	8.83E-48	1.36E-48

APPENDIX B

Exerts From References
(Contains 53 pages)

Solubility of Plutonium Compounds and Their Behavior in Soils[1]

Dhanpat Rai, R. J. Serne and D. A. Moore[2]

ABSTRACT

The solubilities of $^{239}PuO_2$ (c) (crystalline) and $^{239}Pu(OH)_4$ (am) (amorphous) under natural environmental conditions were determined. These data were then used to predict the (i) nature of the solid phases present in contaminated soils, and (ii) total concentration of Pu that can be expected in soil solutions when these Pu solids are present.

Based upon solubility measurements, an estimated value of the log K^c (equilibrium constant at room temperature and an approximate ionic strength of 0.0045) for the dissolution of $^{239}PuO_2$(c) [PuO_2(c) $\leftrightharpoons$ PuO_2^+ + e^-] was found to be −14.8. The estimated value of the log K^c for the dissolution of $^{239}Pu(OH)_4$(am) [$Pu(OH)_4$(am) $\leftrightharpoons$ PuO_2^+ + 2 H_2O + e^-] was found to be −12.8.

Comparison of Pu concentration in equilibrium solutions of contaminated Hanford soils with the PuO_2(c) and $Pu(OH)_4$ (am) solubility lines suggested that $Pu(OH)_4$(am) was absent from all the samples and that two of the samples contained PuO_2(c). The presence of PuO_2(c) was also confirmed by X-ray diffraction of Pu particles isolated from one of the samples.

Additional Index Words: **PuO_2(c), $Pu(OH)_4$(am), equilibrium constant, plutonyl (V), oxidation-reduction, redox potential.**

Rai, D., R. J. Serne, and D. A. Moore. 1980. Solubility of plutonium compounds and their behavior in soils. Soil Sci. Soc. Am. J. 44:490–495.

THE SOLID COMPOUNDS of Pu that may be present in soils have a specific solubility at equilibrium in a given weathering environment and could control the final concentration of Pu in the soil solution. The final concentration could, in turn, largely control the distribution of Pu in the environment. Therefore, knowledge of Pu compounds present in the soil and their solubility are necessary in order to predict the behavior or fate of Pu in soil.

Reliable data on the solubility of crystalline Pu oxide [PuO_2(c)] and amorphous Pu hydroxide [$Pu(OH)_4$(am)], the compounds most likely to form in soils at environmental pH and redox potentials, are lacking (13). Based upon thermodynamic data reported in the literature, an uncertainty of at least five orders of magnitude in the solubility of these compounds is expected (14). An extensive review (2, 3) of the actinides indicate that numerous workers have studied Pu concentrations and distribution with depth in soils around nuclear installations. However, with the exception of Price and Ames (12), none have made any attempt to identify the solid phases of Pu present in soils. Price and Ames (12) isolated plutonium particles from contaminated soils and analyzed them with electron microprobe and X-ray diffraction. They were able to isolate and identify discrete particles of Pu as PuO_2(c), but were not able to identify the nature of other Pu compounds associated with soil silicates. The results of Price and Ames (12) are consistent with the theoretical calculations of Rai and Serne (13) who predicted that the PuO_2(c) would be comparatively stable in the pH and redox potential ranges found in terrestrial environments.

Clearly more information is needed regarding the solubility of various Pu compounds and the nature of the solid compounds that may be present in the soils. The objectives of this study were to: (i) determine Pu concentrations in equilibrium with PuO_2(c) and $Pu(OH)_4$(am) under environmental conditions, (ii) identify Pu compounds in contaminated soils, and (iii) provide guidelines for selecting concentrations of Pu for adsorption experiments to assure that Pu precipitation would be negligible or absent.

METHODS AND MATERIALS

The ^{239}Pu(IV) hydroxide used in this study was prepared by rapid neutralization of a pure ^{239}Pu(IV) nitrate solution (8*M* HNO_3) with NaOH (6). The precipitate was washed with distilled water. The Pu(IV) hydroxide thus prepared is represented in this study as $Pu(OH)_4$(am). As expected, the X-ray diffraction pattern of $Pu(OH)_4$(am) indicated it to be an amorphous compound (Table 2). The crystalline $^{239}PuO_2$(c) (99.1% enriched in ^{239}Pu) microspheres were obtained from Oak Ridge National Laboratory, Oak Ridge, Tennessee. A nearly perfect match of the sample's d spacings with the values reported in American Society for Testing and Materials (4) indicated that the PuO_2(c) sample used for this study was indeed crystalline (Table 1). In order to determine solubility, approximately 8 mg of these ^{239}Pu solids were suspended in 20 ml of 0.0015*M* $CaCl_2$ solution. The samples were adjusted to different pH values with HCl or NaOH. The suspensions were equilibrated with air and shaken for various lengths of time. The pH of the suspensions was periodically readjusted (approximately every fifth day) for the first 3 weeks of the experiment. The pH was measured using a glass electrode. The redox potential (E_m) was measured with a platinum electrode (vs. standard calomel electrode corrected to standard hydrogen electrode).

In order to determine the nature of the plutonium compounds present in contaminated soils, three contaminated soil samples (Z9-4-5A; Z9-4-11A; Z12-1D) from two Hanford waste disposal cribs (Z9 and Z12) were used. The samples were washed once with distilled water to remove soluble salts and then equilibrated with 0.0015*M* $CaCl_2$ solution in duplicate. Equilibrations were also carried out with soil only and soil plus 5 mg of PuO_2(c). As in the case of Pu compounds, the suspensions were equilibrated with air and shaken for various lengths of time.

At various times, the suspensions containing Pu compounds and contaminated soils were centrifuged at 6,000*g* for 40 min and a small aliquot of the supernate was withdrawn for Pu analyses. A preliminary analysis of these solutions indicated a wide variation (as high as 30 fold in some cases) in Pu concentrations of duplicate aliquots withdrawn from a sample. This variation was later found to be due to the inability of centrifugation to completely separate the solid particles from the solution. Filtration through (0.1 and/or 0.015 μm) Nuclepore® filters gave consistent analyses of duplicate aliquots and thus presumably removed the fine solid particles. The Pu activity in solutions was determined by alpha counting in a 2π geometry.

The crystallinity of the Pu samples was determined from X-ray diffraction patterns obtained by using Cu $K\alpha$.

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[2] Senior Research Scientist, Staff Scientist, and Technician, respectively.

Table 1—X-ray diffraction data for Pu samples.

d(Å) from different Pu samples†				
Standard	Pu used in study			
PuO_2(c)	PuO_2(c)	$Pu(OH)_4$(am)	Filtered Pu	Soil Pu
3.08	3.118	A	3.13	3.13
2.67	2.696	A	2.71	
1.894	1.909	A	1.919	1.888
1.617	1.627	A	1.631	1.623
1.548	1.559	A		1.552
1.234	1.239	A		1.235
1.203	1.208	A		1.204
1.199	1.103	A		1.098

† Standard PuO_2(c) data ASTM (1966); A = amorphous; filtered Pu = Pu retained by a 0.1-μm membrane used to filter PuO_2(c) suspension no. 20 equilibrated for 90 days (Table 1); soil Pu = Pu separated from contaminated soil Z9-4-11A (1).

RESULTS AND DISCUSSION

Solubility of Pu Compounds

The concentration of Pu in unfiltered and filtered solutions after contact with $^{239}PuO_2$(c) and $^{239}Pu(OH)_4$(am) for 90 days is given in Table 2. The samples passed through 0.1- and 0.015-μm filters do not differ significantly from each other, indicating that discrete Pu particles >0.015 μm and <0.1 μm are absent from solutions. The Pu concentrations in unfiltered samples were generally close to those in the filtered solutions except in a few relatively high pH samples where the concentration in unfiltered solutions was up to three orders of magnitude higher than in the filtered solutions. Discrete particles of Pu were found when several filters employed in filtration were examined with a scanning electron microscope and an electron microprobe. X-ray diffraction patterns of the Pu retained on a 0.1μm membrane (Table 1) used to filter a PuO_2(c) sample indicated it to be a crystalline PuO_2(c). Thus, the difference in Pu concentration between the unfiltered and filtered solutions can be attributed to the incomplete separation of Pu particles from the unfiltered solutions. Therefore, all subsequent samples were filtered before analysis. At the end of the 90-day equilibration, the X-ray diffraction patterns showed that the PuO_2(c) samples were crystalline and $Pu(OH)_4$(am) samples were amorphous, as was the case at the beginning of the experiment. Thermodynamic prediction (13) and literature data (10) indicate that with time $Pu(OH)_4$(am) will crystallize and change to PuO_2(c). However, the equilibration period employed in this study apparently was not long enough for this change to occur to any measurable extent.

Plutonium concentrations in solution in contact with PuO_2(c) and $Pu(OH)_4$(am) for 90, 130, and approximately 250 days are plotted against pH in Fig. 1 and 2. Values for 90, 130, and 250 days are similar, suggesting that equilibrium had been reached after 90 days. The pH of the solutions was observed to continuously decrease with time (Fig. 1 and 2) presumably due to radiolysis of water caused by alpha decay. With this decrease in pH the concentration of Pu has increased proportionally again suggesting that the Pu concentrations have reached equilibrium values at all of the measured pH values. As expected (13), $Pu(OH)_4$(am) maintains a higher Pu concentration in solution at environmental pH values than does PuO_2(c). The solubilities of both PuO_2(c) and $Pu(OH)_4$(am) decrease with increasing pH. Linear relationships exist between the pH and total Pu concentration in solution in equilibrium with the different Pu compounds. These relationships for PuO_2(c) (Eq. [1]) and for $Pu(OH)_4$(am) (Eq. [2]) are:

Table 2—Concentration of Pu in 0.0015*M* $CaCl_2$ solution after contact with $^{239}PuO_2$(c) and $^{239}Pu(OH)_4$(am) for approximately 90 days.

Sample no.	pH	Log Pu (mol/liter) in solution† Unfiltered	Filtered through 0.1 μm	0.015 μm
		Solutions contacting PuO_2(c)‡		
13	3.80	−6.14	−6.17	−6.12
14	3.80	−6.09	−6.08	−6.05
15	4.30	−6.42	−6.60	−6.57
16	4.30	−6.43	−6.43	−6.44
18	5.40	−5.69	−7.28	−7.29
17	5.45	−6.15	−7.46	−7.47
19	7.30	−6.33	−8.70	−8.55
20	7.30	−5.62	−8.71	−8.78
		Solutions contacting $Pu(OH)_4$(am)‡		
21	3.95	−4.40	−4.44	−4.46
22	4.00	−4.54	−4.54	−4.52
5	4.00	−3.90	−4.31	ND
6	4.00	−3.39	−4.22	ND
24	5.00	−5.26	−5.25	−5.25
23	5.05	−5.43	−5.44	−5.47
8	5.25	−4.99	−5.17	ND
7	5.30	−5.19	−5.31	ND
26	6.60	−6.51	−6.77	−6.79
25	6.70	−6.56	−6.83	−6.98
10	6.80	−5.18	−6.63	ND
9	6.83	−5.71	−6.73	ND
27	7.50	−7.43	−7.54	−7.58
28	7.70	−7.19	−7.77	−7.79
12	7.85	−5.21	−7.11	ND

† All solutions were centrifuged at 6,000*g* for 40 min; ND = not determined; the average values of three subsamples counted from each sample are given and the error (one standard deviation) in all the samples was < ±0.06, except in unfiltered PuO_2(c) samples 19 and 20 and $Pu(OH)_4$(am) samples 7 and 9 where the error varied from ±0.13 to ±0.18.

‡ Approximately 8 mg of crystalline PuO_2 or amorphous $Pu(OH)_4$ were shaken with 20 ml of 0.0015*M* $CaCl_2$.

$$\log(Pu_{total}) = (-3.90 \pm 0.10) - (0.64 \pm 0.02)\ pH \quad [1]$$

$$\log(Pu_{total}) = (-1.19 \pm 0.08) - (0.80 \pm 0.01)\ pH \quad [2]$$

where Pu_{total} is in mol/liter. The measured redox potentials (E_m in V) and pH of PuO_2(c) and $Pu(OH)_4$(am) suspensions (Fig. 3) also exhibited a linear correlation as shown in Eq. [3].

$$E_m = (0.727 \pm 0.011) - (0.0545 \pm 0.0008)\ pH. \quad [3]$$

Rai et al. (15) have shown that the solutions in equilibrium with $Pu(OH)_4$(am) contain mainly Pu(V). Their results also strongly suggest the presence of Pu(V) in solutions contacting PuO_2(c). Pu(V) would be expected to be present predominantly as PuO_2^+ in these solutions because (i) the relative tendency of Pu ions to form complexes is Pu(IV) > Pu(III) > Pu(VI) > Pu(V) (7), (ii) the only anion present in these solutions in significant amounts is Cl^-, which does not form significant complexes with PuO_2^+ (13), and (iii) the species PuO_2^+ remains without further hydrolysis between pH zero and pH of approximately 8 (5, 13). Therefore, the Pu_{total} in Eq. [1] and [2] can be replaced with PuO_2^+. Thus Eq. [1] and [2] can now

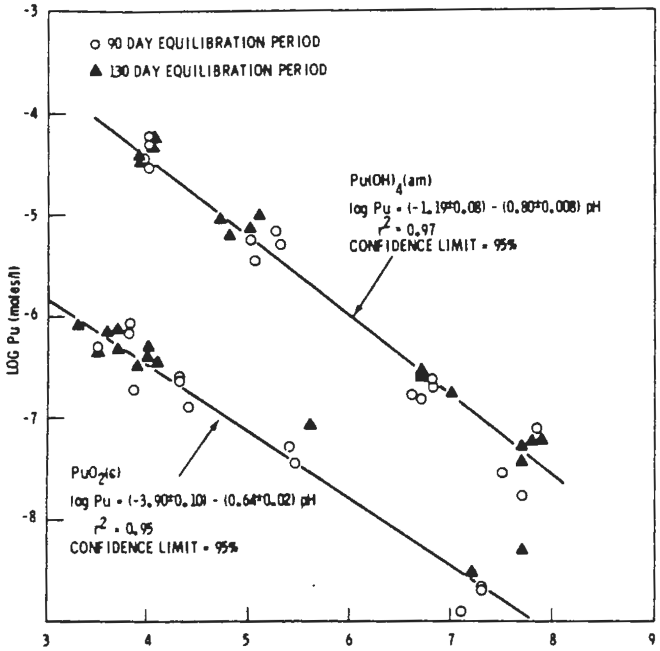

Fig. 1—Concentration of Pu in filtered (0.1 μm) solutions after approximately 90 and 130 days of contact of 0.0015M $CaCl_2$ with $^{239}PuO_2$(c) and $^{239}Pu(OH)_4$(am).

be written as Eq. [4] and [5], respectively.

$$\log (PuO_2^+) = (-3.90 \pm 0.10) - 0.64 \pm 0.02) \text{ pH} \quad [4]$$

$$\log (PuO_2^+) = (-1.19 \pm 0.08) - (0.80 \pm 0.01) \text{ pH}. \quad [5]$$

Estimation of Equilibrium Constants

The solubility of PuO_2(c) and $Pu(OH)_4$(am) is written (Eq. [6] and [7]) in terms of PuO_2^+, because the PuO_2^+ is shown to be the solution species in equilibrium with these compounds (15).

$$PuO_2(c) \rightleftharpoons PuO_2^+ + e^- \quad [6]$$

$$Pu(OH)_4(am) \rightleftharpoons PuO_2^+ + e^- + 2H_2O. \quad [7]$$

The products and reactants in Eq. [6] and [7] are related to the equilibrium constant (K^0) as follows:

$$\log K^0 = \log [PuO_2^+] - pe \quad [8]$$

where [ ] around PuO_2^+ denotes activity and the pe refers to the negative log of the electron activity. The pe is related to the electrochemical potential (Eh in V) (18) by

$$pe = 16.9 \; Eh. \quad [9]$$

For reasons discussed later in this paper, it is inferred that the E_m values are similar to Eh values. Therefore, pe can be calculated from Eq. [9] for its use in estimating the equilibrium constants. Substituting the value of E_m (Eq. [3]) into Eq. [9]

$$pe = (16.9) \; [(0.727 + 0.011) - (0.0545 \pm 0.0008) \text{ pH}]. \quad [10]$$

Substituting Eq. [4] or [5] and Eq. [10] into Eq. [8] and simplifying, the log of the equilibrium concentration constant (log K^c) at room temperature and

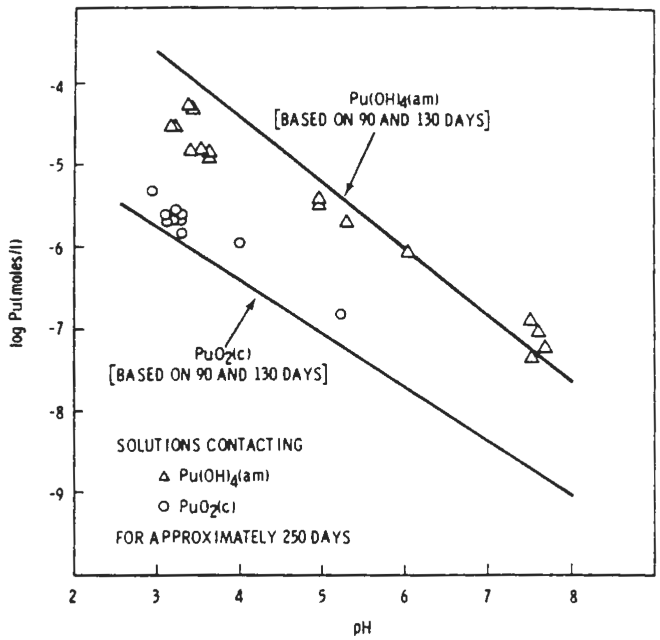

Fig. 2—Concentration of Pu in filtered (0.1 μm) solutions after approximately 250 days of contact of 0.0015M $CaCl_2$ with $^{239}PuO_2$(c) and $^{239}Pu(OH)_4$(am).

low ionic strength ($\simeq$0.0045) for the dissolution of PuO_2(c) according to Eq. [6] can be written as

$$\log K^c = (-16.19 \pm 0.21) + (0.28 \pm 0.02) \text{ pH} \quad [11]$$

and the log K^c for the dissolution of $Pu(OH)_4$(am) according to Eq. [7] can be written as:

$$\log K^c = (-13.48 \pm 0.20) + (0.12 \pm 0.02) \text{ pH}. \quad [12]$$

Equations [11] and [12] hold for a pH range of approximately 4 to 8 (Fig. 1). The errors quoted in Eq. [11] and [12] were calculated using a propagation of errors method described by Mandel (9). Log K^c, at fixed ionic strength and temperature, by definition is a constant. However, log K^c in Eq. [11] and [12] shows a dependence upon pH (approximately 2% deviation per pH unit). This dependence on pH is likely due to experimental errors in measuring PuO_2^+, pH, and E_m. The estimated value of log K^c for

$$PuO_2(c) \rightleftharpoons PuO_2^+ + e^-$$

at the average pH (4.8) value of solutions contacting PuO_2(c) is -14.8. The estimated value of log K^c for

$$Pu(OH)_4(am) \rightleftharpoons PuO_2^+ + 2H_2O + e^-$$

at the average value of pH (5.8) of solutions contacting $Pu(OH)_4$(am) is -12.8. It should be mentioned that the solutions are of low ionic strength ($\simeq$0.005) and thus the concentration equilibrium constant (K^c) is approximately equal to the thermodynamic equilibrium constant (K^0).

A literature review was done in order to compare the equilibrium constants determined in this study with the reported values. A log K^0 for

$$Pu(OH)_4(am) \rightleftharpoons Pu^{4+} + 4 \; OH^- \quad [13]$$

based upon solubility measurements in solutions of pH < 3.5 is reported by Perez-Bustamente (11) to vary

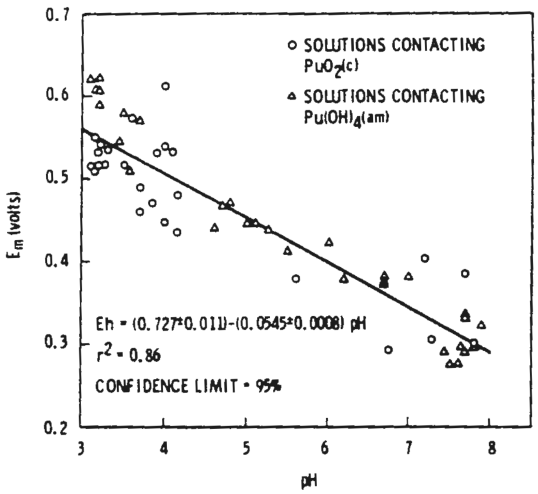

Fig. 3—Relationship of measured redox potential (E_m), with respect to standard hydrogen electrode, and pH of solutions contacting different ^{239}Pu solids.

from −47.3 to −56.3. Baes and Mesmer (5) reported log K^0 for Eq. [13] to vary from −52.0 to −56.0. Smith and Martell (17) selected a value of −47.3 which they believed best represents the log K^0 for this reaction. Clearly, there is wide variation and disagreement in reported values for the solubility product of $Pu(OH)_4$ (am). Based upon the results obtained in the present study, the log K^0 for the solubility product of $Pu(OH)_4$(am) (Eq. [13]) can be estimated in the following manner:

	log K^0	Reference
$Pu(OH)_4(am) \rightleftharpoons PuO_2^+ + 2\,H_2O + e^-$	−12.8	Present study
$PuO_2^+ + 4\,H^+ + e^- \rightleftharpoons Pu^{4+} + 2\,H_2O$	18.6	(8)
$4\,H_2O \rightleftharpoons 4\,H^+ + 4\,OH^-$	−56.0	(16)
$Pu(OH)_4(am) \rightleftharpoons Pu^{4+} + 4\,OH^-$	−50.2	[13]

Assuming the thermodynamic data used in the above equations is correct, an estimated log K^0 of −50.2 for the solubility product of $Pu(OH)_4$(am) is obtained. We prefer to represent the solubility of $Pu(OH)_4$(am) as described by Eq. [7] rather than Eq. [13], because there is a large possibility of error in the thermodynamic data used to derive Eq. [13]. Nevertheless, the estimated solubility product of $Pu(OH)_4$(am) obtained in this study is certainly within the range of values reported.

There are no data available in the literature for the measured solubility constant of PuO_2(c) for comparison with this study. Baes and Mesmer (5) calculated the solubility of PuO_2(c) based upon the thermodynamic data and compared it with the reported log K^0 values (−52 to −56) of the solubility product of $Pu(OH)_4$(am) and found a great difference (approximately 12 log units) between them. They report that such great differences between the precipitated hydrous oxide and the oxide are unusual and suggested that the reported values for PuO_2(c) and/or $Pu(OH)_4$(am) are probably in error by several log units. The difference (2 log units) between the log K^c of PuO_2(c) and $Pu(OH)_4$(am) found in the present study is low as predicted by Baes and Mesmer (5) but is considerably smaller than their estimated difference (8 log units) based upon the extrapolation of log K^0 vs. the reciprocal of the lattice parameters of the actinide dioxides.

Making meaningful redox measurements, hence pe, in unpoised solutions with a platinum electrode is difficult. If reliable values of the equilibrium constant and the PuO_2^+ activity in solution were available, accurate values of pe and/or redox potential could then be calculated from Eq. [8]. The values of redox potential thus calculated for PuO_2(c) and $Pu(OH)_4$(am) suspensions should be similar to each other, as was the case in measured redox potentials (Fig. 3), because the study was conducted using the same isotope of Pu and under similar experimental conditions. Plutonyl (PuO_2^+) concentrations measured in this study were all > $1.0 \times 10^{-9}M$, where accurate measurements of Pu concentration can be made. Baes and Mesmer (5) estimated the log K^0 value of −6.5 for the dissolution of PuO_2(c) (Eq. [14]).

$$PuO_2(c) + 4H^+ \rightleftharpoons Pu^{4+} + 2H_2O. \qquad [14]$$

Perez-Bustamante (11) reported the log K^0 for the solubility product of $Pu(OH)_4$(am) (Eq. [13]) to vary from −47.3 to −56.3. Assuming these reported log K^0 values are correct, redox potentials were calculated using these log K^0 values and the measured PuO_2^+ concentrations in Eq. [8] and [9]. The redox potential thus calculated, E_c, for PuO_2(c) reaction (Eq. [8]) was approximately 0.61 V higher than the E_m. The calculated E_c for $Pu(OH)_4$(am) suspension was found to vary approximately from 0.17 V lower to 0.36 V higher than the E_m. We conclude from these data that the reported value (5) for PuO_2(c) solubility is in error and that the measured E_m may truly represent the equilibrium potential of our suspensions which supports usage of our calculated log K^c values as true equilibrium constants. The specific reasons for this conclusion are: (i) the measured E_m for PuO_2(c) and $Pu(OH)_4$(am) suspensions are similar (Fig. 3) as expected, whereas the E_c for PuO_2(c) and $Pu(OH)_4$(am) are significantly different, (ii) the E_m for $Pu(OH)_4$(am) suspension falls within the range of E_c, (iii) the E_c of PuO_2(c) suspensions fall outside the water stability region, and (iv) the E_c of PuO_2(c) falls in the PuO_2^{2+} stability region, whereas the Pu species in solution were inferred to be PuO_2^+ (13). The measured redox potentials (Fig. 3) appear to be poised. This poising is hypothesized to be due to relatively high concentrations of Pu in the low pH region and/or radiolysis products of water caused by alpha decay. Further studies with the use of redox buffers and solid compounds of different alpha emitting isotopes have been initiated to check these hypotheses.

Identification of Pu Compounds from Contaminated Soils

The presence of Pu compounds in sediments implies that the concentration of Pu in solution will be governed by the solubility of the Pu compounds. Thus, it is important to determine the nature of the solid compounds that may be present in sediment. If no Pu solid compounds are present, sorption reactions alone may govern the concentration of plutonium in solutions.

Large quantities of Pu solids would not be expected

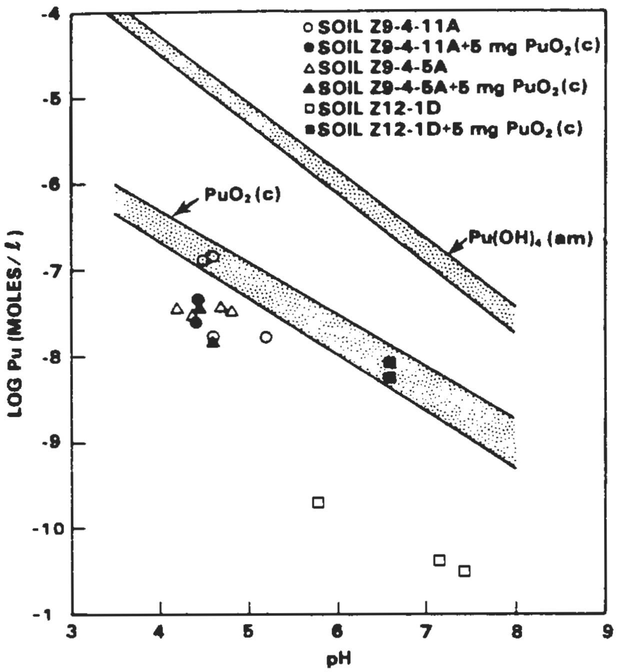

Fig. 4—Concentration of Pu in filtered (0.1 μm) solutions contacting contaminated Hanford soils with different treatments.

to be present in sediments. Therefore, it would be difficult to physically isolate, for identification, the trace amounts of Pu solids that may be present in sediments. It was decided to compare the plutonium concentrations in soil solutions with the experimental solubility of the solid compounds as a means of possibly identifying the plutonium solids that may be present in the sediments.

The soil solution data are plotted in Fig. 4 where experimental solubility lines for PuO_2(c) and $Pu(OH)_4$ (am) are also traced for reference. Soil solution points for soils Z9-4-11A and Z9-4-5A fell very near the PuO_2(c) solubility line; however, the solution points for soil Z12-1D fell considerably below the PuO_2(c) solubility line. When PuO_2(c) was added to these suspensions the solution concentration for Z9-4-11A and Z9-4-5A did not change appreciably. The solution concentration for Z12-1D soil increased considerably and approached that of the PuO_2(c) solubility line. Thus, soils Z9-4-11A and Z9-4-5A appear to contain PuO_2(c) since the soil solution points fell close to the PuO_2(c) solubility line and the soil solution concentration did not change appreciably with the addition of PuO_2(c). The presence of crystalline PuO_2(c) in Z9-4-11A sample, inferred from the solubility data, was confirmed by X-ray diffraction analysis of Pu particles isolated from this sample (Table 1). Concentrations of Pu in solutions containing soil Z12-1D indicate that this soil does not contain PuO_2(c).

The Pu concentration in all the soil solutions studied were much lower than the $Pu(OH)_4$(am) solubility line, indicating that the soils do not contain this compound.

The results presented above help demonstrate the ability of solid compounds to control the solution concentrations. If leaching occurs from Z9-4-11A and Z9-4-5A soils and the leachate percolates into the soils containing no PuO_2(c), the concentration of Pu in solution would be lower than the PuO_2(c) solubility line and would be governed by sorption reactions. On the other hand, Pu concentrations in solutions percolating through PuO_2(c) contaminated sediments would be expected to be similar to the concentrations predicted from the PuO_2(c) solubility line (Fig. 1). Such an event might occur in the immediate vicinity of stored wastes. It is also evident that for the determination of meaningful equilibrium distribution coefficients (*Kd*), in an oxidizing environment, the Pu concentrations must be below the $Pu(OH)_4$(am) solubility line [and preferably below the PuO_2(c) solubility line] (Fig. 1).

Two of the soil samples studied (Z9-4-11A and Z9-4-5A) in this report had received a complex waste with significant amounts of organic ligands with strong potential for forming soluble Pu complexes. However, the observed Pu concentrations are not significantly different than the concentrations present in a dilute PuO_2(c) suspension devoid of organic ligands. It is inferred that the organic ligands originally disposed into these soils have degraded over the period when the wastes were first disposed (approximately 20 years). This inference is supported by the results of Cleveland (J. M. Cleveland, Chief, Transuranium Research Project, USGS, Denver, Colorado, Personal Communication, September 1977) who did not find detectable amounts of organics in Rocky Flats soil that had been contaminated by lathe cooling oil.

LITERATURE CITED

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Influence of an americium solid phase on americium concentrations in solutions

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Abstract—Americium-241 concentrations in solutions contacting contaminated sediments for up to 2 yr were measured as a function of pH. Steady-state concentrations were reached within a few days. The solubility-limited Am concentration was found to decrease approximately 10-fold with one unit increase in pH. The log equilibrium constant for the solubility of $Am_{(soil)}$ solid $[Am_{(soil)} + H^+ \leftrightharpoons Am^+_{(aq.\ complex)}]$ was found to be -4.12. The predictions based upon thermodynamic data suggest that $Am^+_{(aq.\ complex)}$ is likely to be $Am(OH)_2^+$. Although the chemical formula of $Am_{(soil)}$ was not determined, it does not appear to be $Am(OH)_3$(a).

Published data on sorption coefficients of Am by different rocks, soils, and minerals were critically evaluated. Final Am solution concentrations calculated from the sorption coefficients of a variety of earth materials with several solutions agreed well with the concentrations predicted from the solubility of $Am_{(soil)}$ solid, indicating that the sorption coefficient data are controlled by Am precipitation.

INTRODUCTION

AMERICIUM is one of the long-lived actinide waste products of nuclear energy production (SCHNEIDER and PLATT, 1974). To assess possible environmental consequences of storing Am wastes in the lithosphere, the mechanisms governing Am concentration in groundwaters must be known. In recent years many studies have tried to determine the distribution coefficients (K_d)* of Am with a variety of rocks and minerals common to possible geologic repositories (ALLARD *et al.*, 1980; ERDAL, 1979; RELYEA *et al.*, 1979; ROUTSON *et al.*, 1977; SHEPPARD *et al.*, 1976). AMES and RAI (1978) have summarized pre-1978 results on Am K_d experiments. Typically, the reported K_d values have been large (ranging from 100 to 44,000 ml/g) suggesting that Am is highly sorbed by all types of rocks and minerals. However, in most of the Am sorption experiments no attempt was made to either select initial Am concentrations at levels below precipitation limits or to show that precipitation was absent.

Distribution coefficients are meaningful only if precipitation is absent. Precipitation of an Am-solid phase would result in an Am concentration in solution that is controlled by the solubility of the solid phase rather than by sorption reactions. This phenomenon was previously observed in the case of Pu where the maximum Pu concentration in solution contacting Pu-contaminated sediments was controlled by the solubility of a Pu compound (RAI *et al.*, 1980). Therefore, this study was undertaken to determine if the Am concentrations in solutions are controlled by similar solubility constraints and to determine the mechanisms or reactions that can be used to predict Am concentrations in ground waters. Also, due to the high inventory of americium in nuclear wastes, such mechanisms are of vital importance and can be incorporated into geochemical models used to assess the safety of geologic repositories.

* The K_d is defined as the ratio of the equilibrium radionuclide concentration on the solid phase (μCi/g) to the equilibrium concentration of the radionuclide (μCi/ml) in the final solution.

MATERIALS AND METHODS

In the past, liquid radioactive wastes have been disposed in shallow excavated cribs at the Hanford Reservation, Washington. These cribs received a complex waste of Pu and Am. For this study, two contaiminated sediment samples (Z9-4-5A; Z9-4-11A) from the Z9 crib were used. Sediment suspensions (one gram of sediment in 10 ml of solution) had pH values of 3.5–4.3. These contaminated sediment samples were very acidic, even though all the uncontaminated sediments in the Hanford area are alkaline (approximate pH 8). The low pH of these contaminated sediments is most likely due to the acidic nature (approximate pH 2.5) of the liquid waste added to these cribs (AMES, 1976) and may also be due to the oxidation of dissolved nitrogen to HNO_3 by the alpha radiolysis occurring in the wastes (RAI *et al.*, 1981).

The uncontaminated sediments are glaciofluviatile deposits that originated from Columbia River basalt and greenschist facies typical of the Precambrian to Cambrian Belt series (AMES, 1974). The disposal of acidic wastes has altered the crib sediments. These alterations have been discussed by AMES (1974). Two-thirds of the minerals in the contaminated sediments belong to the greenschist facies. These metamorphic minerals include quartz, feldspars including albite, chlorite and hematite. The remaining one-third of the sediment contains minerals of basaltic origin. These include feldspars (labradorite to andesine), augite, glassy high-silica groundmass, and titaniferous magnetite along with minor amounts of apatite, pigeonite, and ilmenite. The sediment samples contain alpha-emitting radionuclides. Because of radiation safety requirements, the analyses are limited to instruments specifically dedicated to alpha-contaminated materials.

The total amounts of ^{241}Am in the contaminated sediments were determined by counting the 60 keV gamma ray on an intrinsic germanium detector (400 mm^2 × 5 mm). Counting samples consisted of 50-ml round-bottomed polypropylene centrifuge tubes, each containing the exact amount (close to one gram) of sediment and 5 ml of H_2O. The tubes were shaken and allowed to settle overnight before counting. Overall efficiency factors were determined by preparing noncontaminated sediment samples in a similar manner after spiking them with aliquots of solution containing a known amount of ^{241}Am.

For the solubility experiments, portions of contaminated sediments were weighed (2 g each) into 50-ml polypropylene centrifuge tubes. These subsamples were then washed with distilled water to remove soluble salts. The washed subsamples were suspended in 20-ml portions of 0.0015 M $CaCl_2$. The pH values of these washed sediment suspensions were adjusted to between 3.5 and 8 using HCl or NaOH. The suspensions were then shaken for a period of approximately 700 days, during which time the pH of the suspensions and the concentrations of soluble Am were determined periodically. The pH of the suspensions was determined by using a combination glass electrode.

To measure the concentration of elements in solution, the solids were separated from solution by filtering the suspensions through 0.015 μm Nucleopore® filters (Nucleopore Corp., Pleasanton, California). RAI *et al.* (1980) have shown that Nucleopore® filters of 0.1 and 0.015 μm pore sizes are more effective in separating suspended solids from solution than centrifugation alone at forces of approximately 6000 *g* for 40 min.

The sediment suspensions were made in 0.0015 M $CaCl_2$. The composition of the equilibrium solution, however, would be influenced by the sediments. Four sediment suspensions, representing a range in pH values (4.35, 5.3, 6.8, and 7.72) and equilibrated for approximately 100 days, were filtered through 0.015 μm membrane filters. The concentration of different elements in these filtrates were determined by neutron activation analysis (LAUL, 1979). In general the concentrations of an element in solutions differing in pH values were similar (Table 1). The increase in Na with the increase in pH is due to the use of NaOH in adjusting pH values. The most abundant elements in solution are Na, Ca, Zn, and Cl.

Sediments were contaminated with ^{239}Pu and ^{241}Am, both of which decay by alpha emission. The alpha energies of ^{239}Pu and ^{241}Am decay are sufficiently different (5.15 MeV and 5.48 MeV, respectively) that surface barrier detectors can be used to measure each isotope. Because alpha counters are generally more efficient than gamma counters, ^{241}Am was counted by alpha spectroscopy. However, Pu wastes generally contain a small fraction of ^{238}Pu which cannot be distinguished from ^{241}Am by surface barrier detectors. Therefore, in 0.015 μm filtrates from a few samples, all Pu was reduced to Pu(III) with $NH_2OH \cdot HCl$, oxidized to Pu(IV) with $NaNO_2$, and extracted with the-

TABLE 1. CONCENTRATIONS OF ELEMENT IN DIFFERENT SOLUTIONS* (0.015 μm FILTRATES) FROM SEDIMENT SUSPENSIONS EQUILIBRATED FOR APPROXIMATELY 100 DAYS

Element	Solution 1	Solution 2	Solution 3	Solution 4
	ppm	ppm	ppm	ppm
Al	31	28	34	34
Ba	2.2	7.4	2.2	4.2
Ca	60	60	60	60
Cl	134	142	140	144
Cr	0.16	0.19	0.12	0.21
Cu	<3	<3	<3	<3
Fe	10.7	11.1	11.4	13.3
Mg	<56	<56	<56	<56
Mn	0.22	0.17	0.18	0.16
Na	34	93	138	189
Ti	3.3	<2.6	<2.6	4.4
V	0.22	<0.04	0.22	0.22
Zn	74	73	86	63
	ppb	ppb	ppb	ppb
Au	1.2	5.2	2.0	4.2
La	10.0	16.6	10.0	12.2
Sc	3.9	4.0	3.3	3.8
Sm	4.2	2.9	3.0	3.4
Th	3.0	2.6	2.8	3.3
	4-5A** ppm	4-11A** ppm		
F^-	9.7 ± 2.2	1.0 ± 0.1		
NO_3^-	3.9 ± 0.4	Nondetectable		
PO_4^{3-}	53.1 ± 24.7	3.2 ± 0.2		
SO_4^{2-}	2.3 ± 0.5	1.4 ± 0.2		

* The pH of Solution 1 = 4.4, Solution 2 = 5.3, Solution 3 = 6.8, and Solution 4 = 7.7; the ionic strength of the solutions was approximately 0.02 M.

** Ion chromatographic analysis of solutions equilibrated for 4 days with 4-5A and 4-11A sediments with pH values of 3.4 and 4.1, respectively.

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noyltrifluoroacetone (MOORE and HUDGENS, 1957). The aqueous phase containing only Am was then analyzed by liquid scintillation counting. Results of Am analysis with and without the removal of Pu from solutions indicated that plutonium removal from solutions did not affect the measured Am concentrations. Thus, no significant amounts of ^{238}Pu were present in these suspensions. Therefore, subsequent analyses for Am were made on 0.015 μm filtrates using surface barrier alpha detectors.

Sorption of Am on tube walls is not expected to control Am behavior in solution, because the results of 4-yr equilibrations show that $< 1\%$ of the total Am activity in each tube was bound to the inner tube surface.

RESULTS AND DISCUSSION

Americium concentrations in solutions contacting subsamples of contaminated sediments (Z9-4-5A and Z9-4-11A) for up to two years are plotted versus pH in Figs 1 and 2. As seen in these figures, values for different time periods are similar, indicating that a steady-state condition had been reached within a few days. The concentration of Am in solution decreases with an increase in pH (Figs 1 and 2). The concentration of Am in solution contacting the Z9-4-5A sediment at any given pH can be estimated from eqn (1), and for the Z9-4-11A sediment from eqn (2).

$$\log \text{Am (mol/l)} = -4.10 - 1.00\,\text{pH} \quad (1)$$

$$\log \text{Am (mol/l)} = -3.54 - 1.11\,\text{pH} \quad (2)$$

The log Am and pH in eqn (1) and (2) are highly correlated as indicated by linear correlation coefficients (r) of >0.96. Using statistical procedures (STEEL and TORRIE, 1960) it was found that the lines described by eqn (1) and (2) are not significantly different from each other. Therefore, data from both sediments were used to derive eqn (3), which describes Am behavior in these sediments. The linear correlation coefficient (r) for eqn (3) was found to be 0.97.

$$\log \text{Am (mol/l)} = -(3.76 \pm 0.24) - (1.07 \pm 0.04)\,\text{pH} \quad (3)$$

No meaningful correlation was found between the changes in concentrations of Am and other cations beside H^+. Of all the cations, only Na^+ was found to increase significantly (Table 1) with the decrease in Am concentration. However, the Na^+ concentration increased by approximately 5-fold while the corresponding average Am concentration decreased by approximately 2000-fold. Thus an ion exchange mechanism relying solely on Na^+ to control the Am concentration is highly unlikely. Following our research reported here, DELEGARD *et al.* (1981) working with contaminated sediments from another Hanford crib also found Am concentrations that are approximately described by eqn (3). Their observed Am concentration in solution did not differ significantly from that calculated by eqn (3) with variations in the sediment-to-solution ratio (0.3–4 g/ml) and concentrations of competing cations (up to 1 M $CaCl_2$ and 0.3 M $Al(NO_3)_3$). Thus, their results also suggest that ion exchange is not the dominant mechanism controlling Am concentration in solution.

If the rate of the dissolution/precipitation reaction that controls the Am concentration is fast and if this is the predominating reaction in most sediments, rocks and soils, then this reaction should determine the maximum concentration of Am possible in the environment. Such a hypothesis also requires that the Am solid phase can be precipitated from constituents

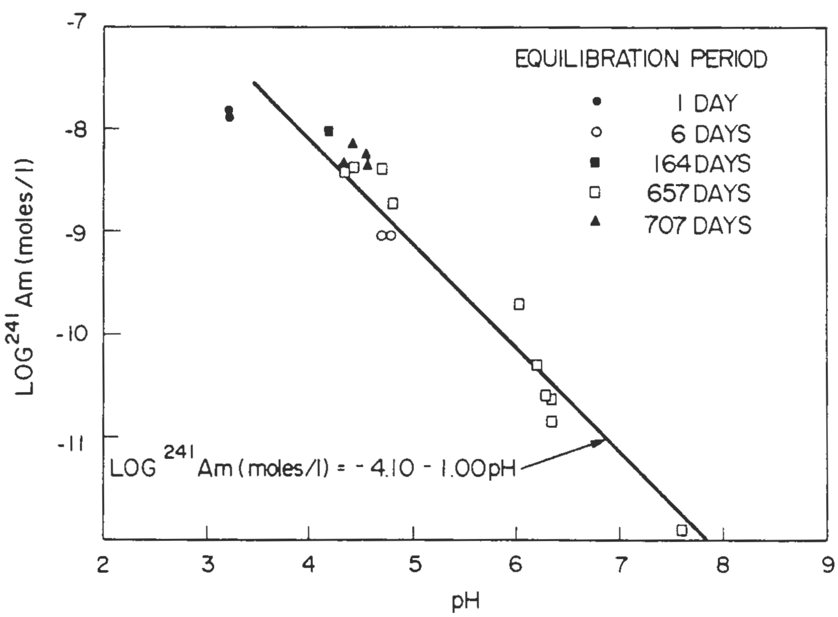

Fig. 1. Effect of pH on Am concentration in solution contacting Z9-4-5A contaminated sediment. Total sampling and counting errors were estimated from triplicate samples and are within the plotted points.

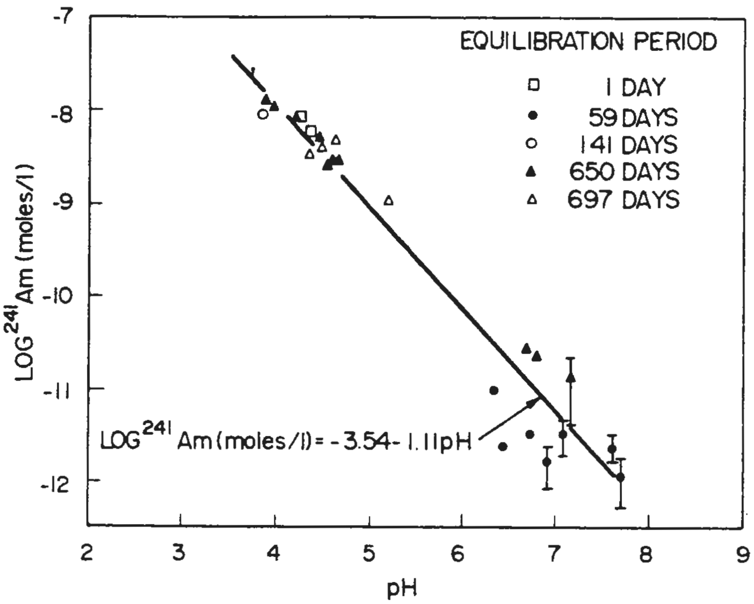

Fig. 2. Effect of pH on Am concentration in solution contacting Z9-4-11A contaminated sediment. Total sampling and counting errors were estimated from triplicate samples and are within the points except where shown by vertical lines.

common to most sediments, rocks, and soils and is not formed from constituents peculiar to the Hanford waste disposal site. To further verify these hypotheses, we recalculated the final solution concentration of Am in K_d experiments with illite that used 0.03 M NaCl, 0.015 M $CaCl_2$, 5.1 M NaCl, and 0.03 M $NaHCO_3$ solutions (RELYEA et al., 1979). The equilibration times in these experiments were under 30 days. The Am concentrations in the NaCl and $CaCl_2$ suspensions were found to be similar to the estimated concentrations determined from eqn (3) as shown in Fig. 3. Although the concentrations of Am in

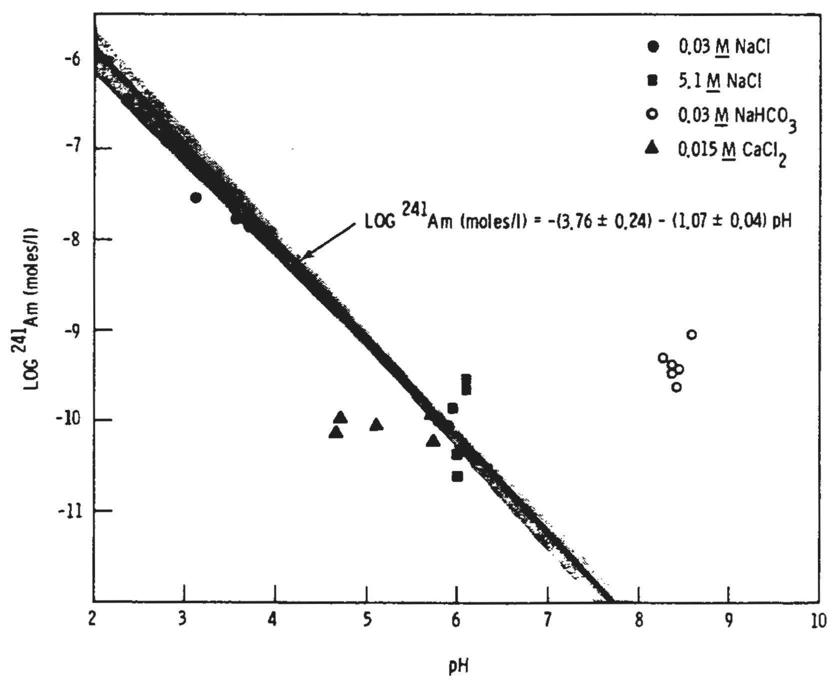

Fig. 3. Comparison of Am concentration in solutions contacting illite (estimated from RELYEA et al., 1979) with the predicted concentration (eqn 3). Shaded area represents 95% confidence limit in the regression line.

illite-$NaHCO_3$ suspensions were all $< 10^{-9}$ M, these concentrations are several orders of magnitude higher than predicted from the contaminated sediment results. Some of the factors that could explain these $NaHCO_3$ suspension data are: (1) incomplete separation of illite, which has large amounts of Am sorbed from the solution (Na at this concentration and pH is a good dispersant for illite); (2) formation of carbonate complexes of Am; and (3) relatively high Am detection limits (minimum detectable concentration was between 10^{-9} and 10^{-10} M). At pH values where the Am concentration falls near or below the detection limits, the third factor will have an overriding influence. To study Am in such a low concentration range, use of different analytical techniques with lower detection limits (such as alpha spectroscopy used in the present study) is necessary.

Because the results on illite (Fig. 3) are for suspensions that were equilibrated for approximately 30 days (in comparison with the Z9-4-5A and Z9-4-11A sediment samples equilibrated for up to 2 yr), we can conclude that the rate of the reaction that limits Am concentration is relatively fast. These results (Fig. 3), which are similar to the results of DELEGARD *et al.* (1981), also show that Na^+ and Ca^{2+} concentrations do not affect the Am concentration and that the maximum Am concentration in these solutions is predictable from eqn (3).

Recently, ALLARD *et al.* (1980) studied the effect of pH and mineral type on Am sorption, using relatively low initial Am concentrations ($\sim 10^{-9}$ M) and low ionic strength solutions. Although ALLARD *et al.* (1980) reported their results as sorption coefficients, we have converted these coefficients into the final Am concentrations in solution. These concentrations are approximate because precise values of different parameters needed for the calculations were not available in their paper. Their results along with the estimated concentration from contaminated sediments (eqn 3) are plotted in Fig. 4. These results are generally similar to Fig. 3 and shows that the maximum concentration of Am in a solution with a pH value of < 6.5 is predicted very well by eqn (3). As was the case in Fig. 3, however, the Am concentrations at pH values > 6.5 appear to be independent of pH, which is in contrast to the Am behavior observed in contaminated sediments (Figs 1 and 2). The factors discussed earlier (incomplete separation of solid from solution, formation of Am-carbonate complex, and detection limits) are the likely reasons for the differences in Am

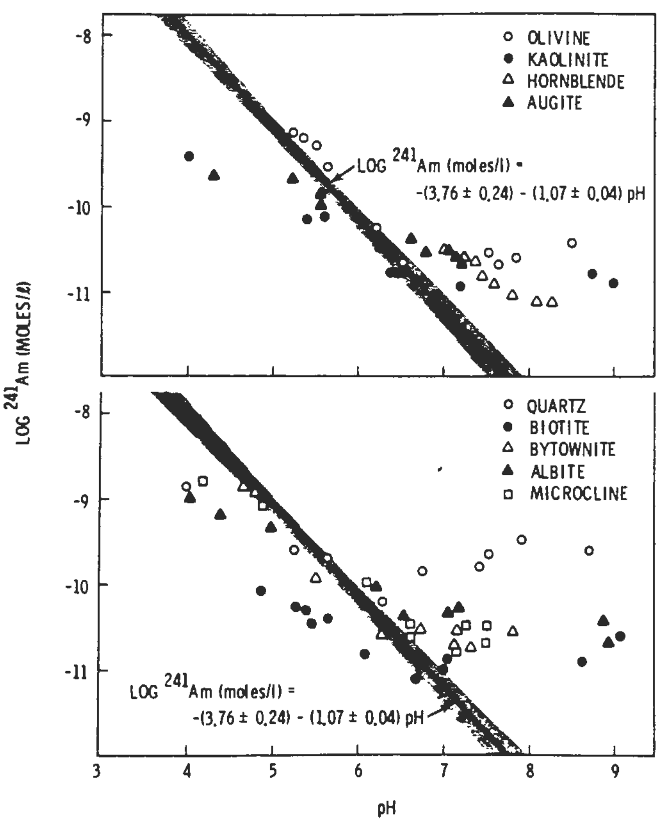

Fig. 4. Comparison of Am concentration in solutions contacting different minerals (estimated from ALLARD *et al.*, 1980) with the predicted concentration (eqn 3). Shaded area represents 95% confidence limit in the regression line.

TABLE 2. COMPARISON OF EXPERIMENTAL AND PREDICTED Am CONCENTRATIONS

Material	Initial log Am (moles/ℓ)	pH	K_d (ml/g)	Log Am (moles/ℓ) Calculated From K_d	Estimated from Eq. [3]	Reference
Argillite	-6.66	8.57	(5400)*	(-13.19)*	-12.91	ERDAL (1979)
Tuff (JA-18)	-6.40	8.44	430	-10.33	-12.77	ERDAL (1979)
Tuff (JA-37)	-6.40	8.64	37000	-12.27	-12.98	ERDAL (1979)
Shale	-7.30	6.8	962(394)**	-9.80(-8.70)**	-11.02	SILVA et al. (1979)
Quartz	-7.30	6.6	1323(12700)**	-9.15(-10.13)**	-10.80	SILVA et al. (1979)
Basalt	-7.30	6.4	1033(14300)**	-9.18(-10.31)**	-10.57	SILVA et al. (1979)
Burbank Soil	-6.75	7.0	1200-8700	-11.09 to -10.23	-11.23	ROUSTON et al. (1977)
S. Carolina Soil	-7.32	5.1	1-67	-9.55 to -7.86	-9.20	ROUSTON et al. (1977)
Muscatine Soil	-7.52	5.3	48309	-13.2	-9.42	SHEPPARD et al. (1979)
Burbank Soil	-7.52	8.1	7143	-12.37	-12.41	SHEPPARD et al. (1979)
Ritzville Soil	-7.52	6.5	9709	-12.51	-10.70	SHEPPARD et al. (1979)
Fuquay Sand	-7.52	5.2	2488	-11.92	-9.31	SHEPPARD et al. (1979)
Hanford Soil	-7.52	8.1	1250	-11.62	-12.41	SHEPPARD et al. (1979)
Idaho Falls Soil	-7.52	8.3	39216	-13.11	-12.62	SHEPPARD et al. (1979)

* The numbers in parentheses are derived from measurements on filtered (0.4 μm) samples.
** The numbers in parentheses are derived from measurements on filtered (0.05 μm) samples.

concentrations observed by ALLARD *et al.* (1980) (Fig. 4) and those observed in contaminated sediments (Figs 1 and 2) at pH values >6.5.

A number of other researchers have also reported on Am sorption by different rocks and soils. In most cases, meaningful treatment of their data in a manner similar to that described above was not possible because of factors such as (1) pH values of 8 or higher where very low concentrations of Am were obtained, (2) pH values either approximate or not reported, (3) initial concentration of added Am either approximate or not reported, (4) large variations in K_d, (5) inadequate methods of separating the solid from solution, or (6) detection limits not reported. However, a few calculations were made from the data reported in the literature (Table 2) just to show that the calculated concentrations are within one or two orders of magnitude of the concentrations predicted from eqn (3). Therefore, these results (Figs 3 and 4, and Table 2) indicate that the final Am concentrations in solutions are limited by a reaction that appears to be common to all the rocks, minerals, soils and sediments.

Knowledge of the mechanisms that control Am concentration in solutions is important. In our experiments with contaminated sediments (Figs 1 and 2), the Am concentration in solutions contacting Z9-4-5A and Z9-4-11A sediments would be 9.5×10^{-7} M and 1.8×10^{-6} M, respectively if all the Am present in the sediments were dissolved. These concentrations are several orders of magnitude higher than the actual solution concentrations observed (Figs 1 and 2); thus most of the Am was present in a solid phase in these experiments. The Am solid phase would amount to approximately 5 μg of Am per gram of contaminated sediment. This presents a major problem in trying to locate physically the specified Am solid phase.

The literature data (Figs 3 and 4, Table 2, DELEGARD *et al.*, 1981) show that regardless of (1) the beginning Am concentrations, (2) the type of the solutions, and (3) the type of sorbing material, the final concentrations of Am in solutions are similar at any given pH, especially where the pH values are <6.5. Furthermore, Am concentrations in the sorption measurement experiments are similar to those in the contaminated sediment experiments. For these reasons it is hypothesized that the concentration of Am in solutions contacting sediments is limited by the solubility of some Am solid phase. Even though Am sorption may occur on solid sorbents or on the container walls, the equilibrium Am concentration will be determined by the solubility of the Am solid phase rather than the sorption reaction as long as an excess of Am solid phase is present.

Whether the Am concentrations are limited by solubility of an Am solid phase or by some undetermined desorption reaction, the Am behavior in these sediments fits the following reaction (not balanced):

$$Am_{(soil)} + H^+ \overset{H_2O}{\rightleftharpoons} Am^+_{(aq.\ complex)}. \quad (4)$$

The value of the log equilibrium constant (K) for eqn (4) was found to be −4.12 and was derived by fitting the data (Figs 1 and 2) to eqn (4) using the least squares method (STEEL and TORRIE, 1960).

In investigating the $Am^+_{(aq.\ complex)}$, predictions based upon the thermodynamic data (APPS *et al.*, 1977) show that solution species of Am(III) are expected throughout the Eh and pH range of environmental importance. To predict the type of aqueous Am(III) species in eqn (4), thermodynamic data summarized by SCHULZ (1976) and that reported by ALLARD *et al.* (1978) were consulted. The value (8.2) of log K_1^c $[(AmOH^{2+})/(Am^{3+})(OH^-)]$ chosen by ALLARD *et al.* (1978) is based upon solvent extraction data of DESIRÉ *et al.* (1969), whereas measurements based upon electrophoresis (MARIN and KIKINDAI, 1969) and more recent measurements based upon electromigration

TABLE 3. EQUILIBRIUM CONSTANTS (K) AT 25°C AND 1 ATM PRESSURE FOR SELECTED SPECIES

Reaction Number	Reaction	Medium	Ionic Strength (μ) M	log K*	Reference
1	$Am^{3+} + OH^- \rightleftharpoons AmOH^{2+}$	NH_4ClO_4	0.005 0	10.7 (10.5)	SHALINETS and STEPANOV (1972) and KOROTKIN (1974a)
2	$Am^{3+} + 2OH^- \rightleftharpoons Am(OH)_2^+$	NH_4ClO_4	0.005 0	20.9 (20.9)	SHALINETS and STEPANOV (1972) and KOROTKIN (1974a)
3	$Am^{3+} + Cl^- \rightleftharpoons AmCl^{2+}$	$HClO_4$	1.0 0	0.01 ± 0.1 (0.9)	SCHULZ (1976)
4	$Am^{3+} + F^- \rightleftharpoons AmF^{2+}$	$NaClO_4$	0.5 0	3.29 (4.27)	AZIZ and LYLE (1969)
5	$Am^{3+} + 2F^- \rightleftharpoons AmF_2^+$	$NaClO_4$	0.5 0	6.11 (7.52)	AZIZ and LYLE (1969)
6	$Am^{3+} + NO_3^- \rightleftharpoons AmNO_3^{2+}$	$HClO_4$	1.0 0	0.2 ± 0.06 (1.12)	SCHULZ (1976)
7	$Am^{3+} + H_2PO_4^- \rightleftharpoons AmH_2PO_4^{2+}$		0	2.51	SILLEN and MARTELL (1971)
8	$Am^{3+} + SO_4^{2-} \rightleftharpoons AmSO_4^+$		0	3.68	SILLEN and MARTELL (1964)

* Values corrected to zero ionic strength are given in parentheses; value of reaction 2 was estimated by SHALINETS and STEPANOV (1972); the values given for reactions 3 and 6 are averages of values stated by three different researchers who are quoted by SCHULZ (1976).

(SHALINETS and STEPANOV, 1972) put the log K_1° values at 11.1 and 10.5, respectively. SHALINETS and STEPANOV (1972) experimentally determined stability constants of hydroxocomplexes $[M(OH)_2^+]$ of Y, Ce, Pm, and Cm. From these values, they estimated the formation constant of $Am(OH)_2^+$ (log K_2° = 20.9). Based upon the distribution chromatography method, KOROTKIN (1974a) mentioned that he obtained values of K_1 and K_2 that were similar to the values reported by SHALINETS and STEPANOV (1972). KOROTKIN (1974a) also states that the difference in K_1 values based upon the solvent extraction (DESIRÉ *et al.*, 1969) and the electromigration methods (MARIN and KIKINDAI, 1969; SHALINETS and STEPANOV, 1972) is due to the suppression of hydrolysis, because of the presence of high ionic strength solutions, in the solvent extraction techniques. The estimated value of the $Am(OH)_2^+$ formation constant by ALLARD *et al.* (1978) is approximately 6 orders of magnitude lower than the value reported by SHALINETS and STEPANOV (1972). Experimental data for the formation constants of $Am(OH)_3^\circ$, $Am(OH)_4^-$ and Am-carbonate species are not available.

The foregoing shows the paucity and variability in existing Am thermodynamic data for some of the important ligands. SCHULZ (1976) and SILLEN and MARTELL (1964, 1971) have summarized the data on formation constants of Am with Cl^-, F^-, NO_3^-, $H_2PO_4^-$, and SO_4^{2-}. These compilations show that experimentally determined formation constants of the above species by several researchers are generally in good agreement with each other. The selected thermodynamic data are given in Table 3.

The activities of the ligands present in significant amounts in solutions contacting Am-contaminated sediments were calculated from data in Table 1 by using the Davies equation (LINDSAY, 1979). These activities in conjunction with the thermodynamic data (Table 3) were used to estimate the relative abundance of different Am solution species (Fig. 5). The lines in Fig. 5 were calculated as though the solid phase was $Am(OH)_3$. It should be recognized that different

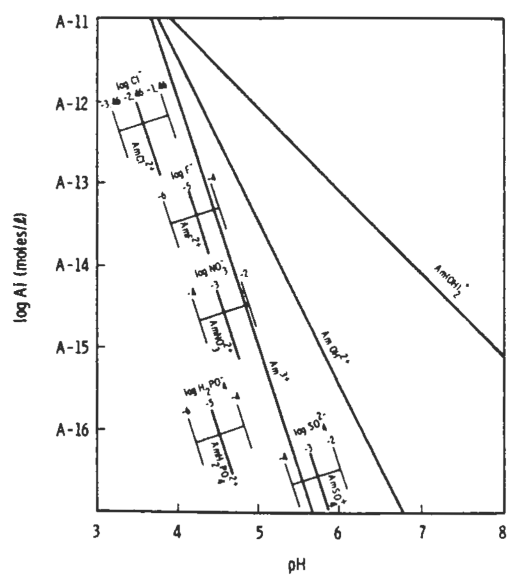

Fig. 5. The activity (Ai) of different Am species, at specified activities of various ligands, in equilibrium with Am(III) hydroxide (log K = A = log Am^{3+} + 3 pH).

solids may give different slopes than those in Fig. 5. Because (1) each solid will have a unique Am^{3+} equilibrium concentration, and (2) all other species (Fig. 5) are in equilibrium with Am^{3+}, the lines for Am(III) species would bear exactly the same proportionality to the Am^{3+} line as shown in Fig. 5. Although $Am(OH)_3^\circ$ or polynuclear Am hydroxy species are not plotted in Fig. 5 because of the lack of thermodynamic data, experimental results of KOROTKIN (1973, 1974a,b) indicate the presence of significant amounts of these species only at pH values >8.5. Other species such as $AmHPO_4^+$, carbonate complexes, and mixed complexes are also not treated because of lack of thermodynamic data. Barring an effect of this limitation, it appears that $Am(OH)_2^+$ is the primary solution species and that the dissolution reaction reported in eqn (4) can now be written as:

$$Am_{(soil)} + H^+ \xrightarrow{H_2O} Am(OH)_2^+ \quad (\log K = -4.12). \qquad (5)$$

To determine the $Am_{(soil)}$ solid phase, the solubility of Am(III) hydroxide ($Am(OH)_3$) was determined. Preliminary results (RAI, RYAN, STRICKERT, MOORE, Battelle Pacific Northwest Laboratory) show the $Am(OH)_3$(a) is approximately 5 orders of magnitude more soluble than $Am_{(soil)}$ indicating that $Am_{(soil)}$ is not $Am(OH)_3$(a). Research is continuing to identify the $Am_{(soil)}$ solid.

In summary eqn (3) [$\log Am(mol/l) = -(3.76 \pm 0.24) - (1.07 \pm 0.04)pH$] can be used to predict the Am concentrations in solutions contacting contaminated sediments from old waste disposal sites and from laboratory contaminated rocks, solids, and minerals. Lithospheric materials (granite, basalt, tuff, salt) that are being considered for high-level waste disposal generally contain alkaline (pH > 7) groundwater. Americium will not be very mobile in this environment because the solubility-limited Am concentration is low and this solution concentration decreases approximately 10-fold for each pH unit increase [eqn (3)]. Because of the possible formation of Am carbonate complexes, eqn (3) may not be directly applicable to high carbonate groundwaters. Care should be taken in applying eqn (3) to surface waters that may contain significant amounts of organic ligands. However, results of CLAYTON *et al.* (1981) indicate that organic ligands, such as humic acid and glycolic acid, do not significantly increase Am concentrations in solutions and that, in some cases, organics may decrease Am concentrations due to complexation with sediment solids.

The log equilibrium constant for the solubility of $Am_{(soil)}$ solid

$$[Am_{(soil)} + H^+ \xrightarrow{H_2O} Am^+_{(aq.\ complex)}]$$

was found to be −4.12. The predictions based upon thermodynamic data suggest that $Am^+_{(aq.\ complex)}$ is likely $Am(OH)_2^+$. Although $Am_{(soil)}$ was not identified, it does not appear to be $Am(OH)_3$(a).

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Mechanisms of Corrosion of Steel in Concrete

ARNOLD ROSENBERG, W. R. Grace and Co.; CAROLYN M. HANSSON, The Danish Corrosion Center; and CARMEN ANDRADE, Instituto Eduardo Torroja de la Construction y del Cemento

No amount of experimentation can ever prove me right;
a single experiment can prove me wrong.

Albert Einstein

Corrosion of reinforcing steel in concrete has become the major cause of failure of modern concrete structures. Successful repair of these structures and the prevention of similar problems in future construction require an understanding of the causes and mechanisms of corrosion. In this chapter, those characteristics of concrete of relevance to reinforcement corrosion are presented first. The basic principles of corrosion science and the main causes of breakdown of the protective qualities are then described. Finally, some comments are given on several parameters of concrete technology which must be taken into account to ensure a reasonably long service life.

Introduction

Good-quality concrete provides excellent protection for steel reinforcement. Chemical protection is provided by concrete's high alkalinity and physical protection is afforded by the concrete acting as a barrier to the access of aggressive species. Presumably because of this excellent protective nature, concrete is generally specified only on the basis of its (28-day) strength with little, if any, regard for its durability. However, despite these inherent protective qualities, corrosion of steel reinforcement has become the most common cause of failure in concrete structures. In such structures as bridges and parking garages, this fact may be attributed in large part to the use of de-icing salts. In other structures, carbonation of the concrete cover and/or salt penetration from sea spray may be responsible for the corrosion. The unexpected rapidity of these effects may, in turn, be due to a number of factors such as incorrect specifications or the lack of control in mixing or placing of the concrete. They may also be due to incorrect use or inadequate knowledge concerning the use of the many cement and concrete additives and replacement materials which have become available in recent years.

The purpose of this chapter is to first present a description of concrete as an electrolyte physically supported by a solid phase, then to briefly summarize those principles of corrosion science of relevance to reinforcement corrosion. Thereafter the two main causes of breakdown of the protective qualities of the concrete are described and, finally, some comments are given on several parameters of concrete technology which must be taken into account to ensure a reasonably long service life.

Concrete As An Electrolyte

In general, the stone and sand constituents of concrete do not play a significant role in the protection or corrosion (no leachable ions) of reinforcing steel. The presence and transport of the corrosion reactants (water, oxygen, and various ions), the corrosion products, and the passage of the ionic current necessary to support corrosion are normally confined to the cement paste phase. It is, therefore, this phase which will be considered here.

The Cement Phase

The composition and hydration of portland cement are described elsewhere in this volume and will not be discussed in detail here. To understand the influence of the cement paste on corrosion, it is sufficient to consider the paste as a two-phase system consisting of the hydrated minerals and a liquid phase–the pore solution. From the point of view of reinforcement corrosion, the controlling parameters are: (1) the composition and quantity of the pore solution; (2) the structure and distribution of the pores, and (3) the presence of the $Ca(OH)_2$ in the hardened paste.

Cement Paste Pore Solution

The composition of the pore solution is the decisive factor in determining whether embedded steel will be passivated or whether it will actively corrode. In recent years, many laboratories have obtained equipment such as that described in Ref. 1 for pressing the solution out of hardened paste, mortar, or concrete and, consequently, a large amount of data is being accumulated on the influence of a number of factors on the composition of the pore solution.[2–4]

These investigations have shown that the highly soluble sodium and potassium salts can give the pore solution of ordinary portland cement a pH of greater than 13 while the pH of blended cements is somewhat lower, as described below. A major application of the technique has been to determine how much of the total chloride content of the cement is present as free chloride ions in the solution and is, therefore, available to attack the iron. Again, the interest has been in how the composition of the cement influences the degree of binding of the chloride ions.

The Structure and Distribution of Pores

The structure, size distribution, and interconnection of pores in the cement phase determine the availability of oxygen and moisture at the steel surface, both of which are necessary for the maintenance of a passive film. They also determine the rate of penetration of chlorides and of carbon dioxide which, as mentioned above, are the two most common culprits in the corrosion of embedded steel.

There are several techniques available for determining the pore-size distribution, those most commonly employed for cement being mercury intrusion porosimetry, vapor adsorption, and vapor desorption. A comparative review of these three techniques is given in Ref. 5. The major disadvantage of the mercury porosimetry and vapor adsorption is that the cement paste must first be thoroughly dried and the drying process alters the pore structure, causing the finer pores to collapse under the capillary forces. Two new techniques which do not suffer from this disadvantage and are also able to determine pore sizes over a considerably wider range than earlier techniques are small-angle neutron scattering[6] and low-temperature calorimetry.[7,8] The results of these two techniques have, independently, been interpreted as showing a clear bimodal distribution of pore sizes corresponding to the gel and capillary pores. It is the capillary pore system which is responsible for the diffusion and permeation processes and, therefore, of importance for corrosion.

The Presence of Calcium Hydroxide

$Ca(OH)_2$ has a very limited solubility in aqueous solutions and the bulk of this hydration reaction product remains as a solid substance embedded in the cement paste. It adds little to the strength of the paste but provides a pH buffer for the pore solution, keeping the solution at a constantly high pH. As described below, the higher the concentration of $Ca(OH)_2$, the longer it takes for a carbonation front to penetrate the concrete cover to the steel surface and the greater the pozzolanic content can be without risk of a significant decrease in pH.

It has been reported[9] that $Ca(OH)_2$ has a second advantageous effect, namely that of precipitating as a coating over the surface of the steel, the pore walls, the mold walls, and so on. This coating of $Ca(OH)_2$ hexagonal platelets constitutes a physical protection of the bars. This is one of the reasons why reinforcement corrosion tests in solutions cannot be simply extrapolated to the real behavior of steel in concrete.

Principles of Corrosion

Electrochemical Process

Corrosion of steel in concrete occurs by an electrochemical reaction.[10] The corrosion process is similar to the action which takes place in a flashlight battery and, as in the case of a battery, the corroding system consists of an anode where electrochemical oxidation takes place, a cathode where electrochemical reduction takes place, an electrical conductor, and an electrolyte (in the case of concrete, this is the cement paste pore solution).

For steel in concrete, the iron is oxidized at the anode (the negative pole) by one of a number of half-cell reactions such as:

$$Fe \rightarrow Fe^{2+} + 2e^- \quad (1)$$

The electrons released at the anode flow through the steel to the cathodic areas, as illustrated in Fig. 1, where they are consumed by the cathodic half-cell reaction. In


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Methods of Steel Corrosion Control and Measurement in Concrete

S. G. EHRLICH AND A. M. ROSENBERG, W. R. Grace & Co.

"Rust Never Sleeps"

Neil Young

The corrosion of steel in concrete is a very costly problem commonly leading to the deterioration of concrete highways, marine structures, bridgedecks, parking garages, and buildings. Several practical methods of reducing the level of corrosion are outlined in this chapter. In order to determine whether or not a specific approach of corrosion prevention is adequate, an effective method of evaluating the level of corrosion is needed. This chapter reviews several techniques used to assess the level of corrosion activity.

Introduction

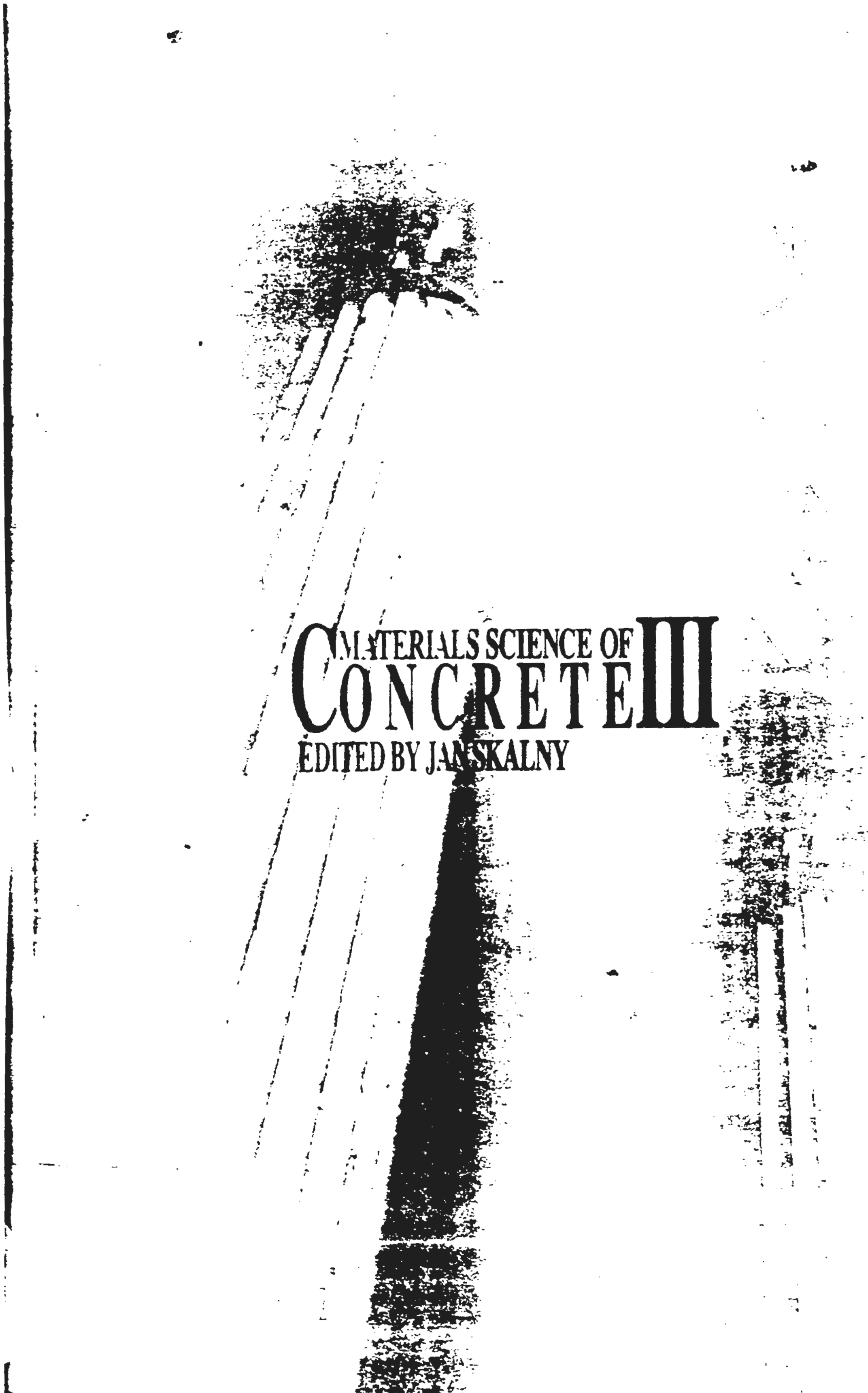
Reinforced concrete is a widely used construction material which possesses many desired performance properties including high strength, durability, low cost, and availability. Concrete can be made to be strong in compression, with compressive strengths of over 150 MPa (typical values of about 40 MPa are usually achieved); however, concrete alone cannot withstand very high tensile stresses (usually only about 10–15% of the compressive strength). Reinforcing concrete with steel produces a composite material which performs well in both compression and tension. Concrete normally provides a protective environment against corrosion of the embedded steel. Good-quality concrete hinders the diffusion of corrosion-inducing species to the metal surface and offers a highly resistive electrolyte which impedes the rate of electrochemical corrosion current flow. In addition, the concrete maintains an alkaline pH, due to the presence of hydroxide ions in the pore solution, which provides the necessary environment to allow the iron to passivate, thus protecting the reinforcing steel from corrosion.

As long as the steel maintains its passive film, the natural tendency of the iron to corrode can be suppressed. However, once this passive film is damaged, corrosion may occur, leading to the production of an iron oxide which may expand to occupy from two to nearly seven times the volume of the original steel. This produces internal tensile forces which can lead to disbondment of the steel from the concrete, and cracking and spalling of the concrete which may result in even greater corrosion since the steel may be left open to the environment.

Many factors can lead to the breakdown of passivation of reinforced steel in concrete, including the ingress of aggressive chloride ions into the concrete, carbonation of the concrete (which lowers the pH of the concrete and alters the passivating conditions), and poor construction practices. Chloride ions can be introduced into the concrete in a number of ways including using sea-dredged aggregates, using chloride-containing admixtures (i.e., calcium chloride as an accelerator), contact of the concrete with salt water, and using chloride-containing deicing salts. If the chloride content in the concrete reaches a high enough concentration, the protective, passive layer on the steel will break down,[1,2] resulting in serious corrosion problems. Corrosion of steel in concrete can also be induced by lowering the originally protective, passivating pH of the pore solution surrounding the steel (which is normally about 12.5), thus bringing the steel into the active region of the Pourbaix diagram,[3] as shown in Fig. 1. The pH is lowered by reaction of the $Ca(OH)_2$ in the pore solution with CO_2 in the air. This is referred to as carbonation:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O \qquad (1)$$

The corrosion of steel reinforcement in concrete bridges, highways, parking garages, and buildings is a very costly concrete durability problem not only in terms of its financial implications but also its structural safety. About half the 500,000 U.S. bridges are in need of structural repair[4] as a result of corrosion. Much can be done to mitigate the deleterious effects of corrosion in concrete, especially during initial construction. This chapter outlines possible methods of corrosion inhibition, and methods of assessing the extent of corrosion activity in concrete. To understand the methods of protecting the reinforcing steel in concrete presented in this chapter, one should first review the mechanisms of the corrosion process which are presented in "Mechanisms of Corrosion of Steel in Concrete," by A. M. Rosenberg et al., in Volume 1 of Materials Science of Concrete.[5]



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Transport of Chemicals Through Concrete

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"What we know is a drop, what we do not know an ocean."
Isaac Newton

This paper deals mainly with the transport of organic fluids through concrete when they come intentionally or by chance into contact with it. After some remarks on the microstructure of hydrated cement paste, the main transport mechanisms, capillary absorption and infiltration, are discussed. Testing arrangements developed in various laboratories are introduced and test results within this rather young field of investigation are presented. The results are discussed, focusing on concrete composition, moisture content, type of fluid, and type of experiment. Finally, research needs appear for a clear understanding of the chemical and physical aspects of the transport phenomena concerned.

Motive and Scope

Chemical products are part of our industrial era. They are beneficial as medicine, fertilizer, plastics, solvents, fuel, and so on. They are dangerous to the health of human beings and animals if not used in the correct doses. Groundwater and soil can be spoiled by poisonous liquids and gases from leaking production, handling, and storage facilities. This is the area where the civil engineer is challenged to design, analyze, execute, and maintain structures in such a way that no material reaches groundwater and soil in concentrations harmful to health.

There are various methods in use to make a structure impervious to fluids. Surface layers of metal, plastic, ceramic tiles, glass plates, and coatings are used, depending on the type of fluid that has to be retained. In the case of water, concrete, clay, and loam are sufficient, as has been demonstrated in dams, pipes,

Transport Mechanisms

Either gas or fluid as a flowing medium is considered as a continuum. Knudsen[8] defined a dimensionless number $Kn = \lambda/L$ (Knudsen number) with λ the mean free path length and L a typical length. This length can be attributed to the pore diameter $2r$. If $Kn < 0.01$, the flowing fluid may be considered as a continuum. When $Kn \approx 1$, it is a slip-flow regime,[9] and when $Kn > 1$, there is Knudsen flow or free molecular flow. The most important contribution to the flow in concrete is in the range $Kn < 0.01$; the other two ranges can be neglected in the present study.

To consider the transport as a continuum process means to study it by macroscopic considerations. The local phenomena, that is, what happens in a real single pore, are not modeled but the average behavior of all pores together is modeled. This macroscopic approach relies upon microscopic observations and theoretical background from physics and chemistry (e.g., the interaction between a liquid and a solid).

The main transport mechanism of a fluid flow in concrete is due to capillary forces and hydrostatic pressure. Gas flow is caused by concentration gradients (or partial pressure gradients) and external pressure. Other sources, such as electrical voltage, are of minor importance. Temperature is implicitly considered since all material coefficients are temperature-dependent.

The flow through a porous medium is proportional to the gradient of the total hydraulic potential. The hydraulic potential is the sum of external forces, such as hydraulic pressure and gravity, and capillary forces.

Assuming a steady state laminar flow, Darcy's law relates the rate of flow dq/dt to the hydraulic pressure gradient dh/dl

$$\frac{dq}{dt} = K \cdot F \frac{dh}{dl} \tag{1}$$

with K the coefficient of permeability and F the cross section exposed to the fluid.

For one-dimensional flow, the advance of a sharp wetting front is given by

$$x(t) = Bt^{1/2} \tag{2}$$

with B the fluid (in the past usually water) penetration coefficient. B is a function of the potential and the interaction of the liquid and the solid. If capillary forces are the only forces, then

$$B = \left(\frac{\sigma \cos\theta r}{2\eta}\right)^{1/2} = \frac{r}{2}\left(\frac{p_c}{\eta}\right)^{1/2} \tag{3}$$

with σ = surface tension, θ = contact angle, r = radius of the cylindrical capillary, η = dynamic viscosity of the fluid, and p_c capillary tension. If a hydraulic pressure p_e acts simultaneously, then

$$B = \frac{r}{2}\left(\frac{p_e + p_c}{\eta}\right)^{1/2} \tag{4}$$

Since most building materials have very narrow pores, the capillary tension is large compared to external forces.

The influence of the external pressure is illustrated by Fig. 5, which shows the ratio between penetration of water with external pressure and without external pressure as a function of capillary radius. It is clear that larger pressure increases the penetration; the more pressure, the larger the capillarity. As far as concrete is concerned, the pores range from nanometers to several micrometers,[5] which means that a pressure of 1 m fluid head should be negligible.

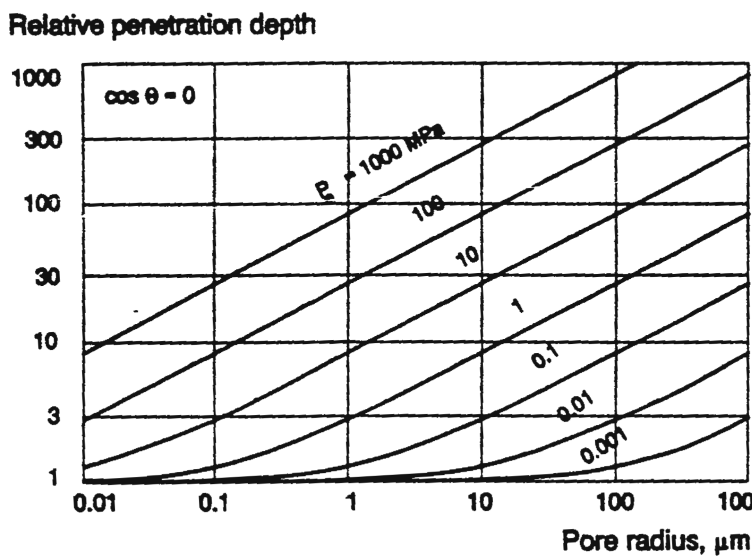

Fig. 5. Influence of external pressure on penetration.

However, there is currently little knowledge about the interaction of arbitrary liquids with concrete, especially with moist concrete. If p_c can be neglected, the penetration coefficient is directly dependent on $(\sigma/\eta)^{1/2}$.

Another quantity is the fluid absorption coefficient A. It links the absorbed mass per unit surface to the absorption time

$$m(t) = At^{1/2} \tag{5}$$

With the porosity ϵ and density of the fluid ρ, it follows

$$A = \epsilon\rho B \tag{6}$$

with the dimensions $kg \cdot m^{-2}\, s^{-1/2}$ for A and $m \cdot s^{-1/2}$ for B. The sorptivity S is A divided by ρ and has the dimension $m \cdot s^{-1/2}$.[10]

The above could be made more general and rigorous if the laws of unsaturated flow were considered.[11,12] Furthermore, the laws governing the simultaneous flow of two liquids—either miscible or not—should be taken into account. These are fields that need more attention in future research.

The diffusion of gases (vapor) through a porous medium can be described by Fick's first law for the steady state and Fick's second law for the unsteady state, which read for the one-dimensional case

$$m = - D \cdot \frac{\partial c}{\partial x} \tag{7}$$

and

$$\frac{\partial c}{\partial t} = D \cdot \frac{\partial^2 c}{\partial x^2} \tag{8}$$

with c = concentration and D = diffusion coefficient. The diffusion coefficient is usually a function of the concentration. Solutions for various initial and boundary conditions are given in Ref. 13. While water vapor and some gases such as methane were investigated in the past, there is almost no data available about the diffusion of vapors of harmful liquids diffusing through concrete. This should also be a field of future research.

Table I. Data of Absorption and Infiltration Tests on Concrete

Fluid	Type of Test*	w/c	Compressive Strength (MPa)	Moist Curing (days)	Age at Testing (days)	Test Duration (days)	Absorbed Fluid (L/m^2)	Sorptivity (mm/d$^{1/2}$)	Penetration Depth (mm)	Penetration Coefficient (mm/d$^{1/2}$)	Ref.	Remarks
n-octane	Inf.	0.6	25	1	28	3			82	47.3	15	
xylene	Inf.	0.6	25	1	28	3			55	31.8	15	
ethyl acetate	Inf.	0.6	25	1	28	3			72	41.6	15	
methyl ethyl ketone	Inf.	0.6	25	1	28	3			77	44.4	15	
chlorobenzene	Inf.	0.6	25	1	28	3			79	45.6	15	
nitrobenzene	Inf.	0.6	25	1	28	3			66	38.1	15	
3-methoxy butanol	Inf.	0.6	25	1	28	3			63	36.4	15	
butyl acetate acetic *n*-butyl ester	Inf.	0.6	25	1	28	3			71	41.0	15	
n-butanol	Inf.	0.6	25	1	28	3			60	34.6	15	
vinyl acetate acetic vinyl ester	Inf.	0.6	25	1	28	3			72	41.6	15	
ethylene glycol	Inf.	0.6	25	1	28	3			25	14.4	15	
methanol	Inf.	0.6	25	1	28	3			37	21.4	15	
sodium chloride, 10% sol.	Inf.	0.6	25	1	28	3			35	20.2	15	
aniline	Inf.	0.6	25	1	28	3			40	23.1	15	
n-butylamine	Inf.	0.6	25	1	28	3			39	22.5	15	
acetone	Inf.	0.6	25	1	28	3			41	23.7	15	
diethylene glycol	Inf.	0.6	25	1	28	3			22	12.7	15	
fuel oil, light	Inf.	0.6	25	1	28	3			54	31.2	15	
water	Inf.	0.6	25	1	28	3			36	20.8	15	
lubricating oil	Inf.	0.5	44	31	140	30	1.02	0.19	34	6.2	18	
triethylene glycol	Inf.	0.5	44	31	140	30	1.27	0.23	37	6.8	18	
diethylene glycol	Inf.	0.5	44	31	140	30	4.46	0.76	29	5.3	18	
lubricating oil	Inf.	0.5	60	31	133	30	0.51	0.09	17	3.1	18	
triethylene glycol	Inf.	0.5	60	31	133	30	1.15	0.21	32	5.8	18	
diethylene glycol	Inf.	0.5	60	31	133	30	2.29	0.42	28	5.1	18	
dichloromethane	Inf.	0.5	50	7	68	3	2.00	1.15	40	23.1	16	

Table I. (Cont'd.)

Fluid	Type of Test*	w/c	Compressive Strength (MPa)	Moist Curing (days)	Age at Testing (days)	Test Duration (days)	Absorbed Fluid (L/m²)	Sorptivity (mm/d$^{1/2}$)	Penetration Depth (mm)	Penetration Coefficient (mm/d$^{1/2}$)	Ref.	Remarks
dichloromethane	Inf.	0.5	53	7	68	3	1.00	0.58	15	8.7	16	special admixture
butanol	Inf.	0.75	26	7	56	7	4.07	1.54	77	29.1	20	
water	Inf.	0.75	26	7	56	7	8.66	3.27	150	56.7	20	
butanol	Inf.	0.57	45	7	44	7	1.40	0.53	18	6.8	20	
water	Inf.	0.57	45	7	44	7	1.66	0.63	50	18.9	20	
butanol	Inf.	0.66	42	3	700	3	7.27	4.20	95	54.8	23	
butanol	Cap.	0.66	42	3	700	3	3.72	2.15	40	23.1	23	
ethyl acetate	Inf.	0.66	42	3	700	3	8.05	4.65	95	54.8	23	
ethyl acetate	Cap.	0.66	42	3	700	3	6.55	3.78	75	43.3	23	
butanol	Inf.	0.66	42	3	700	3	14.48	8.36	125	72.2	23	dried at 105°C
ethyl acetate	Inf.	0.66	42	3	700	3	14.63	8.45	130	75.0	23	dried at 105°C
butanol	Cap.	0.66	42	3	700	3	6.17	3.56	65	37.5	23	dried at 105°C
ethyl acetate	Cap.	0.66	42	3	700	3	13.08	7.55	110	63.5	23	dried at 105°C
n-heptane	Inf.	0.54	48	7	90	3	3.90	2.25			19	
n-heptane	Cap.	0.54	48	7	90	3	3.20	1.84			19	
water	Inf.	0.54	44	7	90	3	3.00	1.73			19	
water	Cap.	0.54	44	7	90	3	2.50	1.44			19	
n-butanol	Cap.	0.68	36	7	121	7	13.00	4.91	105	39.7	21	dried at 105°C
water	Cap.	0.68	36	7	121	7	21.64	8.18	198	74.8	21	dried at 105°C
n-butanol	Cap.	0.61	39	7	107	7	10.18	3.85	85	32.1	21	dried at 105°C
water	Cap.	0.61	39	7	107	7	13.36	5.05	98	37.0	21	dried at 105°C
octanone	Cap.	0.60	46	8	90	3	2.14	1.24	29	16.7	24	
octanone	Cap.	0.30	94	60	90	3	0.49	0.28	8	4.4	24	
pentanone	Cap.	0.60	46	8	90	3	2.22	1.28			24	
pentanone	Cap.	0.30	94	60	90	3	0.41	0.24			24	
n-heptane	Cap.	0.54	48	7	90	3	3.60	2.08	80	46.2	25	
water	Cap.	0.54	48	7	90	3	2.50	1.44	25	14.4	25	
n-heptane	Inf.	0.54	48	7	90	3	4.15	2.40	90	52.0	25	
water	Inf.	0.54	48	7	90	3	2.25	1.30	30	17.3	25	

Table I. (Cont'd.)

Fluid	Type of Test*	w/c	Compressive Strength (MPa)	Moist Curing (days)	Age at Testing (days)	Test Duration (days)	Absorbed Fluid (L/m^2)	Sorptivity ($mm/d^{1/2}$)	Penetration Depth (mm)	Penetration Coefficient ($mm/d^{1/2}$)	Ref.	Remarks
butylacrylate	Inf.	0.38	53	7	68	3	0.27	0.16	12	6.9		special admixture
methacryl acid	Inf.	0.38	53	7	68	3	0.08	0.05	10	5.8		special admixture
2-hydroxyethyl acrylate	Inf.	0.38	53	7	68	3	0.25	0.14	13	7.5		special admixture
2-ethylhexyl acrylate	Inf.	0.38	53	7	68	3	0.19	0.11	12	6.9		special admixture
ethylacrylate	Inf.	0.38	53	7	68	3	0.48	0.28	13	7.5		special admixture
methylmethacrylate	Inf.	0.38	53	7	68	3	0.39	0.22	15	8.7		special admixture
vinyl acetate	Inf.	0.38	53	7	68	3	0.42	0.24	13	7.5		special admixture
methylacryl acid	Inf.	0.37	74	7	68	3	0.12	0.07	22	12.7		
ethyl acrylate	Inf.	0.37	74	7	68	3	0.73	0.42	23	13.3		
vinyl acetate	Inf.	0.37	74	7	68	3	0.39	0.22	15	8.7		
crude oil	Cap.	0.4		7	25	100			33	3.3	26	dried at 105°C
crude oil	Cap.	0.5		7	25	100			30	3.0	26	dried at 105°C
crude oil	Cap.	0.6		7	25	100			28	2.8	26	dried at 105°C

*Inf. = Infiltration
Cap. = Capillary absorption

Table IV. Absorption of Acetone and Water in Concrete After Three Days*

	Concrete				
	1	2	3	4	5
w/c ratio	0.60	0.65	0.65	0.60	0.30
f_{cc} (MPa)	46	53	58	69	94
Volume (mL on 50 cm^2 surface)					
acetone	9	10	8	7	2
water	6	7	5	6	1

*Data from Ref. 24.

Porosity

There are only a few references that supply data on porosity of the concrete. It is an interesting question whether Eq. (6) is valid if the total porosity is implemented in this relation. In Ref. 21, penetration depth and absorbed volume are compared and it appeared that only 3–8 vol% could be filled by butanol if the concrete was stored in an ambient environment and that 12–14 vol% could be filled for an oven-dried concrete. Unfortunately, the total porosity has not been measured but can be estimated to be 15–18 vol%. This means that Eq. (6) has to be used with caution. More research is necessary to investigate the interaction between organic fluid, water, and hydrated cement paste in concrete.

Dynamic Viscosity and Surface Tension

The absorption of a fluid in a porous medium depends on surface tension, dynamic viscosity, and contact angle, as stated by Eq. (3). If all quantities and the pore system of concrete were known, the absorption could be predicted. Since this is not the case, experiments have to be conducted and it can be checked whether a general relation can be confirmed. Test results from Ref. 15 are plotted in Fig. 16 for water-miscible and immiscible fluids and one type of concrete.

Although the scatter is considerable, there is a clear tendency of larger penetration with larger $(\sigma/\eta)^{1/2}$. The correlation is better for fluids that are not miscible with water (numbers 1–10), whereas the miscible fluids deviate the most from the correlation line. This behavior should receive more attention in future research with respect to the interaction of fluid and pore water. It should also be emphasized that the contact angle is assumed to be the same for all fluids, which is certainly not true. But there was no information available about the contact angle of organic fluids and concrete. Looking to Fig. 16, there is the re-

COMPOSITION AND PROPERTIES OF CONCRETE

SECOND EDITION

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ONE
THE NATURE OF THE PROBLEM

1.1 Composition of concrete. Concrete is a composite material which consists essentially of a binding medium within which are embedded particles or fragments of a relatively inert mineral filler. In portland cement concrete the binder or matrix, either in the plastic or in the hardened state, is a combination of portland cement and water; it is commonly called the "cement paste." The filler material, called "aggregate," is generally graded in size from a fine sand to pebbles or fragments of stone which, in some concretes, may be several inches in diameter.

In practical concrete mixtures, the overall proportions of these principal components, the binder and the aggregate, are controlled by the requirements that, (1) when freshly mixed, the mass be workable or placeable, (2) when the mass has hardened, it possess strength and durability adequate to the purpose for which it is intended, and (3) cost of the final product be a minimum consistent with acceptable quality. A diagrammatic representation of the composition of concrete of the proportions used in construction is shown in Fig. 1.1.

The aggregate occupies roughly three-quarters of the space within a given mass. For convenience, particles smaller than about $\frac{3}{16}$ in. in diameter are designated as fine aggregate or sand. Natural coarse aggregates may consist of gravel or crushed stone. Other materials employed as aggregates include slag, cinders, and artificial lightweight aggregates made of burned clay or shale.

The space not occupied by aggregate, roughly one-quarter of the entire volume of an average concrete, is filled with cement paste and air voids. After concrete has been placed, even though it has been compacted with considerable thoroughness, some entrapped air remains within the mass. In a freshly made and compacted concrete of suitable proportions, the volume of unavoidable entrapped air is comparatively small, usually not over 1 or 2 percent. For particular purposes, however, there has developed in recent years the practice of incorporating in the mixture special

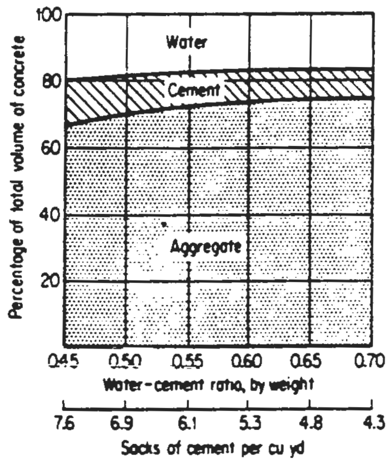


Fig. 1.2. Composition of concrete mixtures of uniform consistency (3 to 4-in. slump).

water content is kept constant, approximately the same consistency is maintained.

From the fact that the water content is practically constant while the cement content varies considerably, it is apparent that the dilution of the paste, expressed, say, as the ratio of water to cement, must be greater for the lean mixes than for the rich ones. Stated in practical terms, it means that as the amount of cement in a mix is reduced, more water must be used per sack of cement, if constant consistency is to be maintained. It is apparent that an intimate relation exists between richness of mix and water-cement ratio in mixes of the same consistency.

In the hardening process, a unit quantity of a particular cement can potentially combine with a specific quantity of water. Thus for a given quantity of cement paste, a paste having a higher water-cement ratio (small percentage of cement) will have a larger volume of potentially uncombined water than will a paste of lower water-cement ratio. Since capillary-pore space derives from uncombined water, the paste in the leaner mixes has a more porous structure than that in the richer mixes.

1.4 Influence of quality of paste upon properties of concrete. The cement paste has been characterized as the active element in concrete. The performance of concrete is largely influenced by the properties of the paste, provided the mineral aggregates are of satisfactory quality. Ordinarily, sound strong aggregates are not difficult to secure.

For a cement of given chemical composition, the strength and porosity of the paste-structure are dependent almost entirely upon the water-cement ratio (see Art. 10.12). So long as plastic workable mixes are used, the lower the water-cement ratio, the greater the strength and water-tightness.

This is true regardless of the richness of mix. Whatever measures of strength are used (compressive, tensile, or flexural strength) the relationships between them and the water-cement ratio are similar [100, 101].[1]

Durability, or resistance to weathering, is a function of both strength and watertightness. The quality of the paste thus has a direct influence upon this important property. This has been shown not only by tests but also by studies of the condition of structures in the field [101].

It is apparent that other properties which are affected by the character of the paste structure will be influenced by the water-cement ratio. For example, the higher the water-cement ratio, the greater the shrinkage of paste due to drying. The volume change of concrete, however, is dependent upon the quantity of paste as well as upon quality of the paste; in some cases the shrinkage due to the effect of increase in water-cement ratio may be offset by the effect of increased quantity of aggregate.

A basis that has been used in the past for selecting a water-cement ratio for a particular job is the compressive strength of concrete. However, even with fairly high water-cement ratios, ample strengths are obtained with most present-day normal portland cements. Hence any limitations that are placed upon the water-cement ratio should also be governed by considerations of resistance to weathering. Recommendations on this basis, for various types of structures and degrees of exposures, have been made available (see Table 6.5 and Ref. 100). In any case, fixing the water-cement ratio gives a measure of control over the potential quality of the concrete.

1.5 Concrete making. The making of concrete is a manufacturing process, even though the plant may often be temporary and the product is made in the field. In many areas, however, concrete is now produced in a central mixing plant and is hauled to the construction site. In any case, the problems of material procurement, of personnel organization, of quality control and economics parallel those of any other manufacturing process. When the plant is temporary, the problems of proper plant layout and widely varying sources of material must be recognized as a part of each job. Furthermore, from a general point of view, because the process of securing a concrete of desired quality is not completed until the concrete structure is finished, each job presents its own peculiar problems of forming, placement, and curing. These considerations call for special experience and judgment on the part of the manufacturer.

An engineer or engineering staff is usually responsible for the technical phases of the process, whether the operating organization is provided by a contractor or by the owner. The engineer must be familiar with the principles of concrete making as well as the art of producing it. He must

[1] Numbers in brackets indicate references listed in Appendix J.

TWO
CONCRETE-MAKING MATERIALS—PORTLAND CEMENT

2.1 Cementing materials. For constructional purposes a cement is a material capable of developing, after appropriate reactions have taken place, those adhesive and cohesive properties that make it possible to bond together mineral fragments to produce a hard continuous compact mass of masonry. There are a variety of cementing materials in use for this purpose; two important classes of such materials are calcareous cements and bituminous binders. The cementing or bonding action of the calcareous cements is attained through a chemical reaction involving lime or lime compounds.

For structures which must sustain and transmit appreciable load and which must offer appreciable resistance to disintegration under a range of adverse conditions of exposure, by far the most important of the cementing materials (except for use in pavements) are the calcareous hydraulic cements. Hydraulic cements have the special property of setting and hardening under water. Key and essential components of these cements are lime and silica. In the presence of water, the lime and silica or lime-silica compounds, react to form ultimately a hardened product containing hydrated calcium silicates.

2.2 Portland cement. For the purposes of this book, the discussion is directed primarily to portland cement, which, of all the hydraulic cements, is in the most widespread use for constructional purposes at the present time. The origin of the name "portland" cement is usually attributed to Joseph Aspdin, a brick mason in England, who in 1824 took out a patent for making artificial stone; he called his product portland cement because the mortar made with it resembled in color the stone which was quarried on the Isle of Portland. The production of material which would approximate the composition and properties of present-day portland cements, however, did not begin in appreciable quantity until the latter part of the nineteenth century.

As manufactured for use in construction work, portland the details of cement manufacture, see Refs. 201, 203, 206. For some historical aspects of cement production, see Refs. 210 to 216.

2.8 Chemical analysis of portland cement. The results of a routine chemical analysis of portland cement are reported in terms of the oxides of the constituent elements [C114]. Table 2.4 indicates the general proportions of the major constituents in the clinker, expressed as oxides, for a range of ordinary commercially made portland cements. It may be noted that these four major constituents account for over 90 percent of the total. Also, it may be noted that the oxide composition varies among the cements represented over a fairly narrow range. However, a relatively small change in composition as indicated by the oxide analysis may result in an appreciable change in the proportions of the actual compounds that make up a cement.

A typical oxide analysis of a type I portland cement is shown in Table 2.5, which includes constituents other than the major ones given in Table 2.4.

The role of the major constituents will be discussed in greater detail in subsequent articles. At this point however, it is pertinent to note the significance of certain other items reported in the usual chemical analysis.

Table 2.4 Major constituents of normal portland cement clinker, in terms of the oxides

Major constituents in terms of the oxides	Percent, by wt	
	Representative average	Approximate range
Lime, CaO	63	60–65
Silica, SiO_2	21	20–24
Alumina, Al_2O_3	6	4–8
Iron, Fe_2O_3	3	2–5

Table 2.5 Typical chemical analysis of a type I portland cement

Principal oxides	Percent, by wt	Other determinations	Percent, by wt
SiO_2	20.67	MgO	2.58
Al_2O_3	5.96	Na_2O	0.12
Fe_2O_3	2.35	K_2O	0.94
CaO	63.62	Loss on ignition	1.37
SO_3	2.13	Insoluble residue	0.26
		Free CaO	1.43

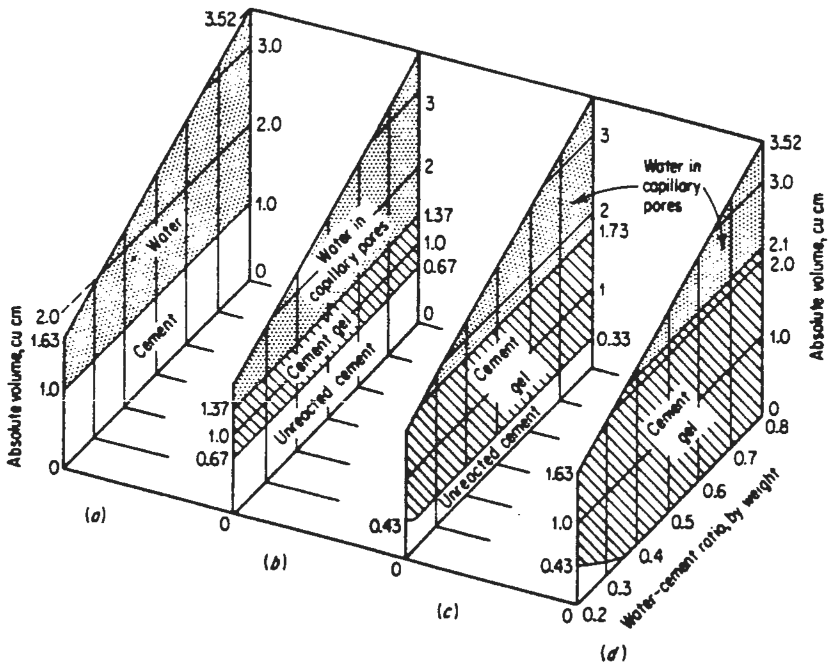


Fig. 2.7. Space relationships for paste components at various stages of hydration. (*a*) Fresh paste; (*b*) reaction one-third complete; (*c*) reaction two-thirds complete; (*d*) reaction completed. Based on concepts in Refs. 230, 236, 245. Assumptions: specific gravity of cement = 3.15. When completely hydrated 1 cu cm of cement produces 2.1 cu cm of cement gel.

Under the assumptions made here, with a paste having a water-cement ratio of 0.35 by weight, the original water-filled space would be completely filled with cement gel at 100 percent hydration, and with pastes having water-cement ratios lower than this, all of the original cement could not be hydrated. There does not appear to be firm evidence as to the exact magnitude of this critical water-cement ratio to permit complete hydration.

It has been estimated that the percent of gel-pore space in cement gel is about 26 to 28 percent [236, 245]. In the range of intermediate water-cement ratios used in ordinary concretes, in which some capillary space would also exist in the cement paste, the porosity of the hardened, fully hydrated cement paste may be 40 to 55 percent.

2.16 Role of paste structure and composition in behavior of concrete. A number of aspects of the behavior of concrete may be predicated from the structure of the hardened cement paste and from the chemical nature of its constituents. Because the basic structure of the hardened paste is a rigid gel with a considerable porosity and a large specific surface, it is capable of holding a substantial quantity of water under the influence of attractive forces of varying degrees of magnitude. It may be expected that the amount of water held within the overall gel structure will vary with humidity (vapor pressure) of the surrounding atmosphere. Some water occupies the capillary-pore space, but a significant amount occupies the gel-pore space. The gain or loss of gel water, by altering the forces within the gel structure, results in expansion or contraction of the paste (and of the concrete in which it may be used). While a part of this volumetric change is reversible, complete drying of the paste results in some volumetric shrinkage that is not recovered by subsequent wetting.

Because of the fine network of interconnected gel pores (and usually also some capillary-pore space, not always interconnected), hardened cement paste is permeable to water. It is to be expected that as hydration proceeds and more of the space between the originally discrete cement grains is filled with cement gel, the permeability will decrease. The permeability of a fully hydrated paste may be of the order of 10^6 times lower than that of a paste only a day or so old. The permeability of a mature paste is comparable to that of fairly dense rocks, such as marble or diorite [236, 245]. Because of the forces induced in water contained in pores of the very small size that exist in cement gel, the flow characteristics of water in such pores are not the same as those of free water [254]. Voids and channels in a concrete mass outside the gel mass per se may, of course, also affect the permeability of concrete.

Because water in the gel pores does not freeze at the same temperature as free water, it may be expected that a paste having a fully developed, dense gel structure will exhibit greater resistance to freezing and thawing than one having a higher volume of water-filled capillary pores. On the other hand, small, non-water-filled air bubbles distributed throughout the mass enhance resistance to freezing and thawing by providing a source of relief to pressures built up by freezing of water in the capillary spaces [252].

The strength of a paste derives in large degree from the bonds formed between the very small particles that compose the cement gel. Generally, the greater the number of such particles and the denser the gel structure, the stronger the gel mass [245]. This is why the ratio of water to cement in the original mix serves as a useful index of potential strength. The amount of pore space (and hence density of paste) that can finally be developed is a function of the initial water content; and the amount of gel that can potentially develop is a function of the relative amount of cement present. Increase in amount of gel, as hydration proceeds, results in increase in strength.

If water is removed from the paste structure, not only is the gel volume decreased, but some of the interparticle attractive forces are increased; thus pastes or concretes tested after drying exhibit greater strength than if they were tested in a fully saturated condition.

Because of the preponderance of lime and lime compounds in cement paste, the paste may be regarded as essentially chemically basic in nature. Hence, exposure to acidic solutions can be expected to cause dissolution and damage to concrete. Even long exposure to chemically pure water can cause lime to be leached, but in a dense concrete, other than superficial reaction is negligible over long periods in pure water.

When certain alumina-bearing compounds are present in the cement of a hardened concrete, its exposure to water containing sulfate ions results in the formation of ettringite, accompanied by a volumetric expansion within the fabric of the hardened paste which can result in disruption of the gel structure. Hence, for concretes that will be exposed to sulfate-containing soils or waters, low C_3A cements (type II or V) are often specified.

The disruption of hardened cement paste that can be caused by delayed hydration of hard burned CaO and MgO has been mentioned in Art. 2.8.

Because CO_2 is present in the atmosphere, under some conditions it may react with the $Ca(OH)_2$ or other lime-bearing compounds in the hardened cement paste. It has been observed that when hardened pastes are exposed to air containing CO_2 at relative humidities ranging from perhaps 35 percent to something less than 100 percent, a decrease in volume occurs that is called "carbonation shrinkage" [203, p. 473]. This shrinkage takes place even though the reaction of CO_2 with $Ca(OH)_2$ gives a product having a volume greater than that of the $Ca(OH)_2$ consumed. The mechanism of this phenomenon is not fully understood; one view that has been postulated is that as the reaction takes place, $Ca(OH)_2$ is dissolved, some of the resulting $CaCO_3$ in solution is deposited elsewhere in the paste structure, and the existing tensile stresses in the gel water cause a decrease in the space previously occupied by the $Ca(OH)_2$ [255]. While surface crazing has been observed to result from carbonation shrinkage, such action is confined to only a very thin layer near the surface and apparently is not harmful to the remaining mass of concrete.

When CO_2 is dissolved in water it produces a weak acid; thus under some circumstances of exposure of paste to CO_2-bearing water, some mild dissolution may be caused.

Compounds of sodium and potassium are usually present in portland cement as minor constituents. These alkalis can react rather strongly with certain silicates in some aggregates, with resultant volumetric expansion and disintegration of a hardened concrete mass. For this reason special steps should be taken to offset this potential reaction if the aggregates to be used contain such silicates. One procedure is to limit the alkali content of the cement to some small amount which experiment and experience has shown has seldom resulted in deterioration. Another procedure is to use a siliceous (pozzolanic) admixture in the concrete mixture that will readily react with both the alkalies and calcium hydroxide during the early stages of the hardening process.

2.17 Specifications requirements for portland cements. Specifications for cement generally include a statement of chemical and physical requirements, methods of testing, limitations on additions, and provisions concerning packaging, marking, storage, and inspection and rejection. Of interest here are the nature of, and reasons for, the chemical and physical requirements.

The principal chemical requirements for the several types of portland cement manufactured under ASTM Specifications are outlined in Table 2.9. The background and implications of these requirements have been discussed in Arts. 2.5, 2.8, and 2.9.

The principal physical requirements of the several types of portland cement manufactured under ASTM Specifications are given in Table 2.10. The usual physical requirements prescribed for acceptance of a cement are concerned with (1) fineness, (2) time of set, (3) soundness, and (4) strength. In addition, for some types of cement, there may be requirements having to do with heat of hydration, false set, and air content of mortar made with the cement. A discussion of the determination of fineness is given in Art. 2.11. Background on the meaning of time-of-set requirements and on false set is given in Art. 2.14. Comments on heat of hydration are given in Art. 2.13. While a basis has been laid for the significance of the soundness test in the discussions of free lime and magnesia in several preceding articles, some summary comments on soundness are pertinent here. Also, some brief comments relative to the strength tests made for acceptance of cement will be made.

Soundness. Unsoundness in (set) cement is caused by undue expansion of some of the constituents, which expansion is manifested by cracking, disruption, and disintegration of the mass. One source of unsoundness in cement is the delayed hydration of free lime incased within the cement particles (see Art. 2.12). A protective film prevents the immediate hydration of the free lime. However, moisture may finally reach the lime after the cement has set, and since lime expands with considerable force when hydrated under restraint, its delayed hydration may disrupt the mass. One advantage of a slow setting cement is that more time is given to hydrate the lime before the mass becomes rigid.

Another possible cause of unsoundness is the presence of too high a magnesia content (see Art. 2.12). Standard specifications limit the magnesia content to 5 percent.

Fine grinding of the raw materials brings them into more intimate contact when burned, so that there is less chance of free lime existing

ELEVEN
PERMEABILITY AND DURABILITY

PERMEABILITY

11.1 Pore structure of concrete. Concrete is inherently porous, as not all the space between the aggregate particles becomes filled with a solid cementing material. To obtain workable mixes it is necessary to use much more water in concrete than is required for hydration of the cement. Furthermore, the absolute volume of the cement and water gradually decreases as chemical combination proceeds, and this makes it impossible for a cement paste of any water-cement ratio to continue to occupy completely the space originally required by the fresh paste; consequenty, the hardened paste develops some voids. In addition, during the mixing of concrete some air is always entrapped in the mass.

As the water and air voids in concrete are generally interconnected, concrete is inherently pervious to water. This is evidenced by its absorption of water by capillary action and by the passage through it of water under pressure. While absorption and permeability may permit disintegrating agencies to damage the concrete or shorten its life, fortunately it is not difficult to obtain concrete that is sufficiently watertight for all practical purposes if materials of good quality are used in proper proportions, if the concrete is well mixed and compacted in place, and if adequate curing is provided.

The porosity of concrete is largely developed during the setting period. Settlement of the solid particles causes the water to rise and form many water channels. Some of the water is trapped below the aggregate particles, and some fills the fine interstices among the cement particles. Hydration of the cement produces a gel which decreases the size of these water voids and increases the watertightness of the concrete (see Art. 2.16) but the voids are never eliminated completely. It is evident that thorough curing is necessary to secure watertight concrete.

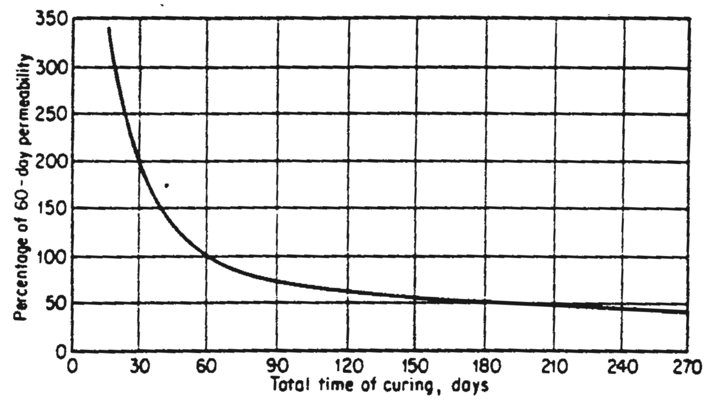


Fig. 11.3. Effect of curing period on permeability. *(From Ruettgers, Vidal, and Wing* [1103].)

though some other materials may be effective, particularly in lean mixes, many produce no beneficial effect. In general, except for pozzolans, the use of extra cement will usually be more effective than the use of other waterproofing admixtures, and the extra cost for an equal effect will usually be less [1100, 1105, 1106].

Water-pressure tests on concrete containing entrained air show that the permeability of concrete is not appreciably affected by entrained air in the percentages ordinarily used on concrete construction if the water-cement ratio remains unchanged [106].

Many surface treatments are effective in reducing leakage through porous concrete when applied to the face subjected to water pressure. The principal ones can be divided into the following classifications:

1. Fabric membranes cemented to the concrete with hot asphalt
2. Asphaltic emulsions
3. Cement plasters, adequately cured
4. Paraffin, silicone compounds, etc. dissolved in volatile solvents
5. Inert fillers in an alkyd resin vehicle

Of these surface treatments the first two are most commonly used when their black color is not objectionable. The other treatments have been most used when a good appearance must be maintained.

11.9 Uniformity of concrete. The permeability test is very sensitive. Minor defects or nonhomogeneous conditions in concrete that would have no appreciable effect on compressive strength influence the leakage through the specimen to a marked degree.

Probably the majority of leaks in concrete structures are due either (1) to defects such as cracks in the structure or (2) to void spaces in the concrete caused by honeycombing or segregation of the constituent materials rather than to inherent porosity of the cement paste or aggregate. To prevent leaks, the mix should be workable so that segregation and honeycomb can be avoided in placing the concrete. The effect of vibratory compaction in reducing the permeability of concrete is shown in Fig .11.4. Care should be taken so that excessive water and laitance do not accumulate at the surfaces of fresh masses and that good bond is obtained between successive lifts. Contraction joints should be designed, if necessary ,with flexible water stops.

11.10 Absorption. Absorption is a physical process by which concrete draws water into its pores and capillaries. In one method of test the concrete is submerged in water for 24 hr, surface-dried, weighed, oven-dried, and weighed again. The difference in the soaked and dry weight is taken as the absorption. It is usually expressed as a percentage of the dry weight. In a second method the concrete is first oven-dried, weighed, boiled in water for 5 hr, cooled in water, and weighed after surface-drying. The percentage absorption is computed as in the first method. The results of these two procedures do not agree, as the loss in weight of a saturated specimen in drying is roughly 5 to 10 percent greater than the absorption after drying [1108].

In both procedures the drying operation withdraws not only the mechanically suspended water but also some of the colloidal water more tenaciously

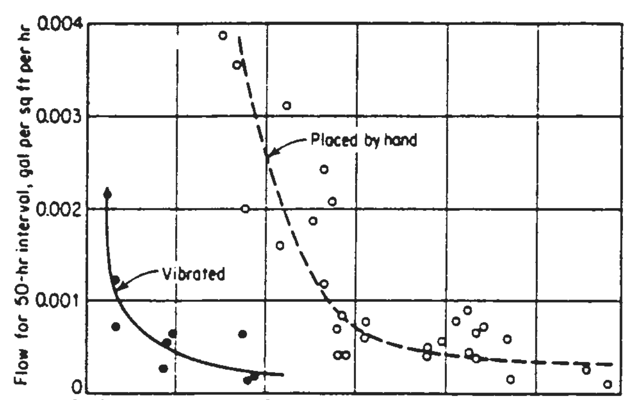


Fig. 11.4. Permeability of hand-placed and vibrated concrete. Slump 2 to 4 in.

held in the cement gel. Hence the absorptions, or porosities indicated by the absorptions, are larger than for the usual temperature-humidity environment of the concrete.

The absorption is considered to be related to the resistance of concrete to weathering, since if no water entered its pores, there would be little or no disintegration caused by freezing or thawing or by aggressive waters. However, actual tests show no reliable correlation of *total* absorption with durability of concrete, but some correlation appears to exist between the *rate* of absorption and durability [110].

DURABILITY

11.11 Deterioration of concrete. The useful life of concrete may be markedly reduced by the disintegrating effects of (1) weathering, including the disruptive action of freezing and thawing and the differential length changes due to temperature variations and alternate wetting and drying, (2) reactive aggregates, (3) aggressive waters in alkali regions, (4) leaching in hydraulic structures, (5) chemical corrosion, and (6) mechanical wear or abrasion. These subjects are covered in some detail in Ref. 1120 by ACI Committee 201.

11.12 Weathering. In severe climates, resistance to weathering is an important consideration. There is, however, no quantitative index or direct laboratory test for weathering resistance. Various accelerated tests to simulate weathering action have been devised; most of these involve alternate cycles of freezing and thawing [1141].

It is considered that the destruction of concrete by freezing is caused by hydraulic pressure developed by the expansion of water when converted to ice, this expansion being about 9 percent. When under pressure, water does not freeze until the temperature is somewhat below the normal freezing temperature of 32°F, but it will freeze even at pressures as great as 30,000 psi provided the temperature drops to about −8°F [1196]. The disruption of concrete by freezing is contingent upon the presence of sufficient water in the void spaces so that high internal pressures will develop, because when the concrete is not sufficiently saturated the expansion of the ice will merely force some of the water into inner voids. Tests have shown that the higher the moisture content of the concrete, the fewer the cycles of freezing and thawing required to rupture the mass, so that when nearly fully saturated an ordinary concrete will disintegrate completely in less than 5 cycles [1141]. But ordinary concrete has many air-filled cavities that cannot readily be filled with water even upon immersion in water. These cavities are entrained air bubbles, pores in the aggregates, and thin fissures under the larger aggregates. The fissures, formed during the period of

APPENDIX C

EXCEL Spreadsheet pusol.xls

Contains copies of worksheets form spreadsheet "pusol.xls":

"Pu solubility" -- 4 pages

"Concreted" -- 2 pages

"Concentrations" -- 5 pages

"Buildup Cal" (file copy) -- 1014 pages
"Buildup Cal" (abbreviated copy) -- 5 pages (i.e., pages 1, 7, 8, 169, 338)

	1 mole			moles/liter	Value	Uncertainty (2*SD)		Value	Uncertainty			Basis
PuO_2	271	g	PuO_2	$[PuO_2]$=	-3.90000	0.10000	"+"	-0.64000	-0.02000	"*"	pH	Rai, Dhanpat, R. J. Serne, & D.A. Moore, "Solubility o Plutonium Compounds and Their Behavior In Soils," Soil Sci. Soc. Am J., Vol. 44, 1980, pg 490-495.
$Pu(OH)_4$	307	g	$Pu(OH)_4$	$[Pu(OH)_4]$=	-1.19000	0.08000	"+"	-0.80000	-0.01000	"*"	pH	
Am	241	g	Am	[Am]=	-3.76000	0.24000	"+"	-1.07000	-0.04000	"*"	pH	Rai, Dhanpat, R. G. Strickert, R. J. Serne, & D.A. Moore, "Influence of an Americium Solid Phase on Americium Concetrations in Solutions," Geochimica et Cosmochimica Acta, Vol 45, 1981, pg 2257-2265.

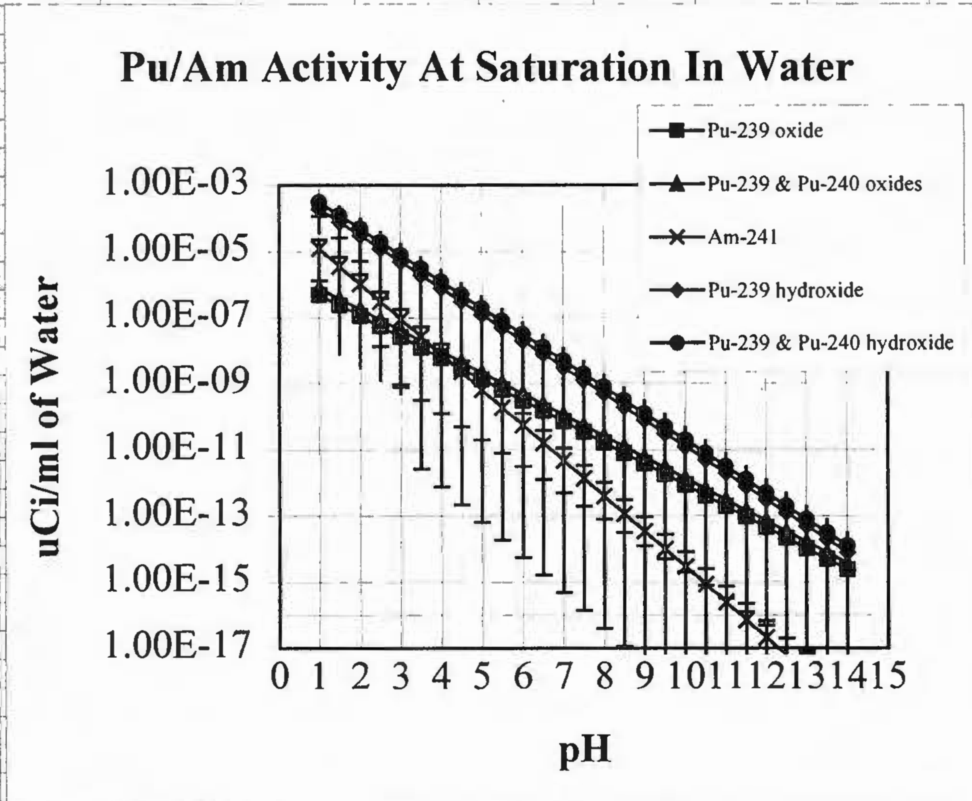
Compound	pH	log K^c		Equilbrium Concentration (moles/liter)		Equilbrium Concentration (g/liter)		Activity (uCi/ml) Pu-239			Pu-239 & Pu-240		
		Value	Uncertainty	Value	Uncertainty	Value	Uncertainty	Value	"+" Uncertainty	"-" Uncertainty	Value	"+" Uncertainty	"-" Uncertainty
PuO_2	1	-4.5400E+00	-5.099E-02	2.88E-05	5.19E-06	7.82E-03	1.41E-03	4.86E-07	1.75E-07	1.75E-07	7.75E-07	1.36E-08	1.36E-08
	1.5	-4.8600E+00	-5.220E-02	1.38E-05	2.54E-06	3.74E-03	6.90E-04	2.33E-07	8.58E-08	8.58E-08	3.71E-07	6.22E-09	6.22E-09
	2	-5.1800E+00	-5.385E-02	6.61E-06	1.26E-06	1.79E-03	3.41E-04	1.11E-07	4.24E-08	4.24E-08	1.77E-07	2.88E-09	2.88E-09
	2.5	-5.5000E+00	-5.590E-02	3.16E-06	6.25E-07	8.57E-04	1.69E-04	5.33E-08	2.11E-08	2.11E-08	8.49E-08	1.35E-09	1.35E-09
	3	-5.8200E+00	-5.831E-02	1.51E-06	3.13E-07	4.10E-04	8.47E-05	2.55E-08	1.05E-08	1.05E-08	4.07E-08	6.36E-10	6.36E-10
	3.5	-6.1400E+00	-6.103E-02	7.24E-07	1.57E-07	1.96E-04	4.25E-05	1.22E-08	5.29E-09	5.29E-09	1.95E-08	3.02E-10	3.02E-10
	4	-6.4600E+00	-6.403E-02	3.47E-07	7.88E-08	9.40E-05	2.14E-05	5.85E-09	2.66E-09	2.66E-09	9.31E-09	1.44E-10	1.44E-10
	4.5	-6.7800E+00	-6.727E-02	1.66E-07	3.97E-08	4.50E-05	1.08E-05	2.80E-09	1.34E-09	1.34E-09	4.46E-09	6.91E-11	6.91E-11
	5	-7.1000E+00	-7.071E-02	7.94E-08	2.00E-08	2.15E-05	5.42E-06	1.34E-09	6.75E-10	6.75E-10	2.13E-09	3.32E-11	3.32E-11
	5.5	-7.4200E+00	-7.433E-02	3.80E-08	1.01E-08	1.03E-05	2.73E-06	6.41E-10	3.40E-10	3.40E-10	1.02E-09	1.60E-11	1.60E-11
	6	-7.7400E+00	-7.810E-02	1.82E-08	5.08E-09	4.93E-06	1.38E-06	3.07E-10	1.71E-10	1.71E-10	4.89E-10	7.70E-12	7.70E-12
	6.5	-8.0600E+00	-8.201E-02	8.71E-09	2.56E-09	2.36E-06	6.94E-07	1.47E-10	8.63E-11	8.63E-11	2.34E-10	3.72E-12	3.72E-12
	7	-8.3800E+00	-8.602E-02	4.17E-09	1.29E-09	1.13E-06	3.49E-07	7.03E-11	4.34E-11	4.34E-11	1.12E-10	1.80E-12	1.80E-12
	7.5	-8.7000E+00	-9.014E-02	2.00E-09	6.47E-10	5.41E-07	1.75E-07	3.36E-11	2.18E-11	2.18E-11	5.36E-11	8.67E-13	8.67E-13
	8	-9.0200E+00	-9.434E-02	9.55E-10	3.25E-10	2.59E-07	8.81E-08	1.61E-11	1.10E-11	1.10E-11	2.57E-11	4.19E-13	4.19E-13
	8.5	-9.3400E+00	-9.862E-02	4.57E-10	1.63E-10	1.24E-07	4.42E-08	7.71E-12	5.49E-12	5.49E-12	1.23E-11	2.02E-13	2.02E-13
	9	-9.6600E+00	-1.030E-01	2.19E-10	8.16E-11	5.93E-08	2.21E-08	3.69E-12	2.75E-12	2.75E-12	5.88E-12	9.78E-14	9.78E-14
	9.5	-9.9800E+00	-1.074E-01	1.05E-10	4.08E-11	2.84E-08	1.11E-08	1.77E-12	1.38E-12	1.38E-12	2.81E-12	4.73E-14	4.73E-14
	10	-1.0300E+01	-1.118E-01	5.01E-11	2.04E-11	1.36E-08	5.53E-09	8.45E-13	6.88E-13	6.88E-13	1.35E-12	2.28E-14	2.28E-14
	10.5	-1.0620E+01	-1.163E-01	2.40E-11	1.02E-11	6.50E-09	2.76E-09	4.04E-13	3.43E-13	3.43E-13	6.44E-13	1.10E-14	1.10E-14
	11	-1.0940E+01	-1.208E-01	1.15E-11	5.08E-12	3.11E-09	1.38E-09	1.94E-13	1.71E-13	1.71E-13	3.08E-13	5.32E-15	5.32E-15
	11.5	-1.1260E+01	-1.254E-01	5.50E-12	2.53E-12	1.49E-09	6.85E-10	9.26E-14	8.53E-14	8.53E-14	1.48E-13	2.57E-15	2.57E-15
	12	-1.1580E+01	-1.300E-01	2.63E-12	1.26E-12	7.13E-10	3.41E-10	4.43E-14	4.24E-14	4.24E-14	7.07E-14	1.24E-15	1.24E-15
	12.5	-1.1900E+01	-1.346E-01	1.26E-12	6.25E-13	3.41E-10	1.69E-10	2.12E-14	2.11E-14	2.11E-14	3.38E-14	5.97E-16	5.97E-16
	13	-1.2220E+01	-1.393E-01	6.03E-13	3.10E-13	1.63E-10	8.41E-11	1.02E-14	1.05E-14	1.02E-14	1.62E-14	2.88E-16	2.88E-16
	13.5	-1.2540E+01	-1.440E-01	2.88E-13	1.54E-13	7.82E-11	4.17E-11	4.86E-15	5.19E-15	4.86E-15	7.75E-15	1.39E-16	1.39E-16
	14	-1.2860E+01	-1.487E-01	1.38E-13	7.64E-14	3.74E-11	2.07E-11	2.33E-15	2.57E-15	2.33E-15	3.71E-15	6.69E-17	6.69E-17

pH	log K^c		Equilibrium Concentration (moles/liter)		Equilibrium Concentration (g/liter)		Activity (uCi/ml) Pu-239			Activity (uCi/ml) Pu-239 & Pu-240		
	Value	Uncertainty	Value	Uncertainty	Value	Uncertainty	Value	"+" Uncertainty	"-" Uncertainty	Value	"+" Uncertainty	"-" Uncertainty
1	-1.9900E+00	-8.040E-01	1.02E-02	4.13E-03	3.14E+00	1.27E+00	1.95E-04	1.58E-04	1.58E-04	3.11E-04	1.96E-04	1.96E-04
1.5	-2.3900E+00	-1.203E+00	4.07E-03	2.05E-03	1.25E+00	6.29E-01	7.78E-05	7.83E-05	7.78E-05	1.24E-04	9.74E-05	9.74E-05
2	-2.7900E+00	-1.602E+00	1.62E-03	9.31E-04	4.98E-01	2.86E-01	3.10E-05	3.56E-05	3.10E-05	4.93E-05	4.43E-05	4.43E-05
2.5	-3.1900E+00	-2.002E+00	6.46E-04	4.05E-04	1.98E-01	1.24E-01	1.23E-05	1.55E-05	1.23E-05	1.96E-05	1.93E-05	1.93E-05
3	-3.5900E+00	-2.401E+00	2.57E-04	1.72E-04	7.89E-02	5.28E-02	4.91E-06	6.57E-06	4.91E-06	7.82E-06	8.17E-06	7.82E-06
3.5	-3.9900E+00	-2.801E+00	1.02E-04	7.18E-05	3.14E-02	2.21E-02	1.95E-06	2.74E-06	1.95E-06	3.11E-06	3.41E-06	3.11E-06
4	-4.3900E+00	-3.201E+00	4.07E-05	2.97E-05	1.25E-02	9.12E-03	7.78E-07	1.13E-06	7.78E-07	1.24E-06	1.41E-06	1.24E-06
4.5	-4.7900E+00	-3.601E+00	1.62E-05	1.22E-05	4.98E-03	3.74E-03	3.10E-07	4.66E-07	3.10E-07	4.93E-07	5.79E-07	4.93E-07
5	-5.1900E+00	-4.001E+00	6.46E-06	4.98E-06	1.98E-03	1.53E-03	1.23E-07	1.90E-07	1.23E-07	1.96E-07	2.37E-07	1.96E-07
5.5	-5.5900E+00	-4.401E+00	2.57E-06	2.02E-06	7.89E-04	6.21E-04	4.91E-08	7.73E-08	4.91E-08	7.82E-08	9.62E-08	7.82E-08
6	-5.9900E+00	-4.801E+00	1.02E-06	8.20E-07	3.14E-04	2.52E-04	1.95E-08	3.13E-08	1.95E-08	3.11E-08	3.90E-08	3.11E-08
6.5	-6.3900E+00	-5.201E+00	4.07E-07	3.32E-07	1.25E-04	1.02E-04	7.78E-09	1.27E-08	7.78E-09	1.24E-08	1.58E-08	1.24E-08
7	-6.7900E+00	-5.601E+00	1.62E-07	1.34E-07	4.98E-05	4.11E-05	3.10E-09	5.11E-09	3.10E-09	4.93E-09	6.36E-09	4.93E-09
7.5	-7.1900E+00	-6.001E+00	6.46E-08	5.39E-08	1.98E-05	1.65E-05	1.23E-09	2.06E-09	1.23E-09	1.96E-09	2.56E-09	1.96E-09
8	-7.5900E+00	-6.400E+00	2.57E-08	2.17E-08	7.89E-06	6.65E-06	4.91E-10	8.28E-10	4.91E-10	7.82E-10	1.03E-09	7.82E-10
8.5	-7.9900E+00	-6.800E+00	1.02E-08	8.71E-09	3.14E-06	2.67E-06	1.95E-10	3.33E-10	1.95E-10	3.11E-10	4.14E-10	3.11E-10
9	-8.3900E+00	-7.200E+00	4.07E-09	3.50E-09	1.25E-06	1.07E-06	7.78E-11	1.34E-10	7.78E-11	1.24E-10	1.66E-10	1.24E-10
9.5	-8.7900E+00	-7.600E+00	1.62E-09	1.40E-09	4.98E-07	4.31E-07	3.10E-11	5.36E-11	3.10E-11	4.93E-11	6.66E-11	4.93E-11
10	-9.1900E+00	-8.000E+00	6.46E-10	5.62E-10	1.98E-07	1.73E-07	1.23E-11	2.15E-11	1.23E-11	1.96E-11	2.67E-11	1.96E-11
10.5	-9.5900E+00	-8.400E+00	2.57E-10	2.25E-10	7.89E-08	6.91E-08	4.91E-12	8.60E-12	4.91E-12	7.82E-12	1.07E-11	7.82E-12
11	-9.9900E+00	-8.800E+00	1.02E-10	9.01E-11	3.14E-08	2.77E-08	1.95E-12	3.44E-12	1.95E-12	3.11E-12	4.28E-12	3.11E-12
11.5	-1.0390E+01	-9.200E+00	4.07E-11	3.61E-11	1.25E-08	1.11E-08	7.78E-13	1.38E-12	7.78E-13	1.24E-12	1.71E-12	1.24E-12
12	-1.0790E+01	-9.600E+00	1.62E-11	1.44E-11	4.98E-09	4.43E-09	3.10E-13	5.51E-13	3.10E-13	4.93E-13	6.86E-13	4.93E-13
12.5	-1.1190E+01	-1.000E+01	6.46E-12	5.77E-12	1.98E-09	1.77E-09	1.23E-13	2.20E-13	1.23E-13	1.96E-13	2.74E-13	1.96E-13
13	-1.1590E+01	-1.040E+01	2.57E-12	2.31E-12	7.89E-10	7.08E-10	4.91E-14	8.81E-14	4.91E-14	7.82E-14	1.10E-13	7.82E-14
13.5	-1.1990E+01	-1.080E+01	1.02E-12	9.22E-13	3.14E-10	2.83E-10	1.95E-14	3.52E-14	1.95E-14	3.11E-14	4.38E-14	3.11E-14
14	-1.2390E+01	-1.120E+01	4.07E-13	3.68E-13	1.25E-10	1.13E-10	7.78E-15	1.41E-14	7.78E-15	1.24E-14	1.75E-14	1.24E-14

Compound	pH	log K^c		Equilbrium Concentration (moles/liter)		Equilbrium Concentration (g/liter)		Am-241 Activity (uCi/ml)		
		Value	Uncertainty	Value	Uncertainty	Value	Uncertainty	Value	"+" Uncertainty	"-" Uncertainty
Am	1	-4.8300E+00	-0.1216553	1.48E-05	6.59E-06	3.56E-03	1.59E-03	1.22E-05	1.09E-05	1.09E-05
	1.5	-5.3650E+00	-0.1236932	4.32E-06	1.96E-06	1.04E-03	4.72E-04	3.57E-06	3.24E-06	3.24E-06
	2	-5.9000E+00	-0.1264911	1.26E-06	5.85E-07	3.03E-04	1.41E-04	1.04E-06	9.68E-07	9.68E-07
	2.5	-6.4350E+00	-0.13	3.67E-07	1.76E-07	8.85E-05	4.23E-05	3.04E-07	2.91E-07	2.91E-07
	3	-6.9700E+00	-0.1341641	1.07E-07	5.30E-08	2.58E-05	1.28E-05	8.87E-08	8.78E-08	8.78E-08
	3.5	-7.5050E+00	-0.1389244	3.13E-08	1.61E-08	7.53E-06	3.87E-06	2.59E-08	2.66E-08	2.59E-08
	4	-8.0400E+00	-0.1442221	9.12E-09	4.88E-09	2.20E-06	1.18E-06	7.55E-09	8.08E-09	7.55E-09
	4.5	-8.5750E+00	-0.15	2.66E-09	1.49E-09	6.41E-07	3.58E-07	2.20E-09	2.46E-09	2.20E-09
	5	-9.1100E+00	-0.156205	7.76E-10	4.53E-10	1.87E-07	1.09E-07	6.43E-10	7.50E-10	6.43E-10
	5.5	-9.6450E+00	-0.1627882	2.26E-10	1.38E-10	5.46E-08	3.33E-08	1.87E-10	2.29E-10	1.87E-10
	6	-1.0180E+01	-0.1697056	6.61E-11	4.23E-11	1.59E-08	1.02E-08	5.47E-11	7.00E-11	5.47E-11
	6.5	-1.0715E+01	-0.1769181	1.93E-11	1.29E-11	4.65E-09	3.11E-09	1.60E-11	2.14E-11	1.60E-11
	7	-1.1250E+01	-0.1843909	5.62E-12	3.95E-12	1.36E-09	9.51E-10	4.66E-12	6.54E-12	4.65E-12
	7.5	-1.1785E+01	-0.1920937	1.64E-12	1.21E-12	3.95E-10	2.91E-10	1.36E-12	2.00E-12	1.36E-12
	8	-1.2320E+01	-0.2	4.79E-13	3.68E-13	1.15E-10	8.88E-11	3.96E-13	6.10E-13	3.96E-13
	8.5	-1.2855E+01	-0.2080865	1.40E-13	1.12E-13	3.37E-11	2.71E-11	1.16E-13	1.86E-13	1.16E-13
	9	-1.3390E+01	-0.2163331	4.07E-14	3.43E-14	9.82E-12	8.26E-12	3.37E-14	5.68E-14	3.37E-14
	9.5	-1.3925E+01	-0.2247221	1.19E-14	1.05E-14	2.86E-12	2.52E-12	9.84E-15	1.73E-14	9.84E-15
	10	-1.4460E+01	-0.2332381	3.47E-15	3.19E-15	8.36E-13	7.68E-13	2.87E-15	5.27E-15	2.87E-15
	10.5	-1.4995E+01	-0.2418677	1.01E-15	9.70E-16	2.44E-13	2.34E-13	8.37E-16	1.61E-15	8.37E-16
	11	-1.5530E+01	-0.2505993	2.95E-16	2.95E-16	7.11E-14	7.11E-14	2.44E-16	4.89E-16	2.44E-16
	11.5	-1.6065E+01	-0.2594224	8.61E-17	8.97E-17	2.07E-14	2.16E-14	7.13E-17	1.49E-16	7.13E-17
	12	-1.6600E+01	-0.2683282	2.51E-17	2.73E-17	6.05E-15	6.57E-15	2.08E-17	4.51E-17	2.08E-17
	12.5	-1.7135E+01	-0.2773085	7.33E-18	8.28E-18	1.77E-15	2.00E-15	6.07E-18	1.37E-17	6.07E-18
	13	-1.7670E+01	-0.2863564	2.14E-18	2.51E-18	5.15E-16	6.05E-16	1.77E-18	4.16E-18	1.77E-18
	13.5	-1.8205E+01	-0.2954657	6.24E-19	7.62E-19	1.50E-16	1.84E-16	5.16E-19	1.26E-18	5.16E-19
	14	-1.8740E+01	-0.3046309	1.82E-19	2.31E-19	4.39E-17	5.56E-17	1.51E-19	3.82E-19	1.51E-19

Radionclide	At Wt	Half-life (yr) (ICRP-38)	SpA (Ci/g)	Basis
Pu-239	239	24065	0.0622095	
Pu-240	240	6537	0.2280608	From Radiolgical Health Handbook
Am-241	241	432.2	3.4350933	

Ratios			
Ratio	Mass	Activity	Refence
Pu-240 /Pu-239	0.0607	0.222527	SAND78-1850
Am-241 /Pu-239		10	



Concrete Depth versus Ph		
Depth (cm)	pH	Basis
0.2	>7	Troxell, et al, "Composition and Properties of Concrete," pg 48; Skalny, Jan, "Material Science of Concrete I," pg 287; & Skalny, Jan and Sidney Miness, "Material Science of Concrete II," pg 202.
0.2	12.5	

Materials Fraction in Concrete					
Material	Wt% Bound		Vol% Bound		Basis
	Upper	Lower	Upper	Lower	
H_20	10.1	7.5	20.3	16	Table 51.71, Tipton, C. R. Jr., "Reactor Handbook Volume I, Materials," pg 1075.
Portland Cement	19.8	15	26.5	21.4	
Sand	77.5	70.1	62.6	53.2	
Density	2.25	2			Table 51.69, Tipton, C. R. Jr., "Reactor Handbook Volume I, Materials," pg 1075.

Pentration		
x(t)=	B $(mm/d^{1/2})*t^{1/2}$ days	Eqn 2, Skalny, Jan, "Material Science of Concrete III," pg 215
B=	56.7	Table I, Skalny, Jan, "Material Science of Concrete III," pg 224

Depth (cm)	Time (days)	Activity (uCi/g concrete)@ Pu-239	Pu-239 /Pu-240	Am-241	Pu form	"@ Assumes water is saturated with radionuclide.		
0.2	1.244E-05	7.10E-10	1.13E-09	4.70E-11	oxide	velocity		
5.67	1	1.25E-12	1.98E-12	4.70E-11	hydroxide	5.470068059	112	0.299669981
8.018591	2	1.25E-12	1.98E-12	4.70E-11	hydroxide	2.348590899	111	0.301358302
9.820728	3	1.25E-12	1.98E-12	4.70E-11	hydroxide	1.80213718	110	0.303075485
11.34	4	1.25E-12	1.98E-12	4.70E-11	hydroxide	1.519271921	109	0.304822362
12.67851	5	1.25E-12	1.98E-12	4.70E-11	hydroxide	1.338505432	108	0.306599797
13.88861	6	1.25E-12	1.98E-12	4.70E-11	hydroxide	1.210101409	107	0.308408692
15.00141	7	1.25E-12	1.98E-12	4.70E-11	hydroxide	1.112803092	106	0.310249987
16.03718	8	1.25E-12	1.98E-12	4.70E-11	hydroxide	1.035771864	105	0.312124661
17.01	9	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.972818203	104	0.314033733
17.93011	10	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.920114333	103	0.31597827
18.80526	11	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.875148228	102	0.317959384
19.64146	12	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.836193597	101	0.319978234
20.44348	13	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.802019574	100	0.322036036
21.2152	14	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.771721651	99	0.324134057
21.95982	15	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.74461819	98	0.326273625
22.68	16	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.720184427	97	0.32845613
23.37801	17	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.698008897	96	0.330683028
24.05577	18	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.677763799	95	0.332955844
24.71496	19	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.659184314	94	0.335276178
25.35701	20	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.642053855	93	0.337645709
25.9832	21	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.626193326	92	0.340066202
26.59466	22	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.611453168	91	0.342539508
27.19236	23	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.597707379	90	0.345067578
27.77721	24	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.584848946	89	0.347652462
28.35	25	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.572786317	88	0.350296321
28.91144	26	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.561440642	87	0.353001433
29.46218	27	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.550743595	86	0.355770199
30.00282	28	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.540635631	85	0.358605156
30.53388	29	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.531064589	84	0.361508983
31.05587	30	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.521984554	83	0.364484516
31.56922	31	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.513354927	82	0.367534756
32.07436	32	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.505139657	81	0.37066288
32.57167	33	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.497306611	80	0.373872262
33.0615	34	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.489827038	79	0.377166482
33.54417	35	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.482675126	78	0.380549344

34.02	36	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.47582763	77	0.384024897	
34.48926	37	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.469263547	76	0.387597453	
34.95223	38	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.46296385	75	0.391271608	
35.40914	39	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.456911254	74	0.395052274	
35.86023	40	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.451090015	73	0.398944697	
36.30571	41	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.44548576	72	0.402954493	
36.7458	42	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.440085334	71	0.407087684	
37.18068	43	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.434876673	70	0.411350731	
37.61053	44	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.42984869	69	0.41575058	
38.03552	45	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.424991175	68	0.420294707	
38.45581	46	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.420294707	67	0.424991175	
38.87156	47	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.41575058	66	0.42984869	
39.28291	48	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.411350731	65	0.434876673	
39.69	49	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.407087684	64	0.440085334	
40.09295	50	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.402954493	63	0.44548576	
40.4919	51	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.398944697	62	0.451090015	
40.88695	52	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.395052274	61	0.456911254	
41.27822	53	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.391271608	60	0.46296385	
41.66582	54	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.387597453	59	0.469263547	
42.04985	55	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.384024897	58	0.47582763	
42.43039	56	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.380549344	57	0.482675126	
42.80756	57	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.377166482	56	0.489827038	
43.18143	58	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.373872262	55	0.497306611	
43.5521	59	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.37066288	54	0.505139657	
43.91963	60	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.367534756	53	0.513354927	
44.28412	61	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.364484516	52	0.521984554	
44.64562	62	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.361508983	51	0.531064589	
45.00423	63	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.358605156	50	0.540635631	
45.36	64	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.355770199	49	0.550743595	
45.713	65	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.353001433	48	0.561440642	
46.0633	66	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.350296321	47	0.572786317	
46.41095	67	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.347652462	46	0.584848946	
46.75602	68	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.345067578	45	0.597707379	
47.09856	69	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.342539508	44	0.611453168	
47.43862	70	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.340066202	43	0.626193326	
47.77627	71	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.337645709	42	0.642053855	
48.11155	72	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.335276178	41	0.659184314	
48.4445	73	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.332955844	40	0.677763799	
48.77518	74	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.330683028	39	0.698008897	
49.10364	75	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.32845613	38	0.720184427	
49.42991	76	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.326273625	37	0.74461819	
49.75405	77	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.324134057	36	0.771721651	
50.07608	78	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.322036036	35	0.802019574	
50.39606	79	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.319978234	34	0.836193597	
50.71402	80	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.317959384	33	0.875148228	
51.03	81	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.31597827	32	0.920114333	
51.34403	82	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.314033733	31	0.972818203	
51.65616	83	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.312124661	30	1.035771864	
51.96641	84	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.310249987	29	1.112803092	
52.27482	85	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.308408692	28	1.210101409	
52.58142	86	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.306599797	27	1.338505432	
52.88624	87	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.304822362	26	1.519271921	
53.18931	88	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.303075485	25	1.80213718	
53.49067	89	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.301358302	24	2.348590899	
53.79034	90	1.25E-12	1.98E-12	4.70E-11	hydroxide	0.299669981	23	5.470068059	
	91					0			

Calculation Table

Layer	1	2	3	4	5	6	7	8	9	10
Thickness of the Layer (cm)	2.00E-01	5.67E+00	8.02E+00	9.82E+00	1.13E+01	1.27E+01	1.39E+01	1.50E+01	1.60E+01	1.70E+01
Day 1	5.81E-09	3.47E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.20E-06	3.76E-13	3.71E-13	3.51E-13	3.21E-13	2.89E-13	2.60E-13	2.35E-13	2.15E-13	1.98E-13
Layer	11	12	13	14	15	16	17	18	19	20
Thickness of the Layer (cm)	1.79E+01	1.88E+01	1.96E+01	2.04E+01	2.12E+01	2.20E+01	2.27E+01	2.34E+01	2.41E+01	2.47E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.83E-13	1.70E-13	1.59E-13	1.50E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13
Layer	21	22	23	24	25	26	27	28	29	30
Thickness of the Layer (cm)	2.54E+01	2.60E+01	2.66E+01	2.72E+01	2.78E+01	2.84E+01	2.89E+01	2.95E+01	3.00E+01	3.05E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.78E-14	8.63E-14	7.30E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14	1.60E-14	1.03E-14	6.29E-15
Layer	31	32	33	34	35	36	37	38	39	40
Thickness of the Layer (cm)	3.11E+01	3.16E+01	3.21E+01	3.26E+01	3.31E+01	3.35E+01	3.40E+01	3.45E+01	3.50E+01	3.54E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	3.69E-15	2.07E-15	1.11E-15	5.76E-16	2.86E-16	1.37E-16	6.28E-17	2.78E-17	1.19E-17	4.93E-18
Layer	41	42	43	44	45	46	47	48	49	50
Thickness of the Layer (cm)	3.59E+01	3.63E+01	3.67E+01	3.72E+01	3.76E+01	3.80E+01	3.85E+01	3.89E+01	3.93E+01	3.97E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.97E-18	7.64E-19	2.87E-19	1.04E-19	3.69E-20	1.27E-20	4.23E-21	1.37E-21	4.34E-22	1.34E-22
Layer	51	52	53	54	55	56	57	58	59	60
Thickness of the Layer (cm)	4.01E+01	4.05E+01	4.09E+01	4.13E+01	4.17E+01	4.20E+01	4.24E+01	4.28E+01	4.32E+01	4.36E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.02E-23	1.18E-23	3.37E-24	9.43E-25	2.57E-25	6.88E-26	1.80E-26	4.59E-27	1.15E-27	2.82E-28
Layer	61	62	63	64	65	66	67	68	69	70
Thickness of the Layer (cm)	4.39E+01	4.43E+01	4.46E+01	4.50E+01	4.54E+01	4.57E+01	4.61E+01	4.64E+01	4.68E+01	4.71E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	6.79E-29	1.60E-29	3.70E-30	8.41E-31	1.87E-31	4.10E-32	8.82E-33	1.86E-33	3.87E-34	7.91E-35
Layer	71	72	73	74	75	76	77	78	79	80
Thickness of the Layer (cm)	4.74E+01	4.78E+01	4.81E+01	4.84E+01	4.88E+01	4.91E+01	4.94E+01	4.98E+01	5.01E+01	5.04E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.59E-35	3.14E-36	6.12E-37	1.17E-37	2.21E-38	4.12E-39	7.55E-40	1.36E-40	2.43E-41	4.26E-42
Layer	81	82	83	84	85	86	87	88	89	90

Thickness of the Layer (cm)	5.07E+01	5.10E+01	5.13E+01	5.17E+01	5.20E+01	5.23E+01	5.26E+01	5.29E+01	5.32E+01	5.35E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	7.38E-43	1.26E-43	2.12E-44	3.54E-45	5.81E-46	9.42E-47	1.51E-47	2.39E-48	3.73E-49	5.76E-50

Pu-239/Pu-240

Layer	1.00E+00	2.00E+00	3.00E+00	4.00E+00	5.00E+00	6.00E+00	7.00E+00	8.00E+00	9.00E+00	1.00E+01
Thickness of the Layer (cm)	2.00E-01	5.67E+00	8.02E+00	9.82E+00	1.13E+01	1.27E+01	1.39E+01	1.50E+01	1.60E+01	1.70E+01
Day 1	3.65E-09	2.18E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.38E-06	2.36E-13	2.33E-13	2.20E-13	2.02E-13	1.81E-13	1.63E-13	1.48E-13	1.35E-13	1.24E-13
Layer	11	12	13	14	15	16	17	18	19	20
Thickness of the Layer (cm)	1.79E+01	1.88E+01	1.96E+01	2.04E+01	2.12E+01	2.20E+01	2.27E+01	2.34E+01	2.41E+01	2.47E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.15E-13	1.07E-13	1.00E-13	9.40E-14	8.86E-14	8.37E-14	7.92E-14	7.50E-14	7.11E-14	6.70E-14
Layer	21	22	23	24	25	26	27	28	29	30
Thickness of the Layer (cm)	2.54E+01	2.60E+01	2.66E+01	2.72E+01	2.78E+01	2.84E+01	2.89E+01	2.95E+01	3.00E+01	3.05E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	6.14E-14	5.41E-14	4.58E-14	3.71E-14	2.87E-14	2.12E-14	1.49E-14	1.00E-14	6.44E-15	3.95E-15
Layer	31	32	33	34	35	36	37	38	39	40
Thickness of the Layer (cm)	3.11E+01	3.16E+01	3.21E+01	3.26E+01	3.31E+01	3.35E+01	3.40E+01	3.45E+01	3.50E+01	3.54E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.32E-15	1.30E-15	7.00E-16	3.61E-16	1.79E-16	8.57E-17	3.94E-17	1.75E-17	7.48E-18	3.09E-18
Layer	41	42	43	44	45	46	47	48	49	50
Thickness of the Layer (cm)	3.59E+01	3.63E+01	3.67E+01	3.72E+01	3.76E+01	3.80E+01	3.85E+01	3.89E+01	3.93E+01	3.97E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.24E-18	4.80E-19	1.80E-19	6.55E-20	2.32E-20	7.95E-21	2.65E-21	8.62E-22	2.73E-22	8.40E-23
Layer	51	52	53	54	55	56	57	58	59	60
Thickness of the Layer (cm)	4.01E+01	4.05E+01	4.09E+01	4.13E+01	4.17E+01	4.20E+01	4.24E+01	4.28E+01	4.32E+01	4.36E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.52E-23	7.40E-24	2.12E-24	5.92E-25	1.62E-25	4.32E-26	1.13E-26	2.88E-27	7.22E-28	1.77E-28
Layer	61	62	63	64	65	66	67	68	69	70
Thickness of the Layer (cm)	4.39E+01	4.43E+01	4.46E+01	4.50E+01	4.54E+01	4.57E+01	4.61E+01	4.64E+01	4.68E+01	4.71E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.26E-29	1.00E-29	2.32E-30	5.28E-31	1.18E-31	2.57E-32	5.53E-33	1.17E-33	2.43E-34	4.96E-35
Layer	71	72	73	74	75	76	77	78	79	80

Thickness of the Layer (cm)	4.74E+01	4.78E+01	4.81E+01	4.84E+01	4.88E+01	4.91E+01	4.94E+01	4.98E+01	5.01E+01	5.04E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.98E-36	1.97E-36	3.84E-37	7.36E-38	1.39E-38	2.58E-39	4.74E-40	8.55E-41	1.52E-41	2.67E-42
Layer	81	82	83	84	85	86	87	88	89	90
Thickness of the Layer (cm)	5.07E+01	5.10E+01	5.13E+01	5.17E+01	5.20E+01	5.23E+01	5.26E+01	5.29E+01	5.32E+01	5.35E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.63E-43	7.91E-44	1.33E-44	2.22E-45	3.64E-46	5.91E-47	9.46E-48	1.50E-48	2.34E-49	3.61E-50

Pu-239

Layer	1.00E+00	2.00E+00	3.00E+00	4.00E+00	5.00E+00	6.00E+00	7.00E+00	8.00E+00	9.00E+00	1.00E+01
Thickness of the Layer (cm)	2.00E-01	5.67E+00	8.02E+00	9.82E+00	1.13E+01	1.27E+01	1.39E+01	1.50E+01	1.60E+01	1.70E+01
Day 1	5.81E-09	3.47E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.20E-06	3.76E-13	3.71E-13	3.51E-13	3.21E-13	2.89E-13	2.60E-13	2.35E-13	2.15E-13	1.98E-13
Layer	11	12	13	14	15	16	17	18	19	20
Thickness of the Layer (cm)	1.79E+01	1.88E+01	1.96E+01	2.04E+01	2.12E+01	2.20E+01	2.27E+01	2.34E+01	2.41E+01	2.47E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.83E-13	1.70E-13	1.59E-13	1.50E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13
Layer	21	22	23	24	25	26	27	28	29	30
Thickness of the Layer (cm)	2.54E+01	2.60E+01	2.66E+01	2.72E+01	2.78E+01	2.84E+01	2.89E+01	2.95E+01	3.00E+01	3.05E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.78E-14	8.63E-14	7.30E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14	1.60E-14	1.03E-14	6.29E-15
Layer	31	32	33	34	35	36	37	38	39	40
Thickness of the Layer (cm)	3.11E+01	3.16E+01	3.21E+01	3.26E+01	3.31E+01	3.35E+01	3.40E+01	3.45E+01	3.50E+01	3.54E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	3.69E-15	2.07E-15	1.11E-15	5.76E-16	2.86E-16	1.37E-16	6.28E-17	2.78E-17	1.19E-17	4.93E-18
Layer	41	42	43	44	45	46	47	48	49	50
Thickness of the Layer (cm)	3.59E+01	3.63E+01	3.67E+01	3.72E+01	3.76E+01	3.80E+01	3.85E+01	3.89E+01	3.93E+01	3.97E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.97E-18	7.64E-19	2.87E-19	1.04E-19	3.69E-20	1.27E-20	4.23E-21	1.37E-21	4.34E-22	1.34E-22
Layer	51	52	53	54	55	56	57	58	59	60
Thickness of the Layer (cm)	4.01E+01	4.05E+01	4.09E+01	4.13E+01	4.17E+01	4.20E+01	4.24E+01	4.28E+01	4.32E+01	4.36E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.02E-23	1.18E-23	3.37E-24	9.43E-25	2.57E-25	6.88E-26	1.80E-26	4.59E-27	1.15E-27	2.82E-28
Layer	61	62	63	64	65	66	67	68	69	70

Thickness of the Layer (cm)	4.39E+01	4.43E+01	4.46E+01	4.50E+01	4.54E+01	4.57E+01	4.61E+01	4.64E+01	4.68E+01	4.71E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	6.79E-29	1.60E-29	3.70E-30	8.41E-31	1.87E-31	4.10E-32	8.82E-33	1.86E-33	3.87E-34	7.91E-35
Layer	71	72	73	74	75	76	77	78	79	80
Thickness of the Layer (cm)	4.74E+01	4.78E+01	4.81E+01	4.84E+01	4.88E+01	4.91E+01	4.94E+01	4.98E+01	5.01E+01	5.04E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.59E-35	3.14E-36	6.12E-37	1.17E-37	2.21E-38	4.12E-39	7.55E-40	1.36E-40	2.43E-41	4.26E-42
Layer	81	82	83	84	85	86	87	88	89	90
Thickness of the Layer (cm)	5.07E+01	5.10E+01	5.13E+01	5.17E+01	5.20E+01	5.23E+01	5.26E+01	5.29E+01	5.32E+01	5.35E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	7.38E-43	1.26E-43	2.12E-44	3.54E-45	5.81E-46	9.42E-47	1.51E-47	2.39E-48	3.73E-49	5.76E-50

Am-241

Layer	1	2	3	4	5	6	7	8	9	10
Thickness of the Layer (cm)	2.00E-01	5.67E+00	8.02E+00	9.82E+00	1.13E+01	1.27E+01	1.39E+01	1.50E+01	1.60E+01	1.70E+01
Day 1	3.19E-11	8.23E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.16E-09	8.90E-12	8.78E-12	8.32E-12	7.61E-12	6.85E-12	6.16E-12	5.58E-12	5.09E-12	4.68E-12
Layer	11	12	13	14	15	16	17	18	19	20
Thickness of the Layer (cm)	1.79E+01	1.88E+01	1.96E+01	2.04E+01	2.12E+01	2.20E+01	2.27E+01	2.34E+01	2.41E+01	2.47E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.33E-12	4.04E-12	3.78E-12	3.55E-12	3.34E-12	3.16E-12	2.99E-12	2.83E-12	2.68E-12	2.53E-12
Layer	21	22	23	24	25	26	27	28	29	30
Thickness of the Layer (cm)	2.54E+01	2.60E+01	2.66E+01	2.72E+01	2.78E+01	2.84E+01	2.89E+01	2.95E+01	3.00E+01	3.05E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	2.32E-12	2.04E-12	1.73E-12	1.40E-12	1.09E-12	8.01E-13	5.64E-13	3.79E-13	2.43E-13	1.49E-13
Layer	31	32	33	34	35	36	37	38	39	40
Thickness of the Layer (cm)	3.11E+01	3.16E+01	3.21E+01	3.26E+01	3.31E+01	3.35E+01	3.40E+01	3.45E+01	3.50E+01	3.54E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	8.74E-14	4.91E-14	2.64E-14	1.36E-14	6.77E-15	3.24E-15	1.49E-15	6.60E-16	2.82E-16	1.17E-16
Layer	41	42	43	44	45	46	47	48	49	50
Thickness of the Layer (cm)	3.59E+01	3.63E+01	3.67E+01	3.72E+01	3.76E+01	3.80E+01	3.85E+01	3.89E+01	3.93E+01	3.97E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	4.67E-17	1.81E-17	6.80E-18	2.47E-18	8.74E-19	3.00E-19	1.00E-19	3.26E-20	1.03E-20	3.17E-21
Layer	51	52	53	54	55	56	57	58	59	60

Thickness of the Layer (cm)	4.01E+01	4.05E+01	4.09E+01	4.13E+01	4.17E+01	4.20E+01	4.24E+01	4.28E+01	4.32E+01	4.36E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	9.53E-22	2.79E-22	7.99E-23	2.23E-23	6.10E-24	1.63E-24	4.26E-25	1.09E-25	2.73E-26	6.69E-27
Layer	61	62	63	64	65	66	67	68	69	70
Thickness of the Layer (cm)	4.39E+01	4.43E+01	4.46E+01	4.50E+01	4.54E+01	4.57E+01	4.61E+01	4.64E+01	4.68E+01	4.71E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.61E-27	3.79E-28	8.78E-29	1.99E-29	4.44E-30	9.72E-31	2.09E-31	4.42E-32	9.17E-33	1.87E-33
Layer	71	72	73	74	75	76	77	78	79	80
Thickness of the Layer (cm)	4.74E+01	4.78E+01	4.81E+01	4.84E+01	4.88E+01	4.91E+01	4.94E+01	4.98E+01	5.01E+01	5.04E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	3.77E-34	7.45E-35	1.45E-35	2.78E-36	5.25E-37	9.76E-38	1.79E-38	3.23E-39	5.75E-40	1.01E-40
Layer	81	82	83	84	85	86	87	88	89	90
Thickness of the Layer (cm)	5.07E+01	5.10E+01	5.13E+01	5.17E+01	5.20E+01	5.23E+01	5.26E+01	5.29E+01	5.32E+01	5.35E+01
Day 1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Forty Years Later	1.75E-41	2.99E-42	5.04E-43	8.38E-44	1.38E-44	2.23E-45	3.57E-46	5.65E-47	8.83E-48	1.36E-48

Summary Table

	Layer 0		Layer 1		Layer 90	
	pCi/ml	pCi/g	pCi/ml	pCi/g	pCi/ml	pCi/g
Pu-239/Pu-240	1.38E-06	6.89E-07	2.36E-13	1.18E-13	3.61E-50	1.81E-50
Pu-239	2.20E-06	1.10E-06	3.76E-13	1.88E-13	5.76E-50	2.88E-50
Am-241	9.16E-09	4.58E-09	8.90E-12	4.45E-12	1.36E-48	6.82E-49

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		PARSONS		**Appendix C of Calculation**						**Cal. No. 730047-01001-01**			
2		R_d=	$1+P_b*K_d/Th$							Eqn. E.8			
3													
4		p_b	bulk density (g/cm^3)										
5		K_d	distriubtion coefficent for radionuclide (cm^3/g)								ANL/EAD/LD-2		
6		Th	volumetric water content										
7		R_d	ratio of average water velocity to radionuclide velocity										
8		K_d	for Pu is	1000	at pH 11	and	8500	at pH 7	(Table E.6)				
9		K_d	for Pu is	2000	and	Am-241	20				RESRAD Version 6.0		
10													
11		Data											
12		Variable	Value		Units			$1/R_d$ (assumed)			$1/R_d$ (referenced data)		
13			Value	Stdev				pH 7	pH 11		pH 7	pH 11	
14		days per year water present on surface	60	30	days		Pu	0.1	0.1		4.27E-05	8.54E-05	
15		time since contamination	40	5	yr		Am				0.004252	0.004252	
16		pH near surface layer (2 mm)	7		>			value (g/ml)	Stdev				
17		pH below near surface layer (2 mm)	11.5				p_b=	2.125	0.125				
18		Water fraction (vol)	0.1815	0.0215									
19		Pu Kd near surface	1000										
20		Pu Kd below near surface	2000										
21		Am Kd	20										
22		Flow rate											
23		**row in Concrete worksheet**		**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
24		**Upper layer boundary (cm)**		**0.2**	**5.67**	**8.018590899**	**9.820728**	**11.34**	**12.678505**	**13.88861**	**15.00141**	**16.03718**	**17.01**
25		**Day**		**0.00**	**1.00**	**2.00**	**3.00**	**4.00**	**5.00**	**6.00**	**7.00**	**8.00**	**9.00**
26		Activity (uCi/ml) Inflow Concentration Used		1.13E-09	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12
27		Activity (uCi/ml) Inflow Concentration Pu-239		7.10E-10	1.25E-12	1.25E-12	1.25E-12	1.25E-12	1.25E-12	1.25E-12	1.25E-12	1.25E-12	1.25E-12
28		Activity (uCi/ml) Inflow Concentration Pu-239/Pu-240		1.13E-09	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12	1.98E-12
29		Activity (uCi/ml) Inflow Concentration Am-241		4.70E-11	4.70E-11	4.70E-11	4.70E-11	4.70E-11	4.70E-11	4.70E-11	4.70E-11	4.70E-11	4.70E-11
30	**time since contamination**		**flow volume (ml of water)**	**Activity (uCi/g concrete)[@]**			**"@ Assumes water is saturated with radionuclide.**						
31	**Years**	**days cover in water (90 wet and 90 drying)**											
32	0	0	NA	2.05E-10	0	0	0	0	0	0	0	0	0
33	1	1	0.99281735	5.81041E-09	3.4745E-14	0	0	0	0	0	0	0	0

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	PARSONS			Appendix C of Calculation						Cal. No. 730047-01001-01			
249	2	37	0.08517133	9.02551E-08	1.3232E-13	8.36542E-14	3.77E-14	1.24804E-14	3.055E-15	5.66E-16	8.23E-17	9.67E-18	9.42E-19
250	2	38	0.08402794	9.07295E-08	1.3232E-13	8.42611E-14	3.81E-14	1.27024E-14	3.129E-15	5.84E-16	8.55E-17	1.01E-17	9.93E-19
251	2	39	0.08292939	9.11977E-08	1.3232E-13	8.48605E-14	3.86E-14	1.29265E-14	3.204E-15	6.03E-16	8.89E-17	1.06E-17	1.05E-18
252	2	40	0.08187284	9.16599E-08	1.3232E-13	8.54524E-14	3.91E-14	1.31529E-14	3.281E-15	6.21E-16	9.23E-17	1.11E-17	1.1E-18
253	2	41	0.08085567	9.21164E-08	1.3232E-13	8.60369E-14	3.95E-14	1.33814E-14	3.359E-15	6.41E-16	9.58E-17	1.16E-17	1.16E-18
254	2	42	0.07987549	9.25674E-08	1.3232E-13	8.66141E-14	4E-14	1.3612E-14	3.438E-15	6.6E-16	9.95E-17	1.21E-17	1.22E-18
255	2	43	0.07893012	9.3013E-08	1.3232E-13	8.71841E-14	4.05E-14	1.38448E-14	3.518E-15	6.8E-16	1.03E-16	1.27E-17	1.29E-18
256	2	44	0.07801754	9.34534E-08	1.3232E-13	8.7747E-14	4.1E-14	1.40797E-14	3.6E-15	7.01E-16	1.07E-16	1.32E-17	1.35E-18
257	2	45	0.0771359	9.38889E-08	1.3232E-13	8.83029E-14	4.14E-14	1.43167E-14	3.682E-15	7.21E-16	1.11E-16	1.38E-17	1.42E-18
258	2	46	0.07628349	9.43196E-08	1.3232E-13	8.88518E-14	4.19E-14	1.45559E-14	3.766E-15	7.43E-16	1.15E-16	1.44E-17	1.5E-18
259	2	47	0.07545873	9.47456E-08	1.3232E-13	8.93939E-14	4.24E-14	1.47971E-14	3.851E-15	7.65E-16	1.19E-16	1.5E-17	1.57E-18
260	2	48	0.07466016	9.51671E-08	1.3232E-13	8.99293E-14	4.29E-14	1.50405E-14	3.938E-15	7.87E-16	1.24E-16	1.57E-17	1.65E-18
261	2	49	0.07388641	9.55843E-08	1.3232E-13	9.0458E-14	4.33E-14	1.52859E-14	4.025E-15	8.09E-16	1.28E-16	1.64E-17	1.73E-18
262	2	50	0.07313624	9.59972E-08	1.3232E-13	9.098E-14	4.38E-14	1.55333E-14	4.114E-15	8.33E-16	1.33E-16	1.71E-17	1.82E-18
263	2	51	0.07240846	9.6406E-08	1.3232E-13	9.14956E-14	4.43E-14	1.57828E-14	4.204E-15	8.56E-16	1.37E-16	1.78E-17	1.91E-18
264	2	52	0.07170199	9.68108E-08	1.3232E-13	9.20047E-14	4.48E-14	1.60344E-14	4.295E-15	8.8E-16	1.42E-16	1.85E-17	2E-18
265	2	53	0.0710158	9.72117E-08	1.3232E-13	9.25075E-14	4.53E-14	1.6288E-14	4.388E-15	9.05E-16	1.47E-16	1.93E-17	2.1E-18
266	2	54	0.07034894	9.76089E-08	1.3232E-13	9.3004E-14	4.58E-14	1.65435E-14	4.482E-15	9.3E-16	1.52E-16	2.01E-17	2.2E-18
267	2	55	0.06970052	9.80024E-08	1.3232E-13	9.34944E-14	4.62E-14	1.68011E-14	4.577E-15	9.56E-16	1.57E-16	2.09E-17	2.31E-18
268	2	56	0.06906971	9.83923E-08	1.3232E-13	9.39786E-14	4.67E-14	1.70606E-14	4.673E-15	9.82E-16	1.62E-16	2.18E-17	2.42E-18
269	2	57	0.06845572	9.87788E-08	1.3232E-13	9.44567E-14	4.72E-14	1.73221E-14	4.771E-15	1.01E-15	1.68E-16	2.26E-17	2.53E-18
270	2	58	0.06785782	9.91619E-08	1.3232E-13	9.49289E-14	4.77E-14	1.75855E-14	4.87E-15	1.04E-15	1.74E-16	2.35E-17	2.65E-18
271	2	59	0.06727531	9.95417E-08	1.3232E-13	9.53953E-14	4.82E-14	1.78509E-14	4.97E-15	1.06E-15	1.79E-16	2.45E-17	2.77E-18
272	2	60	0.06670756	9.99183E-08	1.3232E-13	9.58558E-14	4.86E-14	1.81181E-14	5.072E-15	1.09E-15	1.85E-16	2.54E-17	2.9E-18
273	2	61	0.06615394	1.00292E-07	1.3232E-13	9.62974E-14	4.91E-14	1.83873E-14	5.175E-15	1.12E-15	1.91E-16	2.64E-17	3.03E-18
274	2	62	0.06561388	1.00662E-07	1.3232E-13	9.67201E-14	4.96E-14	1.86583E-14	5.279E-15	1.15E-15	1.97E-16	2.75E-17	3.17E-18
275	2	63	0.06508684	1.0103E-07	1.3232E-13	9.71246E-14	5.01E-14	1.89311E-14	5.385E-15	1.18E-15	2.04E-16	2.85E-17	3.31E-18
276	2	64	0.06457229	1.01394E-07	1.3232E-13	9.75113E-14	5.06E-14	1.92058E-14	5.492E-15	1.21E-15	2.1E-16	2.96E-17	3.46E-18
277	2	65	0.06406976	1.01756E-07	1.3232E-13	9.78807E-14	5.1E-14	1.94823E-14	5.6E-15	1.24E-15	2.17E-16	3.07E-17	3.61E-18
278	2	66	0.06357878	1.02115E-07	1.3232E-13	9.82333E-14	5.15E-14	1.97605E-14	5.709E-15	1.27E-15	2.24E-16	3.19E-17	3.77E-18
279	2	67	0.06309892	1.02471E-07	1.3232E-13	9.85697E-14	5.2E-14	2.00405E-14	5.82E-15	1.3E-15	2.31E-16	3.31E-17	3.94E-18
280	2	68	0.06262977	1.02825E-07	1.3232E-13	9.88903E-14	5.25E-14	2.03223E-14	5.932E-15	1.34E-15	2.38E-16	3.43E-17	4.11E-18
281	2	69	0.06217092	1.03176E-07	1.3232E-13	9.91955E-14	5.29E-14	2.06057E-14	6.046E-15	1.37E-15	2.45E-16	3.56E-17	4.29E-18
282	2	70	0.06172202	1.03524E-07	1.3232E-13	9.94858E-14	5.34E-14	2.08908E-14	6.161E-15	1.4E-15	2.53E-16	3.69E-17	4.47E-18
283	2	71	0.0612827	1.0387E-07	1.3232E-13	9.97616E-14	5.39E-14	2.11775E-14	6.277E-15	1.44E-15	2.6E-16	3.83E-17	4.66E-18
284	2	72	0.06085263	1.04214E-07	1.3232E-13	1.00023E-13	5.43E-14	2.14659E-14	6.394E-15	1.47E-15	2.68E-16	3.96E-17	4.86E-18
285	2	73	0.06043149	1.04555E-07	1.3232E-13	1.00271E-13	5.48E-14	2.17558E-14	6.513E-15	1.51E-15	2.76E-16	4.11E-17	5.06E-18
286	2	74	0.06001897	1.04894E-07	1.3232E-13	1.00506E-13	5.53E-14	2.20473E-14	6.633E-15	1.54E-15	2.84E-16	4.25E-17	5.28E-18
287	2	75	0.05961479	1.0523E-07	1.3232E-13	1.00728E-13	5.57E-14	2.23403E-14	6.755E-15	1.58E-15	2.93E-16	4.4E-17	5.49E-18
288	2	76	0.05921866	1.05565E-07	1.3232E-13	1.00937E-13	5.62E-14	2.26347E-14	6.878E-15	1.62E-15	3.01E-16	4.56E-17	5.72E-18
289	2	77	0.05883033	1.05897E-07	1.3232E-13	1.01134E-13	5.66E-14	2.29306E-14	7.002E-15	1.65E-15	3.1E-16	4.72E-17	5.96E-18
290	2	78	0.05844954	1.06227E-07	1.3232E-13	1.01319E-13	5.71E-14	2.32279E-14	7.128E-15	1.69E-15	3.19E-16	4.88E-17	6.2E-18
291	2	79	0.05807605	1.06555E-07	1.3232E-13	1.01493E-13	5.75E-14	2.35266E-14	7.255E-15	1.73E-15	3.28E-16	5.05E-17	6.45E-18

	A	B	C	D	E	F	G	H	I	J	K	L	M
7215	40	163	0.12301413	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7216	40	164	0.12668861	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7217	40	165	0.13071347	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7218	40	166	0.1351482	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7219	40	167	0.14006748	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7220	40	168	0.14556655	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7221	40	169	0.15176914	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7222	40	170	0.1588394	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7223	40	171	0.16700075	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7224	40	172	0.1765665	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7225	40	173	0.18799259	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7226	40	174	0.20197376	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7227	40	175	0.21963341	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7228	40	176	0.24293874	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7229	40	177	0.27574785	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7230	40	178	0.3270879	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7231	40	179	0.42626925	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13
7232	40	180	0.99281735	2.19676E-06	3.7553E-13	3.70516E-13	3.51E-13	3.21066E-13	2.89E-13	2.6E-13	2.35E-13	2.15E-13	1.98E-13

	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
1	PARSONS			Appendix C of Calculation										Cal. No. 730047-01001-01			
7215	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7216	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7217	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7218	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7219	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7220	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7221	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7222	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7223	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7224	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7225	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7226	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7227	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7228	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7229	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7230	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7231	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14
7232	1.83E-13	1.7E-13	1.59E-13	1.5E-13	1.41E-13	1.33E-13	1.26E-13	1.19E-13	1.13E-13	1.07E-13	9.78E-14	8.63E-14	7.3E-14	5.92E-14	4.58E-14	3.38E-14	2.38E-14

ATTACHMENT D

Guidance for Spectrum Analysis (Parsons, 2001)

Parsons

Guidance for Spectrum Analysis Process

August 31, 2001

Parsons
1955 Jadwin
Richland, Washington

APPROVALS AND CONCURRENCES

Title	Name (Print)	Signature	Project (no.)	Type (A/C)
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Project Specific Authorization for Use				

Types: A = authorization for use/approval, C = Technical Concurrence
NA indicates not applicable

CHANGE HISTORY

Revision	Date	Change	Basis
0		Entire Document	Initial issuance.

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ACRONYMS AND ABREVIATIONS

CF_i	Correction Factor for process "i"
cm	centimeters
cpm	counts per minute
DCGL	derived concentration guideline level
dpm	disintegrations per minute
DQO	Data Quality Objective
FWHM	full width half maximum
HP	health physicist
ICRP	International Commission on Radiation Projection
keV	1000 electron volts
LSR	Libraries Of Specific Radionuclides
MCA	multichannel analyzer
NCR	nonconformance report
NCRP	National Commission on Radiation Protection and Measurement
NIST	National Institute of Standards and Technology
PHP	project health physicist
PM	photomulitplier tube
QA	quality assurance
RIW	Radionuclide Identification worksheet
ROI	region of interest (URSA specific)
SOP	standard operating procedure
UNC	uncertainty
URSA	Universal Radiation Spectrum Analyzer manufactured by Radiation Safety Associates, Inc.
⊠Ci	1 X 10^{-6} Curies

1.0 INTRODUCTION

The purpose of this document is to provide guidance to Health Physicists (HPs) or Nuclear Scientists in the process of selecting, using, and analyzing energy specific radiation emissions data using spectroscopy. This guidance is used in conjunction with standard operating procedures such as:

- SOP-R-MCA-02, *Gamma Spectroscopy Instrument Operation,* Parsons Infrastructure and Technology Group, Inc., Richland. Washington current version.
- SOP-R-MCA-02, *Gamma Spectroscopy Instrument Operation.* Parsons Infrastructure and Technology Group, Inc., Richland, Washington current version.

This document addresses the use of radiation spectroscopy for collection of radiological data use in Parsons' field activities to support various clients. Radiation spectroscopy allows the collection of radiation flux data as a function of energy for energetic photons (i.e., gamma rays and X-rays), alpha particles, beta particles, and neutrons. The sections of this document addressing the various types and methods of spectroscopy will be included in this document, as the equipment is obtained and the need is identified. The change history will only indicate sections actually containing information.

This document is written for the use of professional Health Physicists and Nuclear Scientists and is not intended for use by others. It assumes a significant level of background information. This document is intended to provide guidance for completion and ensure the consistency of these activities. Specifically it will assist in the generation of reproducible and accurate data of the highest quality. The information in this document is addresses professional scientific decision, for which proceduralization is not practicable.

The major sections of this document address:

- Gamma Rays/ X-rays Spectroscopy,
- Alpha Spectroscopy,
- Beta Spectroscopy,
- Neutron Spectroscopy,
- Modeling,
- Survey Techniques, and
- Uncertainty.

Each section is intended to provide the support information and the process for implementation of spectroscopy in these areas to provide the data required by Parsons' various projects.

1.1 Definitions

Geometry as used in this procedure refers to the relative configuration between:

- The radiation source and the detector (e.g., point source beneath detector centerline a 1 cm from the detector face) and the material,
- The distribution of the radioactive material in the radiation source.
- The type and amount of any materials between the source and the detector.

The materials associated with the radiation source and any associated container including back-scatter surfaces.

Health Physicist is professional with at least 2 years of experience in implementing health physicist (radiological safety activities and/or radiological laboratory analysis) activities as described by the National Health Physics Society.

Mutichannel Analyzer (MCA) is an instrument with the capability of collection of radiation flux data as a function of radiation energy when attached to a suitable detector. These instruments typically have associated hardware/software for the identification of radionuclides in addition to the assessment of detected flux.

Nuclear Scientist is an individual with a background in nuclear engineering or radiochemisty and at least 2 years of experience in the implementation of radiological analyses.

Photomultipler (PM) tube receives light pulses from a detector and produces a current pulse proportional to the energy of the photons received by the tube and this pulse can then be sorted and counted by equipment such as an MCA. The solid state equivalent is the photodiode.

Region of interest (ROI) is a set of spectral data peak typically associated with a radionuclide. This set of peaks is used when quantifying activity.

Resolution is a measure of the ability of the detector, photomultipler tube, and MCA system to include a discrete energy count in the appropriate MCA channel. In other words how uncertain (i.e., wide) the energy peak is. The resolution is the full width at half maximum of the full energy peak (FWHM) divided by the height of the energy peak (see Knoll, 1989).

1.2 Selection of Spectroscopy Types

To assess if spectroscopy is applicable and if applicable the appropriate types and methods to be used to collect the data it is essential to:

- review the projected radiological conditions at the site,
- identify the type of data necessary to meet the project objectives, and
- establish the appropriate data quality objectives (e.g., a method for establishing data quality objectives can be found in EPA, 2000 and EPA, 1987).

Then the determination of the viability of the process based on the projected DQOs can be evaluate using the following steps:

1. Identify the radionuclides that maybe present due to past activities at the site in the samples.
2. Project the credible range of activities and activity ratio for these radionuclides.
3. Identify the projected background radiation levels (i.e., radionuclides, ambient flux, and activity concentration) associated with the general environment and specific materials (e.g., uranium decay series, thorium decay series, K-20) including decay progeny.
4. Review the radiation emissions of the materials present and assess the feasibility of detection using the various methods based on this data.
5. Evaluate interferences related to background and potential material present.
6. Project system geometries for in situ measurements and collected samples, to assess required correction for flux attenuation and impact of source dispersion on detection capability, measurement accuracy, modeling costs, and regulatory acceptance.
7. Identify viable mechanism for radionuclide identification and quantification.
8. Identify interferences and limitations associated with the method that would limit the viability of an approach.
9. The feasibility of obtaining confirmatory data (e.g., 2 spectral peak, radiation flux of a specific type) to reduce the uncertainty in the results.
10. Identify potentially cost effective alternative methods (i.e., sampling and analysis, controlling various radiation fluxes based on a conservative upper bound).
11. Identify relationship that would allow extrapolation of radiation data for a radionuclide from other radionuclide data, including reliability, defensibility, and regulatory acceptance.
12. Assess equipment, procedures, standards, and trained personnel availability for the various approaches.
13. Assess the approaches cost, schedule, safety, and regulatory compliance impacts to implement and defend.
14. Based on this data identify approach for various radionuclides that provide the best solution for project success, with emphasis on schedule, cost, technical feasibility, and regulatory acceptance.

In assessing the approach it is helpful to sort types and energies of radiations based on range in materials, well as interference (i.e., spectral overlaps) associated with the suite of expected radiation emissions.

The survey/analysis approach is typically documented in the work plan for the activity. In all cases the basis for the decision should be formally documented. Note, as project conditions change the approaches may need to be modified to provide a cost effective and safe mechanism for meeting the project goals.

2.0 GAMMA RAYS/ X-RAYS SPECTROSCOPY

Gamma Ray/X-ray spectroscopy can be done with various types of detectors associated with a multichannel analyzer (MCA). Typically the MCA will use software to identify radionuclides and assess activity rather than permanently encode analysis routines. In some cases two software packages maybe involved one for use when the MCA is attached and the other for use with just the computer. This software package(s) is subject to the same requirements for verification and validation that is applicable to other types of software, under the applicable Parsons quality assurance (QA) program, such as QA-19.2.

2.1 NaI Based Spectroscopy

A typical NaI based Spectrometer consists of 6 pieces as shown in Figure 1 with associated cables and NaI crystal/PM-Tube packaging. Parsons currently has a Universal Radiation Spectrum Analyzer (URSA) which integrates the High Voltage supply, Pre-amplifier, and MCA into a single unit. The Fidler detector currently owned by Parsons has a beryllium window on the NaI crystal's integrated PM-Tube package.

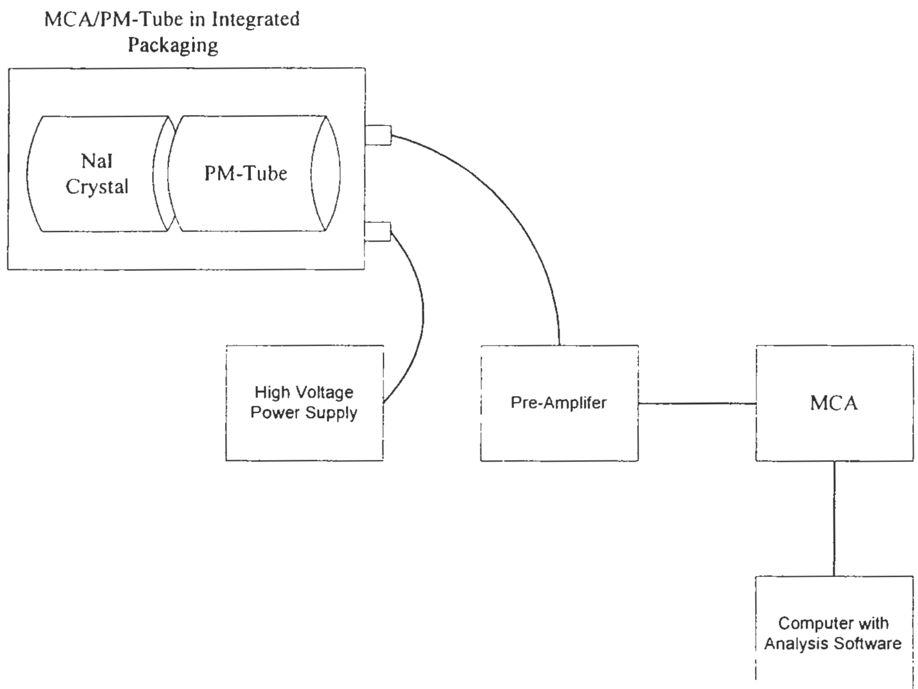
2.1.1 Detector Selection

In choosing a NaI based spectroscopy system it is important to consider the detector characteristics, particularly crystal size and window material. Thin crystal, such as the Fidler, tend to be more effective at characterizing low energy photon emissions while large crystals such as the 3 X 3 (i.e., a 3 inch diameter cylinder 3 inch high) crystal is more effective at characterizing the higher energy portions of photon spectra (i.e., gamma rays and X-rays). In addition, the lower the thickness and atomic number of the surface coatings (i.e., typically measured as density thickness) the more effective the detector is at measurement of lower energy emissions. Crystal size typically needs to increase as:

- the flux to be detected decreases,
- the speed of travel (i.e., for surveys) increases,
- or the counting times (i.e., for static counting and surveys) decreases

The exception to this is when the photons of interest are low energy and then large diameter thin crystal allow the large detection area but decrease the background associated with the higher energy photons that would be detected in the additional volume of a larger crystal. Crystals with a well within the crystal allow the detection efficiency based on crystal geometry to exceed 2⦸ thus significantly increasing the detection efficiency. Very large and specialized crystal shapes and sizes are often cost prohibitive. Detector selection is often the balances of what is practicable with the technically ideal solution, with detector selection being controled by the data quality objectives and considerations of practicality. If the choice of crystal size and shape is not obvious or addressed by

Figure 1 Typical NaI Spectrometer Package



specific guidance then it is typically appropriate to select a detector based on simple Monte Carlo modeling (see Section 6.0) of the detector response to determine what detector will allow you to meet your DQOs and schedule, within the acceptable range of costs.

Parsons currently has a Fidler crystal (see technical information in the Technical Manual section of the Parsons SOP manual). 1 X 1 (i.e., a 1 inch diameter cylinder 1 inch high), 2 X 2, and 3 X 3 crystal are readily available for sale or rent.

2.1.2 MCA Setup

The setup of an MCA system is dependent on the equipment to be used. Each system currently used by Parsons will be addressed briefly. In all cases setup should be based on a through review of the manufacturer provided documents.

2.1.2.1 Universal Radiation Spectrum Analyzer (URSA) with NaI Detector

Most of the setup parameters for the URSA system are addressed in procedure SOP-R-MCA-01, Gamma Spectroscopy Instrument Operation (URSA) and SOP-R-MCA-02, Gamma Spectroscopy Instrument Calibration (URSA). As part of the setup process for the URSA (see

Figure 2) the Project Health Physicist (PHP) will need to provide some specific direction on the setup of the equipment. Sections 1.2, 2.0, 2.1, and 2.1.1 address the initial identification of the required equipment.

Smoothing factors are used to remove some of the spurious statistical fluctuations in the spectral data. A smoothing factor is basically some type of moving average. Smoothing is most important during the peak identification process of the spectral analysis and the analyst will typically look at various values to so that the most effective credible peak identification can be obtained. The smoothing factor for data collection is typically set so that the low energy peaks in the Cs-137 spectra can are just below the resolution of the instrumentation. The URSA peak smoothing scales are 1, 8, 16, 24, 36, and 48. Based on past experience and a review of resolution of the Cs-137 spectra the PHP will establish the appropriate smoothing factor.

During setup the PHP will need to provide the projected initial operating **High Voltage and Maximum High Voltage** for the detector. This information should be present in the detector's manual/literature or from the manufacturer, although the initial operating high voltage may be more effectively determined based on past experience with the detector once sufficient data is available. The PHP may elect to reduce the Maximum High Voltage recommended by the manufacturer to reduce the noise at low energies. This will typically result in the need to increase the pre-amplifier gain during the setup activities (see SOP-R-MCA-02).

The **recalibration period** for the equipment setup is typically based on manufacturer recommendations, although this should be modified in experience with the equipment or similar equipment for the intended usage indicates other values are more appropriate. For the activities associated with setup and calibration of the URSA (see SOP-R-MCA-02) the recalibration periods in Table 1 have been established pending better data.

Figure 2 URSA MCA General Operations Screen

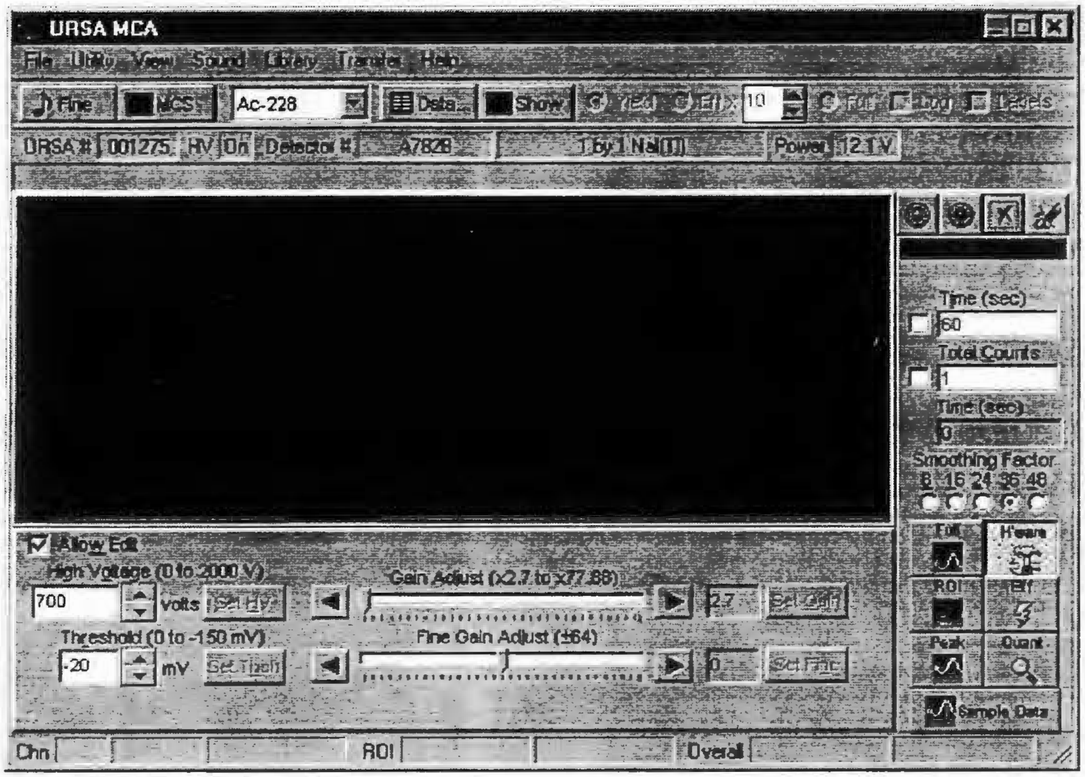


Table 1 Calibration Expiration Period	
Activity	**Typical Re-Setup/Calibration Period (choose less those listed) (months)**
Setup	12
Energy Calibration	12 or Setup expiration
ROI	12 or Energy Calibration expiration
Efficiency Calibration	6 or ROI expiration

Choice of the **calibration source** must be based on the projected radionuclides of interest and those potentially present in the background materials and the ambient environment. The selection of the calibration source(s) should be to span the energy range of interest as determined based on Sections 1.2 and 2.1.3. Where feasible a peak every 200 to 300 keV is preferred with a total activity of less than 500,000 cpm in the detector corrected for the area and projected position of the source. In addition a 1 ☒Ci Cs-137 source is helpful for setup and calibration of the system. These sources must be traceable to the National Bureau of Standards and Technology (NIST) or an equivalent organization. If quantification is not required then, the source traceability need only address identification/purity of the radionuclides and a general indication of the radionuclides relative activity. When specifying **spectra lines** for radionuclide identification the specification of a primary and secondary line with a known relative activity ratio is preferred.

To establish the **count times** (or required number of counts) for spectral collection the PHP must consider:

- the established data quality objectives and how to effectively achieve them including the balancing of background data count times and location/sample count times.
- practicable limitations of cost, schedule, and personnel exposure.
- whether it is feasible to review results and then re-initiate data acquisition at a later time if further data is needed for a location/sample to meet the data quality objectives.
- the projected radioactivities of the various radionuclides that may be present.
- the level at which the activity can be treated as not requiring detailed quantification (i.e., the point at which only a less than number is required) for the limiting case radionuclides, and
- a typical count time is about 30 minutes for in situ measurements at environmental levels and about 5 to 10 minutes for sample counting but is dependent on source activity.

It is important to recognize that count time (or required number of counts) is always a balance between practicality and data accuracy, which must reflect the data quality objectives.

2.1.3 Analysis of NaI Spectra

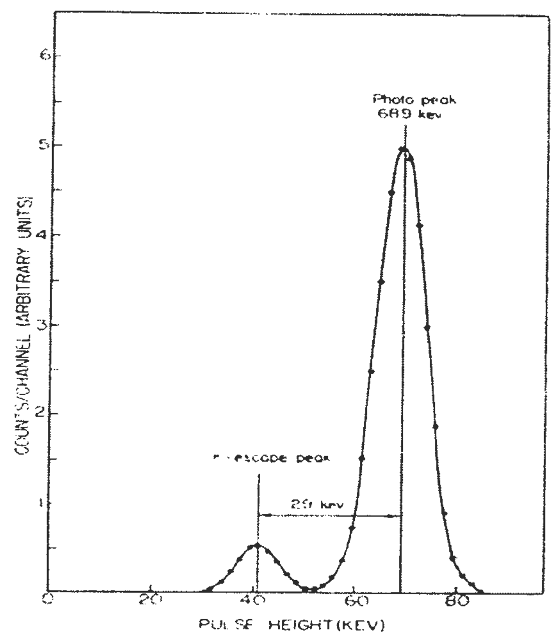
The software associated with MCA provides an integrated system of peak analysis for the identification of radionuclides and peak height analysis to assess activity of the radionuclide. When interpreting NaI spectrometer results various effects, which may be dependent on crystal size and geometry, must be considered. These peaks are best characterized based on experimental data but can be projected using Monte Carlo analyses. The discussions in this section are based on Shafroth,1967; Knoll, 1989; and Crouthamel, 1970.

2.1.3.1 Peak Identification and Quantification Interferences

When attempting to identify and quantify radionuclides in the environment or a sample, the potential interferences associated with NaI spectroscopy will need to be considered. This includes the continuums and peaks produced that are not useful for the identification and quantification of the radionuclides present and the presence of ambient background radiation and radioactive material. These interferences result in peaks that do not support radionuclide identification and quantification and effect that significantly reduce the resolution of the peaks of interest. In some cases for low count rate peaks the peak may be totally obscured by these interferences. In addition, background or source material of interest may also produce peaks that totally obscure a peak of interest. Also a peak may result in the identification of several radionuclides most or all of which are not present or not of interest. Thus the review of spectral data to identify radionuclides and quantify the activity present must involve a detailed analysis of the results with support information to provide an assessment of radionuclides present, their quantity, and the uncertainty associated with this determination. The sections that follow provide a brief introduction to some of the potential interferences.

The **characteristic X-ray escape** peaks are one effect (see Figure 3). In the photoelectric absorption process, the absorber (i.e., about 29 keV) emits a characteristic X-ray for NaI. If this X-ray escapes before absorption (i.e., many of the X-rays emitted near the detector surface may escape) this energy is not detected. Thus energy deposited in the detector is decreased by the energy of these X-rays, that escape; resulting in a second peak with energy equal to the photopeak minus the energy of the characteristic X-ray. This peak is generally called the X-ray escape peak and is most significant in low incident gamma ray energies and for detectors, like the Fidler, with high surface to volume ratios.

Figure 3 X-ray Escape Peak (Shafroth,1967)



The **compton continuum** is another characteristic of the interaction of radiation with the affects the spectra. Compton scattering produces a continuum of energies from the scattering of radiation (see Figure 4). At several hundred keV compton scatter becomes important. Since only a fraction of the incident energy is absorbed in compton scattering the variability of this fraction results in a continuous distribution of energies rather than a discreet peak. This continuum can interfere with peak identification.

Figure 4 Compton Continuum (Shafroth,1967)

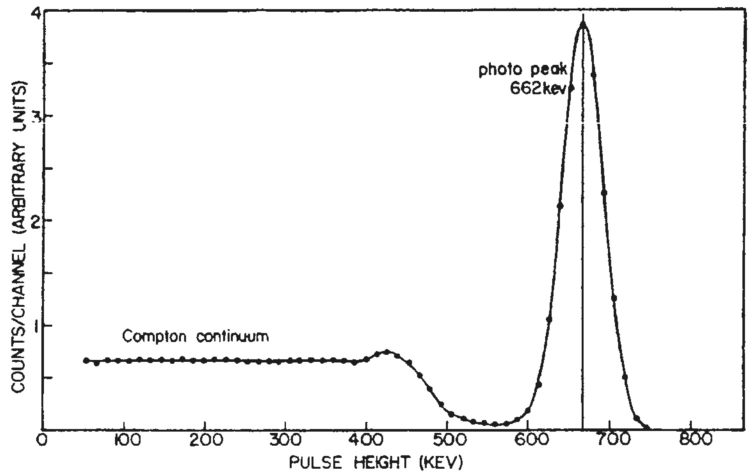
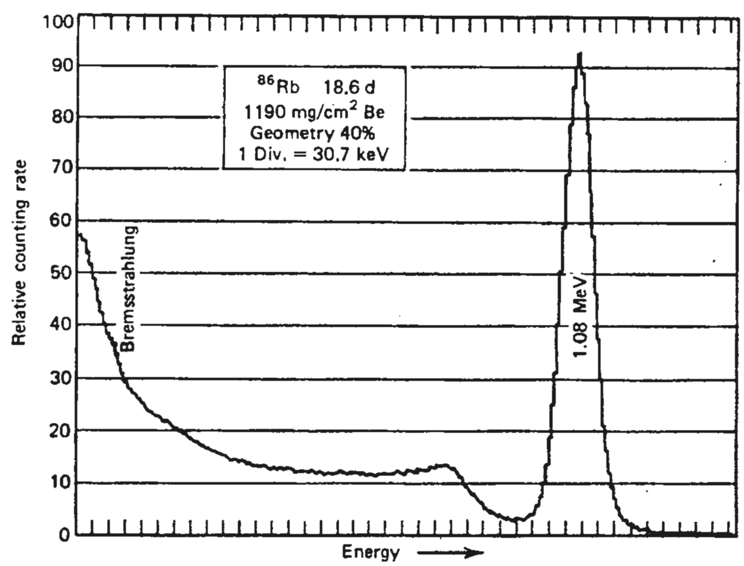


Figure 5 Bremsstrahlung Escape (Knoll, 1989)



The **bremsstrahlung escape** continuum (see Figure 5) is a source of interference with peak identification. This is caused by the escape of some of bremsstrahlung photons which decreases the energy absorbed in the detector based on the amount of energy lost. The fraction lost increases significantly as the energy of the incident photon increases.

A similar process involving the loss of the **secondary electrons** also occurs near the surface of the crystal and may cause an effect similar to characteristic X-ray escape or bremsstrahlung escape if the crystal is small (e.g., a Fidler crystal). This effect is more significant for higher energy photons since the secondary elections will have a higher energy and thus a longer range.

The **backscatter peak** (see Figure 6) may also be present in spectra. A peak in the vicinity of 0.2 to 0.25 MeV caused by gamma rays from the source that have interacted with the surrounding materials, including the detector wall, by compton scattering.

The **annihilation peak** if the source included positron emitters or the photon spectra has energies in excess of 1.2 MeV so pair creation can occur, then the photons associated with positron annihilation (i.e., 0.51 MeV) (see Figure 6) may occur in the spectra. If the 0.51 MeV is pronounced you may also multiples of this energy due to simultaneous detection of annihilation photons.

In addition **background material** and the **ambient environment** provides various sources of radiation with their own characteristic peaks that interfere with radionuclide identification based on peak identification. Typically this impact can be minimized by electronic subtracting out the applicable background spectra if it is available. Typically these are the naturally occurring radionuclides (e.g., see **Table 2**) and in some cases other isotopes maybe present due to commercial usage of radionuclides and possibly fallout. In addition to the natural environment ambient background, there are also various materials that may contain or have associated radioactive material (e.g., see Table 3) which will also produce interference in the data collected. Thus it is important to consider the impacts of background radiation and the approach for correcting for this impact (e.g., typically background subtraction).

These interferences result in false peak and peak broadening which must be considered during peak identification. In addition, any peak maybe be an indicator of several different radionuclides thus other consideration must be used to support peak identification. Whenever feasible radionuclide identification should be based on multiple peaks that occur in the correct relative ratios. Finally the credibility of the presence of the radionuclide must be considered.

2.1.4 Peak Identification/Quantification Library

Peak identification libraries are needed for the peak identification process and the activity quantification process. These libraries need to include both peak energy and yield data. The default libraries supplied by the URSA manufacturer are based on David Kocher's *Radioactive Decay Data Tables* (DOE/TIC-11026). All peak identification/quantification libraries must be based on a recognized source of spectral data. Currently the preference for the source of this data, in order of preference, is:

1. U.S. Department of *Energy 's National Nuclear Data Center (NNDC)* at Brookhaven National Laboratory (access is available through the internet),
2. David Kocher's *Radioactive Decay Data Tables* (DOE/TIC-11026), or
3. ICRP,s (International Commission on Radiation Protection) *Radionuclide Transformations Energy and Intensity of Emission*, Annals of the ICRP, ICRP Publication 38.

Use of library data sources is questionable and a specific justification of such a decision needs to be documented. Peak libraries should include all credible radionuclides including those associated with background. Any library used must be approved by the PHP and, if it is not an existing library, it must be documented and reviewed, as if it were a Parsons' calculation.

Figure 6 Annihilation Radiation Related Peaks (Crouthamel, 1970)

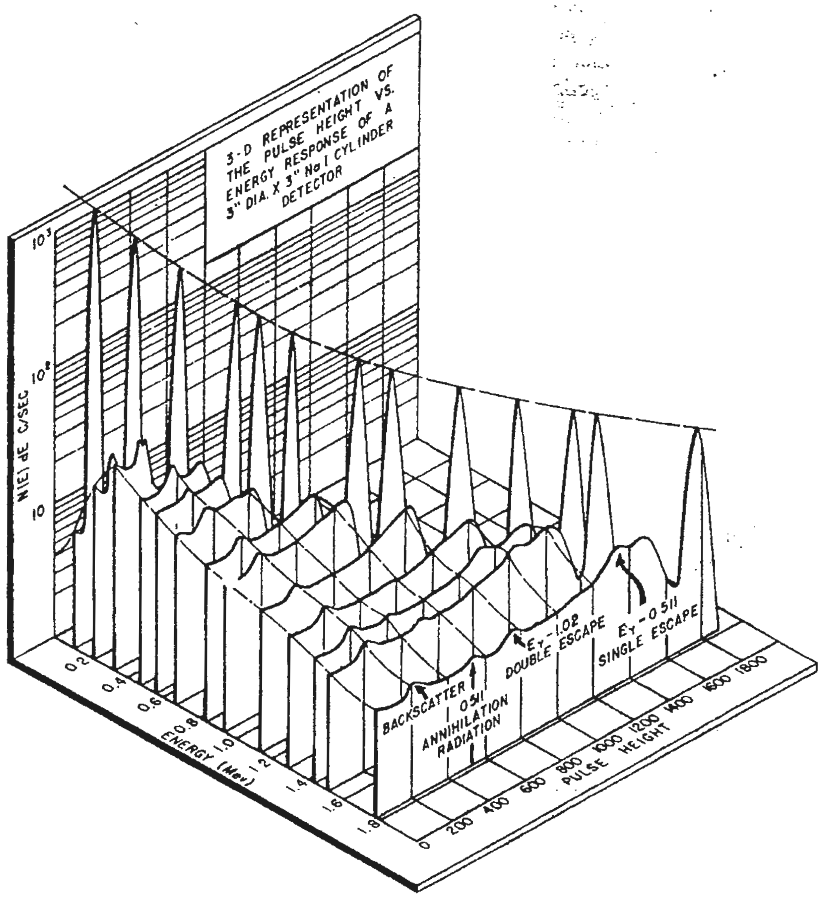


Table 2 Naturally Occurring Radionuclides (ICRP-38, NCRP-93 & NCRP-94)

Radionuclide	Parent	Source	Alpha	Beta	Gamma/ X-ray
			Emission Energies (MeV)		
H-3	cosmogenic	natural (very low abundance)		0.00568	
Be-7	cosmogenic	natural (very low abundance)			0.478
C-14	cosmogenic	natural		0.04945	
Na-22	cosmogenic	natural (very low abundance)		0.215	0.511, 1.28
K-40	primordial	natural (about 0.0118% of natural K, usually a small fraction compared to U in most soil/rock based materials)		0.585	1.46
Rb-87	primordial	natural (Rb abundance is less than 1% of K)		0.111	
Th-232	cosmogenic	natural (activity is typically 1 to 4 times the U-238 activity)	9.9 - 4.1		
Ra-228	Th-232	Th-232		0.055	
Ac-228	Ra-228	Th-232		1.2 – 2.1	0.34 – 0.96
Th-228	Ac-228	Th-232	5.3 – 5.4		0.08
Ra-224	Th-228	Th-232	5.4 – 5.7		0.24
Rn-220 (gas)	Ra-224	Th-232	6.3		
Po-218	Rn-220	Th-232	6.8		
Pb-212	Po-218	Th-232		0.35 - 0.59	0.24 – 0.3
Bi-212	Pb-212	Th-232	6.0 – 6.1	1.6 – 2.3	0.04 - 1.7
Po-212	Bi-212	Th-232	8.8		
Tl-208	Bi-212	Th-232		1.3 – 1.8	.5 – 2.6
U-235	cosmogenic	natural (in natural uranium about 4.5% to 5% of U-238 activity)	4.3 – 4.6		0.14 – 0.2
Th-231	U-235	U-235		0.14 – 0.31	0.03 – 0.08
Pa-231	Th-231	U-235	4.9 – 5.0		0.02 –0.08
Ac-227	Pa-231	U-235	4.8 – 5.0	0.4	0.02 – 0.09
Th-227	Ac-227	U-235	5.7 – 6.1		0.05 – 0.31
Fr-223	Ac-227	U-235		1.2	0.05 – 0.24
Ra-223	Th-227/ Fr-223	U-235	5.6 – 5.8		1.5 – 0.33
Rn-219 (gas)	Ra-223	U-235	6.4 – 6.8		0.27 - 0.4
Po-215	Rn-219	U-235	7.4		
Pb-211	Po-215	U-235		0.29 – 1.39	0.410 – 0.83
At-215	Po-215	U-235	8.0		
Bi-211	Pb-211/ At-215	U-235	6.2 – 6.6		0.35
Po-211	Bi-211	U-235	7.5		0.57 – 0.9
Tl-207	Bi-211	U-235		1.4	
U-238	cosmogenic	natural	4.15, 4.2		
Th-234	U-238	U-238		0/103, 0.193	0.063, 0.093
Pa-234m	Th-234	U-238		2.29	0.765(0.3%), 1.00 (0.6%)
U-234	Pa-234m	U-238	4.72, 4.77		0.053 (0.2%)
Th-230	U-234	U-238	4.62, 4.68		0.068(0.6%)

Table 2 Naturally Occurring Radionuclides (ICRP-38, NCRP-93 & NCRP-94)

Radionuclide	Parent	Source	Alpha	Beta	Gamma/ X-ray
			Emission Energies (MeV)		
Ra-226	Th-230	U-238	4.6, 4.78		0.186
Rn-222 (gas)	Ra-226	U-238	5.49		
Po-210	Rn-222	U-238	6.0		
Pb-214	Po-210	U-238		0.65, 0.71, 0.98	0.295, 0.352
Bi-214	Pb-214	U-238		1.0, 1.51, 3.26	0.609, 1.12, 1.76
Po-214	Bi-214	U-238	7.69		
Pb-210	Bi-214	U-238		0.016, 0.061	0.047
Bi-210	PB-210	U-238		1.16	
Po-210	Bi-210	U-238	5.31		

Table 3 Common Comsumer or Industrial Product Radionuclides

Radionuclide	Source	Alpha	Beta	Gamma/X-ray
		Emission Energies (MeV)		
Ra-226 & progeny	Instrumentation Dials (i.e., luminous materials), lighting rods	Various see **Table 2**.		
Th-232/U-238/U-235 & progeny	Building materials, ceramics, counter weight, or high density weights, ceramic glazes, fly ash	Various see **Table 2**.		
Th-232	Welding Rods, Lantern Mantels, special glass (e.g., lenses)	Various see **Table 2**.		
Am-241	Smoke Detectors, Pace Makers, density gauges	5.49, 5.44		0.060, numerous lines below this region
H-3	Lights/lighting, luminous materials		0.00568	
K-40	Fertilizers, dental products		0.585	1.46
Co-60	Various Irradiation and gauging sources, Spark gap irradiators, spark tubes & glow lamps (i.e., fluorescent tube starters)		0.0958, 0.626	1.17, 1.33
Ni-63	Voltage regulators, surge protectors, spark tubes & glow lamps (i.e., fluorescent tube starters)		.0171	
Kr-85	Lighting, electronic tubes, spark tubes & glow lamps (i.e., fluorescent tube starters)		0.251	0.514
Cs-137	Various Irradiation and gauging sources, Voltage regulators, surge protectors		0.173, 0.425	0.662
Pm-147	Luminous materials, spark tubes & glow lamps (i.e., fluorescent tube starters)		.062	
Po-210	Static eliminators	5.31		
Pb-210	Voltage regulators, surge protectors	Various see **Table 2**.		
Pu-239	Density gauges	5.1, 5.2		numerous lines in the less than 0.03 region
Pu-238	Pacemakers	5.46, 5.5,		numerous lines in the less than 0.03 region

2.1.4.1 Libraries Of Specific Radionuclides (LSR)

Typically MCA radionuclide/isotope identification/quantification software allow development of libraries of specific radionuclides (LSR). These LSRs reduce the number of false identification of peaks that may have multiple attributions. However, they may also result in the failure to appropriately identify and/or quantify radionuclides, if the LSR is not complete. When establishing an LSR it is important to include all radionuclides that may be present associated with the location, sample, material background, and/or ambient environment. In addition, all peaks that are significant contributors to the flux (i.e., 1%) need to be identified, even if they will not be used for identification and quantification of the radionuclide, they may represent an interference to another radionuclide. This becomes particularly important when a more common radionuclide has a peak that may interfere (i.e., cause false identification or quantification) of another radionuclide because it has a minor peak in the same region. These interferences complicate the interpretation of spectra significantly particularly for radionuclides with very low action levels/DQOs.

The LSRs developed must meet the criteria for a library, as specified in Section 2.1.4. As long as the library from which the LSR is generated is appropriately documented, the documentation of the LSR can be limited to the working datasheets and project specific documentation. However, it should to added to the LSR Listing datasheet in the SOP Manual and verified by a Health Physicist.

2.2 Analysis of NaI Spectra

Spectrum analysis is initiated by setting up the URSA or running the URSA software on a computer. Select the appropriate ROI for the spectra being analyzed. Identify the spectra to be analyzed and associated background(s) spectra, then initiate a Radionuclide Identification worksheet (see Appendix A) (RIW). The analysis number on the RIW is sample/location spectrum file name proceeded by "RIW-". If quantification is required page 2 of the RIW will be completed.

2.2.1 Radionuclide Identification

The background spectrum for the sample/location spectrum of interest should be loaded as the background spectra and the sample/location spectra as the active spectrum. Document the background spectra's file name(s) on the RIW and assign it an identification (which is unique for this datasheet). Where multiple background files maybe applicable the sample/location spectrum maybe analyzed with each and the results used to select the background most appropriate to the sample/location. Background subtraction should improve the resolution on the peaks of interest.

Once the spectra are active, use the URSA software to find the various peaks and repeat this process with the various smoothing factors, as needed, to eliminate noise based peak identification but not eliminating real peaks. If several smoothing factors appear appropriate treat each one as a separate case and assign it the existing analysis number followed by a lower case Greek letter with first letter assigned to the smallest smoothing factor to be evaluated and then increasing both as needed. If multiple smoothing factors are used in the analysis, the smoothing factor analysis must include all available smoothing factors between the smallest and largest smoothing factors used. Review the peak identification visually and eliminate inappropriate peak identification and add any peaks that may have been missed. Have the software conduct a peak identification analysis and print out a copy of the peak identification report. Record the RIW number, a dash (i.e., "-"), "P", a dash (i.e., "-"), the background filename identifier from the datasheet, and if necessary a dash (i.e., "-") followed by the smoothing factor lower case Greek identifier. Review the outputs of this peak identification process against the projected interferences discussed in this document and identify any peak may be inappropriately identified. Then review of the radionuclides identified for confirming peaks and credible radionuclides that maybe present. Identify the peaks that appear to be clearly appropriately identified and those that are clearly misidentified and annotate this on the record.

If a peak is identified several times be sure to resolve, which multiple identifications may be valid. The determination maybe based on determining if the relative fraction of the peak that should be assigned to each identification is appropriately apportioned for the confirmatory peak and other information (i.e., known relative ratios of radionuclides based on known relationships, such as progeny or natural relative isotopic ratios). If there are peaks that have multiple identifications note this on the report for later followup. Also clear identify any unidentified peaks for followup. Sign and date this report near the identification number on this report. This gives real time results of the radionuclides identified and activity present and may lead to additional steps being performed. The radionuclide identification should be completed initially through peak centroid +/- 10 keV (or a value specified by the PHP and noted in the comment section of datasheet GD-R-MCA-1-2, Appendix A) comparison and confirmed through comparison of the full width at half maximum (FWHM) of the software library and the results. Through the use of these two techniques the potential for misidentification can be limited.

Repeat the process described above based on peak identification for an analysis based on FWHM. The "P" in the identification number will be an "F" for the FWHM analysis. Repeat this process to address all applicable smoothing factors and background data sets.

Use these reports and any available support data to complete the analysis and the Radionuclide Identification worksheet (see Appendix A) (RIW). Identify these reports on the RIW and attach them to the RIW. Radionuclide identification should use both sets of data and where applicable any data reports based on alternative backgrounds and smoothing factor data to attempt to eliminate multiple identification of peaks and unidentified peaks documenting this on the radionuclide identification worksheet. The analyst will document the basis for radionuclide identification on the RIW. Where there is multiple identification of peaks that cannot be resolved based on other data the HP may show alternatives for the radionuclides identification, then the limit case (i.e., limiting case for the specific analysis or evaluation being made) radionuclide will be used in subsequent analysis. Note, when several alternative radionuclides are identified use of these radionuclides in the analysis should not exceed an applicable fraction greater than one. Laboratory based analysis may also be used to resolve peaks with multiple identification or unidentified peaks if determined to be justified by the PHP and Project Manager.

2.2.2 Radionuclide Quantification

Quantification of the activity is based on the ROI and associated peak identification. For the radionuclide identification the URSA should be calibrated for the specific or span the range of the radionuclide of interest in the ROI being addressed. This should include consideration of confirmatory peaks. Note, quantification can only be done based on traceable sources. The activity projected by the URSA using the quantification results will be based on the specific geometry of the calibration sources used in quantification. The sources are typically point or small area sources. However, the material being characterized is often in a different relative geometry with attenuation of the flux occurring from the source and intervening materials. To defend quantification of the activity present it will be necessary to model the impact of the geometry including potential variability in the geometry and correct the difference from the calibration source geometry.

Often in situ quantification provide a more accurate assessment of true conditions where the material is not uniformly distributed at the location or located on the surface at the location. Laboratory sample for non-uniform contamination generate inconsistent (i.e., randomly providing ultra-conservative or non-conservative results in some cases) results depending on:

- Whether the random sampling process collected the locations of high contamination and
- Whether the material collected contained large amounts of contaminated material.

If the sample is high localized (e.g., surface contamination) the amount of matrix required to meet the minimum analytical requirements typically results in significant dilution of the sample and significant under estimation of the surface activity concentration. In addition, in situ quantification can provide a more practicable solution.

To correct for geometry effects it is necessary to accurately model (i.e., assess) relative flux associated with:

- The detector-source geometry to provide the calibration baseline,
- The credible detector-source geometries to provide an assessment of the potential correction for the difference between the calibration geometry and the potential conditions, and
- Model the credible detector-source geometries to include consideration in the variability of material thickness, composition, and density in assessing these differences.

Once the data has been modeled, the geometry correction factor(s) (GCF) can be calculated for each credible geometry (including consideration of material thickness, composition, and density) using:

GCF = (credible detector-source geometry flux based on modeling)
/(detector-source geometry to provide the calibration baseline flux modeling).

Once the range of GCF (with their associated uncertainties are established) the range of and a typical GCF for a measure can be established. The typical GCF is a probability weighted average for the various credible GCFs. The projected activities measured by the URSA are multiplied by the GCF or the range of GCFs to assess the range of activity that maybe present for a specific measurement. In making these assessments it is essential to consider the propagation of error in the results and provide the associated uncertainties. (see Section 9.0)

These results should be documented consistent with the applicable Parsons and project calculation documentation procedure/requirements.

2.3 Intrinsic Germanium Spectroscopy

Reserved for later use.

3.0 ALPHA SPECTROSCOPY

Reserved for later use.

4.0 BETA SPECTROSCOPY

Reserved for later use.

5.0 NEUTRON SPECTROSCOPY

Reserved for later use.

6.0 MODELING

The purpose of modeling is to determine the relationship between the calibration geometry and the field geometry to allow quantification of the measured activity. Typically the intent is to assess the difference in the detected flux in the detector for the two conditions so a correction factor based on the relative ratio for assessment of activity can be developed. Such modeling would involve the assessment of the relative changes in the detected flux between the calibrated conditions and the field conditions. Often the field conditions must be projected based on a range of conditions that might exist. When assessing the calibration and field conditions it is import to address:

- Relative distance and position of the source relative to the detector,
- The materials and geometry of the detector,
- The materials present between the source and the detector,
- The source geometry, materials, and the activity distribution within the materials,
- Potential back-scatter surfaces (location and material),
- When assessing material properties the type of material and its density will need to be addressed, and
- The probability of the various variable field conditions existing.

The acceptable uncertainty and level of detail associated with this data and the selection of the software used to model the relative relationships is based on the requirements of the DQOs. In all cases the uncertainties in the modeling and the propagation of these uncertainties in results must be considered.

Currently Parsons typically uses MCNP software for this modeling. All modeling activities must be clearly documented consistent with Parsons and the project requirements for the documentation of calculations. Further, the software used must be validated and verified for this use consistent with the Parsons and project procedures and requirements.

The results of the modeling are normally an assessment of the Correction Factor (CF_i) between the field geometry detected flux (FGFi) and the calibration geometry's detected flux (CGF_i) for field geometry "i". Specifically:

$$CF_i = FGF_i / CGF_i.$$

Where defensible, probabilities can be assigned to the various field configurations (P_i) then a typical Correction Factor (CF_t) can be provided where:

$$CF_t = \sum_i P_i * CF_i .$$

When calculating CF_is and CF_t ensure that the propagation of error is considered to provide an assessment of uncertainty. The CF data will normally include the range of applicable CF_is, and CF_t

with 95% confidence level uncertainties. The workplan, sampling and analysis plan, and/or the DQOs will establish:

- What modeling is required,
- The acceptable uncertainties (i.e., typically 95% confidence level two tailed),
- Which CFs are calculated and how they are used.

All CF determination shall be clearly documented in a calculation consistent with Parsons' and the project's requirements and procedures.

7.0 SURVEY TECHNIQUES

The survey techniques used by Parsons should be consistent with:

- MARSSIM,
- NMSS Decommissioning Standard Review Plan (NUREG-1727)
- Manual for Conducting Radiological Surveys in Support of License Termination (NUREG/CR-5849),
- Analysis of the Ability of Current Health Physics Instruments to Predict Dose in Exposed Individuals (NUREG/CR-4239),
- Human Performance in Radiological Survey Scanning (NUREG/CR-6364),
- A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys (NUREG-1505),
- Measurement Methods for Radiological Surveys in Support of New Decommissioning Criteria (NUREG-1506),
- Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions (NUREG-1507),
- applicable Parsons SOPs,
- applicable project requirements and procedures,
- the project DQOs, and
- good health physics practices

In selecting survey techniques it is important to consider:

- DCGLs and associated DQOs for the project,
- the type, energy, and projected flux of the radiation to be detected,
- possible inference/confounding-factors in interpretation of the data based on the projected radionuclides of interest in the background environment,
- the detection limitations for the instrumentation based on survey height and scanning rate,
- scanning heights should be consistent with projected averaging areas/volumes for contamination based on the DQOs and field conditions,
- the human factor limitations for personnel (e.g., detection of change, such as meter movement versus sound, easy of repetitive handling of the equipment),
- when scanning versus static counts will be used,
- when energy based radionuclide identification maybe appropriate,
- where direct survey versus smears/material-sampling should be used,
- the environmental conditions at the site,
- practicability limitations in the selection of equipment,
- regulatory acceptance of the equipment,
- availability of established procedures and protocols, and
- availability of the instrumentation and personnel required.

The basis of the selection of survey instrumentation types and techniques will be fully documented in the DQO and SAP documentation.

8.0 DATA VALIDATION AND VERIFICATION

The data validation and verification process consists of several components, such as:

- Project's DQO or equivalent based data validation and verification process as addressed in Section 8.1 of this document.
- Project's or Parsons' process for the investigation of apparent data errors during collection as addressed in Section 8.2 of this document,
- Validation and verification of the software used in support of radiological survey and analysis activities that are addressed by applicable project or Parsons procedures, such as QA-19.2, *Quality Assurance Procedure, Computer Software Verification and Validation*, *l*, *Quality Assurance Manual,* Parsons, Richland, Washington,
- Validation and verification of modeling and other calculations that are addressed by applicable project or Parsons procedures such as, *Preparation of Calculations*, *Project Procedures Manua*l, Parsons, Richland, Washington,
- Resolution of nonconformance reports (NCRs) associated with data that are addressed by applicable project or Parsons procedures such as, QA-15.0, *Quality Assurance Procedure, Nonconformance Control*, *Quality Assurance Manual,* Parsons, Richland, Washington.

8.1 General Data Validation and Verification Process for Verified Field Data

The general data validation and verification activities discussed in this document are intended to support the data validation and verification process associated with the specific project. When ever discrepancies are identified the appropriate project and QA procedures (e.g., NCR process) should be implemented, as needed. The first step in the data validation and verification process is to review the data documentation and ensure that it meets the requirements of the applicable procedures and requirements. Verify that the appropriate paperwork is in place and signed by the data collector and verifier.

Once it has been established that the appropriate documentation is available the analysts and data collectors should review the data for the following technical considerations, prior to its release to the customer:

- Are the data technical consistent,
  - Is the behavior of the data consistent with known scientific principles,
  - Are the changes in the data discontinuous or the rate of change incongruous, such that the data suggests that a recording or collection error may have occurred.
  - Do the results fall below background at a frequency or in an amount that would suggest a recording or collection error beyond the normal fluctuations of background.
  - Does the data imply the unexplained creation or loss of flux or material beyond the variability expected in the statistical fluctuation of the data.

- Is the activity and the associated units consistent with the credible range of data values.
- Review the specific activity of the source materials to verify that the mass, density, and activity have credible values.
- Are there any non-credible radionuclides identified based on the data.
- Are the radionuclides that should be present represented in the data at credible levels.
- Are the relative ratio of activity and hazards consistent with known scientific information.

• Were appropriate and current calibration sources used.

- Are all the sources used in the calibration of the instrument traceable with current calibrations.
- Do the sources used in the calibration span the energy range of interest.
- Are the activity levels of the sources consistent with the capability of the instrumentation and at a level and accuracy to meet the quantification required in the DQOs.
- Is there evidence that the source have been damaged so that the calibration may not be valid.
- Is the source geometry consistent with that needed to meet the DQOs or has justified modeling been performed to address the impact of the source geometry.
- Is the energy response behavior consistent with expected energy response and/or scientific principles.
- Are there coatings on the source that may degrade the energy of the emitted photons.

• Is there appropriate documentation for all calibrations sources in the records,

• Were appropriate peaks selected for radionuclide/isotope identification and quantification of activity,
  - Are the peaks selected for radionuclide identification part of the designated radionuclide/progeny spectra.
  - Are there interferences from background, detector/instrument response, or other radionuclides that may have resulted in an incorrect interpretation of this data.
  - Were confirmatory peaks selected and evaluated to verify the interpretation of the primary peaks.
  - Are the relative activity ratio between the primary and other peak associated with radionuclide consistent with the yields for each peak.
  - Does the peak analysis and FWHM produce consistent results.
  - Are there peaks with duplicate identifications that can be separated.
  - Are the unidentified peaks and how will their identification be resolved.
  - Is it feasible to quantify the activity based on the activity level of the peak and the interference from other sources of spectral data.

• Are the background values credible and are the background data consistent with the statistical variability expected,
• Are the expected progeny present and in the appropriate ratios (Note, when making this assessment the variation in solubility of the progeny and presence of gaseous progeny may affect these ratios significantly),
• Are the expected background radionuclides present.

- Are there any radionuclides identified or present in concentrations that are not credible or at least require followup,
- Have appropriate background data sets been obtained,
- Is there consistency between these values and the other survey data,
- Are the radionuclides present in credible relative ratios,
- Is additional count time required to resolve spectra appropriately,
- Are there unidentified peaks that require resolution,
- Are there potential mis-identified peaks (e.g, impact of interferences),
- Does the equipment appear to be functioning properly,
- Were any technical concerns/inconsistencies appropriately followed up on and resolved,
- Has the appropriate quality control/verification samples been taken,
- Are there any other outstanding technical, operational, or quality issues associated with the data. (Carefully review any comments on the datasheets as an indication of such impacts.)

Review the survey results using other techniques to verify that they are consistent with the results from these calculations. Consider progeny and other radiation emissions. If there are inconsistencies issue an NCR to document resolution of this potential inconsistency. The explanation or justification of any inconsistencies should be documented in a manner consistent with Parsons or the project's procedures and requirements addressing calculations.

If samples are sent for analysis then review these sample results and compare them with the in situ measurements for this activity. If the values are not consistent (i.e., with the projected uncertainties of the two results) review the data for potential problems and issue and NCR to document resolution of this potential inconsistency. The explanation or justification of any inconsistencies should be documented in a manner consistent with Parsons or the project's procedures and requirements addressing calculations.

It is recommended that appropriate statistical tests be applied to the various data sets to verify that statistical anomalies are not present in the data. Statistical anomalies in the data shall be treated like any other data discrepancy and handled accordingly.

8.2 Resolution of Field Data Verification Problems

Until the data quality and associated uncertainty are resolved the data should be labeled as suspect and not used for safety or environmental protection determination, unless the data is assumed to be the most conservative value. If there is an apparent problem associated with data collection the HP or Project Manager should initiate an NCR documenting the apparent problem. The HP shall review the apparent problem to determine its impact on data quality. If the data is determined to be suspect and thus not usable this should be documented on the NCR form and the process resolved under the NCR process. If the HP determines that the data is usable then in addition to the implementation of the NCR process the HP shall provide a technical justification of the data validity in the form of a Parsons calculation which must be prepared, reviewed and issued in a manner consistent with applicable project and Parsons procedures and requirements.

In establishing the potential validity of impacted or suspect data the HP should review the source and probability of occurrence of the event or condition that cause the impact. Determine the additional uncertainty this condition may have on the resulting data. Then the HP should determine if the data has any functional value based on this uncertainty.

9.0 UNCERTAINTY

Uncertainty in the results for these measurements must always be determined and justified based on sound scientific/engineering data and practice. This uncertainty may come from many sources including:

- Statistical variability in the nuclear decay and counting process.
- Measurement error inherent in the equipment.
- Visual uncertainties resulting from interpolating a scale.
- Variability of the natural environment and the materials being measured.
- Uncertainty in the calibration of the equipment.
- Inherent bias in the measurement or measure data set.
- Statistical variability or inhomogeneity in the item or area being measured.
- Human observation and recording errors or intentional misrecordings.

With the exception of **human observation and recording errors or intentional misrecordings** the process will attempt to minimize and quantify these errors. The procedural and guidance process used in this activity is intended to minimize the potential human observation and recording errors or intentional misrecordings errors.

The **statistical variability** associated with the various process (e.g., the **nuclear decay and counting process**) is addressed using counting statistics and increasing the count times and number of counts/sample taken. Typically most thing in nature have lognormal distributions with the exception of basic natural process like radioactive decay, which is normal (i.e., pure guasian distribution). As the activity levels (i.e., count rates) decrease poisson statistics should be applied to the evaluation of this data. Whenever a statistical distribution other than those described above is used to characterize data associated with this activity a clear justification for the choice must be provided as a basis for this alternative distribution based on the physical characteristics of the process and not just on the apparent statistical behavior of a very limited data set. The confidence level to which uncertainties are to be established should be based on the DQO process with a default assumption that all uncertainties in data should be established at the 95% confidence level.

The **measurement error inherent in the equipment** are quantified by the calibration and accuracy check process for the instrumentation. Further, potential failure can be projected by the control charting process. The upper and lower bounds of the acceptable uncertainties are established based on the DQO process. The accuracy check boundary and the calibration uncertainty maybe used to assess the uncertainty associated with the equipment, although use of the actual calibration and accuracy check uncertainty maybe used. Data like the fine tuning results from the MCA can be used to assess instrument variability in addition to the calibration error. The preference in establishing the uncertainty of the data is to do a detailed analysis of all the data and propagate the error as appropriate or model it with monte carlo analysis. In addition **visual uncertainties resulting from interpolating a scale** must be considered in this uncertainty as discussed below. However, a default solution for equipment uncertainty (UNC) is:

$$UNC = SQRT\ (\ UNC_{calS}^2 + UNC_{calF}^2 + UNC_{act}^2 + UNCvis^2 + UMDA^2) + MDA$$

where:

UNC_{calS} is the specified uncertainty of the calibration source and/or the outside calibration. If there is more than one value involved this value is the square root of the sum of the squares of the values (Bevenington, 1969).

UNC_{calF} this is the uncertainty based on the field calibration ignoring the uncertainty in the calibration sources based on statistical variability and background. This should determined based on good health physics practices and the information in NUREG/CR-5849, NUREG-1575, and NUREG-1507). If a modeling correction factor is use then the uncertainty of UNC_{calF} and correction factor should be consolidated using the square root of the sum of the squares of the values (Bevenington, 1969).

UNC_{act} is the uncertainty in the accuracy or tuning checks, which can be estimated as the 95% confidence level for the entire set of values generated.

UNCvis this is 50% of the smallest marked subdivision for an analog readout. For a digital readout it is the smallest value record by the read out (e.g., if the readout is 95.6 then the uncertainty is 0.1). (Typically can be ignore for most MCAs.)

MDA is the minimum detectable amount (a.k.a., minimum detectable activity) value for the measurement system. This can be computed as described in NUREG-CR-5849, NUREG-1506, or in a specifically reference technical document included in with the calculation. If the MDA is assigned a distribution of values based on a technical defensible scientific approach this value should be set to zero in the calculation of UNC.

UMDA is the 95% confidence level uncertainty in the MDA value if calculated.

Variability of the natural environment and the materials being measured is based on characterization by multiple measurement of the environment, either background or sample/location variability for the area of interest. (Note, in counting statistic count for extended times is the same as making multiple counts in this extended time.) The 95% confidence level uncertainty for the entire set of values generated

If there is a known **inherent bias in the measurement or measure data set** this value should be subtracted out of the result. If the bias is not known then it is presumed to be adequately addressed in the **measurement error inherent in the equipment.** If there is a known bias it should be removed prior to determining the **measurement error inherent in the equipment.**

The **statistical variability or inhomogeneity in the item or area being measured** is extremely difficult to assess accept as partially quantified in the **variability of the natural environment and the materials.** Typically the balance of this uncertainty can only be addressed qualitatively.

9.1 Minimum Detectable Amount (MDA)

It is important to quantify the Minimum Detectable Amount (MDA) that the in-situ spectroscopy is capable of detecting to determine if the DCGLs can be met using this technology. To do this one must consider that the in-situ equipment is used to count a specific location for longer times than the 1 minute scalar static count that is used with survey instrumentation. The MDA is estimated using the following equation from NUREG/CR-5849, "Manual for Conducting Radiological Surveys in Support of License Termination".

$$\mathrm{MDA} = \frac{2.71 + 4.65 * \sqrt{B_R * t}}{t * E * \frac{A}{100}}$$

- Where:MDA is the minimum detectable amount in dpm/100 cm^2
- B_R is the background count rate in cpm
- t is the count time in minutes
- E is the efficiency of the detector in cpm/dpm
- A is the active area of the detector in cm^2

Using this equation with the detector information the MDA values for various count times and detectors can be estimated. The use of the ROI has the net effect of lowering the background count rate for that specific region. Radionuclide specific efficiencies and associated MDAs can be developed for other radionuclides as needed. Other formulas such as those in NUREG-1506 can be used to estimate the MDA. The basis used for assessing the MDA should be clearly documented. In addition, it is equally important to document how the MDA is used in subsequent analyses.

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QA-19.2, *Quality Assurance Procedure, Computer Software Verification and Validation*, Parsons Infrastructure and Technology Group, Inc., Richland, Washington, current version or equivalent Project specific nonconformance procedure..

APPENDIX A

Datasheets

Parsons	LSR Listing		GD-R-MCA-1-1-____________
Initiated By (print)	Signature	Date	Sheet _____ of _____

Name	Radionuclide followed by energies in MeV in parenthesis	Radiation Type	Source of Information	Established by					
				Developed By:			Verified		
				Print	Signature	Date	Print Initials	Initial	Date

Source Reference

ID.	Description
1	U.S. Department of *Energy 's National Nuclear Data Center (NNDC)* at Brookhaven National Laboratory (access is available through the internet)
2	David Kocher's *Radioactive Decay Data Tables* (DOE/TIC-11026)
3	ICRP,s (International Commission on Radiation Protection) *Radionuclide Transformations Energy and Intensity of Emission*, Annals of the ICRP, ICRP Publication 38

Parsons	Radionuclide Identification Worksheet					GD-R-MCA-1-2-____________		
Quantification Required	Yes		No		If "Yes" include a page 2 for each sheet	Sheet _____ of _____		Page 1

Peak		Sample Filename	LSR:		Radionuclide		
Channel	Energy (keV)		Background Filename	Basis	Primary		Alternative (in order)
					Id.	Fraction	Id.

Comments:

Completed by (print)		Completed by (signature)		Date	

Authorized For Use

PHP (Print)		PHP Signature		Date:	

Data Verified

HP (Print)		HP Signature		Date:	

Parsons	Radionuclide Identification Worksheet	GD-R-MCA-1-2-____________

Quantification Required	Yes		No		Mass of sample (g) (if applicable): ________	New LSR (optional):	Sheet _____ of _____	Page 2

Peak Energy (keV) used			ROI (Optional)	Radionuclide	Correction Factor (if applicable)				Activity	
1st	2nd	3rd			CF_g (units?) ________	Source (cal. #)	CF_v (units?) ________	Source (doc. # or cal. #)	URSA (units?)	Net (units?).

Comments:

Completed by (print)		Completed by (signature)		Date	
Authorized For Use					
PHP (Print)		PHP Signature		Date:	
Data Verified					
HP (Print)		HP Signature		Date:	