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GAMMA-RAY SPECTRA OF THE PRODUCTS OF FAST NEUTRON FISSION OF U^{235} AND U^{238} AT SELECTED TIMES AFTER FISSION

by

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ABSTRACT

Experimental measurements of the gamma-ray pulse height distributions due to the products of fast-neutron-induced fission of U^{235} and U^{238} are presented. The measurements were made at nine selected times after fission from 15 minutes to 3 days. Irradiation times and counting intervals were chosen to minimize saturation and decay effects.

The experimental data were used to calculate 100 energy bin distributions of the absolute number of photons/fission-sec. by means of absolute calibrations of the collimated NaI(Tl) detector. The number of fissions in each sample was determined radiochemically. Machine computation was used extensively.

SUMMARY

Problem

Values of exposure rates from fission product sources have been determined from gamma-ray spectra measured from very shortly after the instant of fission to about 25 minutes post-fission. Prior to this work no experimental information existed for later times. Values of exposure rates have been calculated from fission yield and decay scheme information on the individual fission products at times from 30 minutes post-fission to much later. A discrepancy of nearly a factor of two exists between extrapolations of the two kinds of information. Because of the importance of this exposure rate information to fallout studies and casualty prediction capabilities, it was desired to establish reliably the value of the exposure rate per deposited fission per unit area as a function of time.

The method chosen was to measure the gamma-ray spectra of the products of fast neutron fission of U^{235} and U^{238} at selected times after fission. The post-fission times selected were 1/4, 1/2, 1, 2, 5, 10, 24, 48, and 72 hours. Emphasis was put on the 1 hour time, as it is widely used for normalization of fallout fields.

Findings

Gamma-ray spectra from the products of fast neutron fission of U^{235} and U^{238} have been measured. By calibration of the NaI(Tl) detector with calibrated sources, radiochemical determination of the number of fissions in each sample, and the use of suitable machine computation, the energy bin distribution of the absolute number of photons/fission-sec has been obtained.

This is fundamentally useful information, and it will be used to calculate exposure rates and normalization factors, which will be subsequently reported.

INTRODUCTION

The work described in this report was initiated to provide basic experimental information on the gamma-ray spectra of the gross fission products of uranium as a function of time after fission. Although this information has a wide variety of uses, it was sought here primarily to resolve a discrepancy between the extrapolations of exposure rates per deposited fission per unit area that had been calculated from experimental vs. computed gamma-ray spectra.

Any calculation of exposure from fallout requires a knowledge of the exposure rate resulting from a known spectral distribution from fission products on the ground. The spectral distribution changes in intensity and energy distribution with time. To permit the comparison of exposure rates measured under various conditions a normalization factor is commonly used in fallout studies. This factor gives the exposure rate, in roentgens per hour per kiloton-equivalent of unfractionated fission products per square mile ($R/hr\text{-}KT\text{-}mi^2$), at a point three feet above a uniformly contaminated infinite smooth plane at a given time after fission. The exposure rate for these conditions can be calculated from experimental measurements of gamma-ray spectra, or from computed gamma-ray spectra. A number of calculations of both types have been carried out, and these have been reviewed by Keith and Shelton.[1]

Only two sets of experimental data[2,3] of gamma-ray spectra have been widely utilized. One[2] of these extends for approximately 25 minutes after fission and the other[3] for only 45 seconds. The gamma-ray spectra which have been computed from fission yield and decay scheme information are usually given[4,5] for times of 30 minutes to very long times after fission. The exposure rates calculated from the computed spectra are given for the same time interval. The method used in the calculations of computed spectra suffers from the uncertainties in the yields and decay schemes of many of the important short-lived fission products.

Extrapolations to a common point of the logarithm of the normalization factor obtained from the two types of determination show poor agreement when plotted against the logarithm of time after fission. Furthermore, the computation of gamma-ray spectra cannot profitably be

extended to earlier times because of increasing uncertainties in the input data. Resolving the discrepancy required expanding the experimental measurements of the gamma-ray spectra to provide overlap of experimental and computed data.

In the planning of the experimental work, a number of factors were considered. For one thing, the time of greatest interest from an operational viewpoint is usually considered to be one hour post-fission; many computations relating to fallout studies involve quantities measured at one hour post-fission. As mentioned above, it was necessary to overlap the times at which experimental and computed spectral information existed. A further consideration was that the measurements be performed on unfractionated fission product mixtures that are similar to the detonation products of nuclear weapons.*

To accommodate these requirements, gamma-ray spectra were measured at selected times from 15 minutes to 3 days after fission, including 1 hour post-fission. Also, the products of fast-neutron fission of both U^{235} and U^{238} were used to simulate debris from fission and thermonuclear weapons.

The gamma-ray spectra measured in this work are of considerable interest in shielding work and from a more fundamental point of view, in the physics of fission.

EXPERIMENTAL

In the experimental portion of this work, the pulse-height distributions due to the gamma-rays of the fission products of both U^{235} and U^{238} samples were measured with a calibrated detector at nine specified times after irradiation with fast neutrons. Irradiations were carried out in duplicate at separate times with samples not previously irradiated.

The main steps in the experimental procedure were: (1) assembly of detector, shield, and pulse height analyzer, (2) calibration of the detector, (3) preparation of the samples, (4) irradiation and counting of the samples to obtain pulse height distributions, (5) readout of the data in a form suitable for machine computation, and (6) radiochemical

*An extension of the present work to fractionated mixtures is in progress at this Laboratory, under the sponsorship of the Office of Civil Defense.

determination of the number of fission events in each sample.

The calibration of the detector was an important and lengthy task, but a description of it is not essential to an understanding of the experiments. Consequently, it is described in Appendix A of this report. The other steps in the experimental procedure mentioned above are described below.

Detector, Shield and Pulse Height Analyzer Assembly

The detector of the pulse-height analysis system consists of a 5-in. diameter by 5-in. long NaI(Tl) cylindrical crystal optically coupled to the photocathode of an RCA type 8054 3-in. diameter photomultiplier tube. The unit is a Matched Window Assembly from the Harshaw Chemical Company. The plastic base of the phototube was removed and a voltage divider string was included in a stainless steel cup for ease of connection to the other equipment.

The lead shield for the detector has the shape of an ellipsoid with external dimensions of 17 inches in diameter and 28 inches long. The lead varies in thickness from 4 inches around the phototube base to 5 inches at the sides, to a maximum of 9-5/16 inches on the source side of the detector. A 1/4-inch steel shell encloses the lead.

The shield has a collimator coaxial with the crystal, a cylindrical hole 1/2 inch in diameter and 8-3/8 inches long. A cylindrical polyethylene block, 2-3/8 inches in diameter and 1-11/16 inches thick is placed over the collimator in a recess in the lead shield. This plastic block removes almost all of the beta-rays emitted by the fission product samples without appreciably attenuating the gamma-rays.

The shield assembly is placed in a steel yoke fitted with a device to permit the orientation of the collimator relative to the zenith. All measurements were made with the collimator pointing straight up since this gave the least backscattering of the gamma-rays emitted by the samples.

Operating high voltage for the phototube is provided through an external high voltage DC supply, model 412A, purchased from the John Fluke Manufacturing Co., Inc. The output signal of the photomultiplier tube is fed to an external cathode follower preamplifier and then into a linear amplifier, Model 901A, Cosmic Radiation Lab. Inc. The amplified pulses are then analyzed for height in a model CN-1024 1024-channel Pulse Height Analyzer System produced by Technical Measurements Corporation.

The analyzer system included a pulse height logic unit, Model 210B, a magnetic tape recorder, and its associated buffer storage control,

Model 221. The logic unit provided better linearity of response than the more commonly used Model 210. The tape recorder provided temporary data storage and fast readout of the analyzer. Each pulse-height distribution was identified by a tag-word generator which utilizes the first eight channels of the ferrite core memory, and consequently no data are recorded in these channels. This identification was carried through the magnetic tape readout to the card readout described in the section on data output.

The entire detector, shield and pulse-height analyzer assembly was mounted in a mobile laboratory trailer which permitted the placement of the system near the accelerator at which the irradiations were carried out. This was necessary for the counting of the samples at relatively short times after irradiation.

Sample Preparation

The samples for the spectral measurements were pieces of uranium metal foil 0.038 mm thick and about 0.8 cm^2 in area, weighing approximately 40 mg. each. Spectrographic analysis showed the material was 99.8% pure uranium. The U^{235} utilized had an abundance of 93.2% of the mass 235 isotope, while the U^{238} consisted of more than 99.9% of the mass 238 isotope. Packaging for irradiation and counting was designed to prevent the escape of the volatile fission products from the samples. Each foil piece was heat-sealed in polyvinyl alcohol film thick enough, 0.003 in., to stop all fission fragments within the plastic. The polyvinyl alcohol wrapping was trimmed down to the circular sealed area and the entire packet was then hermetically sealed between two layers of 0.004 inch thick polyethylene film.

Irradiation and Counting of Samples

The samples were irradiated at the 45-MeV electron linear accelerator of the General Atomic Division of General Dynamics, Inc., at La Jolla, California. This accelerator produces a high flux of fast neutrons over a small area by means of a water-cooled neutron converter. During irradiation the samples were fastened to the neutron converter in a central position. With this configuration, fluxes of up to 10^{12} neutrons/cm^2-sec were obtained. The neutrons, which are produced by the (γ,n) and (γ,pn) reactions in the converter after the accelerated electrons are converted to gamma-rays, have a spectrum that is similar to that of the neutrons produced in the fission process.[6] A radiochemical analysis for Np^{239}, formed by (n,γ) reactions on U^{238}, compared to the number of fissions in the same sample showed that the thermal neutron background was less than 0.001 of the fast neutron flux.

In Table 1 are given the lengths of the various irradiations and

the counting times of the pulse-height distributions. Duplicate measurements under the same conditions were made on the products of fission of both fissile nuclides. The durations of the shorter irradiations and the corresponding counting intervals were chosen to provide good counting statistics and yet to minimize saturation effects during irradiation and decay effects during counting. The lengths of the longer irradiations were limited by transportation and scheduling requirements and by the cost of accelerator time. It was found to be possible to obtain at more than one time of interest after fission pulse-height distributions from the samples irradiated for longer times.

TABLE 1

Irradiation and Counting Times

Length of Irradiation (min)	Period of Count (after midpoint of irradiation) (min)
2	14-16
4	28-32
7	56.5-63.5
15	112.5-127.5
40	285-315
	570-630
120	1365 - 1515
	2730 - 3030
	4095 - 4545

The time intervals given in Table 1 were measured relative to the beginning of each irradiation with a stopwatch or electric clock. The pulse-height analyzer had an appreciable and variable dead time associated with its operation. The actual amount of time available for measurement during the counting intervals was obtained from a live timer gated by the analyzer.

The samples were counted as follows. The samples were trimmed of excess polyethylene and fastened flat on a thin polyethylene sheet interposed between the sample and the absorber to prevent any contamination and stretched tightly over the polyethylene β-ray absorber.

The samples were positioned exactly in the center of the absorber to obtain reproducible geometry.

Data Output

The pulse-height data was recorded in a ferrite core memory in the analyzer. These data were rapidly transferred to magnetic tape for storage. As the tape could not be read into a computer, the pulse-height distribution data had to be put into a form suitable for processing by the IBM-704 at this Laboratory. The tape was read back into the memory of a similar pulse-height analyzer which then read out the data through an IBM-523 Gang Summary Punch on punched cards.[7]

Fission Determinations

Determination of the number of fission events produced in each sample was accomplished by post-counting radiochemical measurements of Mo^{99} in the sample and its associated polyvinyl alcohol wrapping. The polyvinyl alcohol film contained fission fragments emitted from the surface of the uranium sample. Previously determined calibration factors permitted conversion of the results of Mo^{99} analyses to the absolute number of fissions in each sample with an estimated error of about $\pm$ 5%.

DATA HANDLING AND RESULTS

The basic experimental information obtained in this work consisted of the pulse-height distributions due to the gamma-rays emitted by the products of fast neutron fission of U^{235} and U^{238}. These measurements were made in duplicate at time intervals such that the midpoint was 1/4, 1/2, 1, 2, 5, 10, 24, 48 and 72 hours after the midpoint of an irradiation. The irradiations were short compared to the elapsed time until counting.

Corrections were applied to the unprocessed data in preparation for their normalization and subsequent unfolding into corresponding gamma-ray spectra. A pulse-height distribution corresponding to the ambient background was subtracted. Where it was appropriate (at times of 2 hours or less after fission), a blank corresponding to the radioactivity induced in the plastic wrappings of the samples was subtracted. This blank was due almost entirely to the C^{11} formed by (γ,n) and $(n,2n)$ reactions on C^{12} in the plastic materials. In the U^{238} samples these nuclear reactions give rise to 6.7 day U^{237}. The gamma-rays from the decay of U^{237} have low energies, and can be neglected at the shorter

times after fission. However, they become important at about 1 day after fission. This last correction was made by calibrating the detector for a known amount of U^{237} and measuring radiochemically the amount of U^{237} present in the U^{238} samples counted at 24, 48 and 72 hours.

After the corrections were applied, all of the pulse-height distributions were normalized on the basis of the radiochemically-determined number of fissions produced in each sample.

The normalization of the pulse-height distributions to net counts per channel per fission permitted the comparison of the duplicate results. Figure 1 shows the corrected duplicate pulse-height distributions of the fission products of U^{235} at 1 hour after fission. The general agreement of the two distributions is seen to be excellent. This degree of agreement was usual. However, the most divergent sets of duplicates differed from one another by approximately 10% overall. Each set of duplicate (in two cases, triplicate) pulse-height distributions was then averaged to smooth these small differences.

The pulse-height distributions were unfolded into gamma-ray spectra by an iteration technique, which is described by Hubbell and Scofield[8] and Scofield.[9] The unfolding is accomplished with the aid of an IBM-704 computer. The essential features of the unfolding programs are given by Smith and Scofield.[10] However, their program was modified extensively so that it could handle 1024 channels and 100 energy bins.

The pulse-height distributions from known amounts of individual gamma-rays were unfolded as a check on the calibration and technique. The results of this check are shown in Table 2.

As a further demonstration of the technique and to obtain insight into the effects of interaction of gamma-rays in the unfolding process, the pulse-height distributions of two known mixtures of gamma-rays were processed. The gamma-rays were present in equal abundances. The results are given in Table 3.

In all cases the unfolded results showed the largest portion of each of the gamma-rays in the correct energy bin with smaller portions in the immediately adjacent bins.

In Table 4 the mid-bin energies and width of each of the 100 energy bins selected are listed. The results of the unfoldings for the products of U^{235} fission are given in Tables 5 through 13 for 1/4, 1/2, 1, 2, 5, 10, 24, 48 and 72 hours after fission. The data for the products of U^{238} fission are given in Tables 14 through 22 for the same times after fission. The format is that of the computer readout (e.g. E-03 is read 10^{-3}).

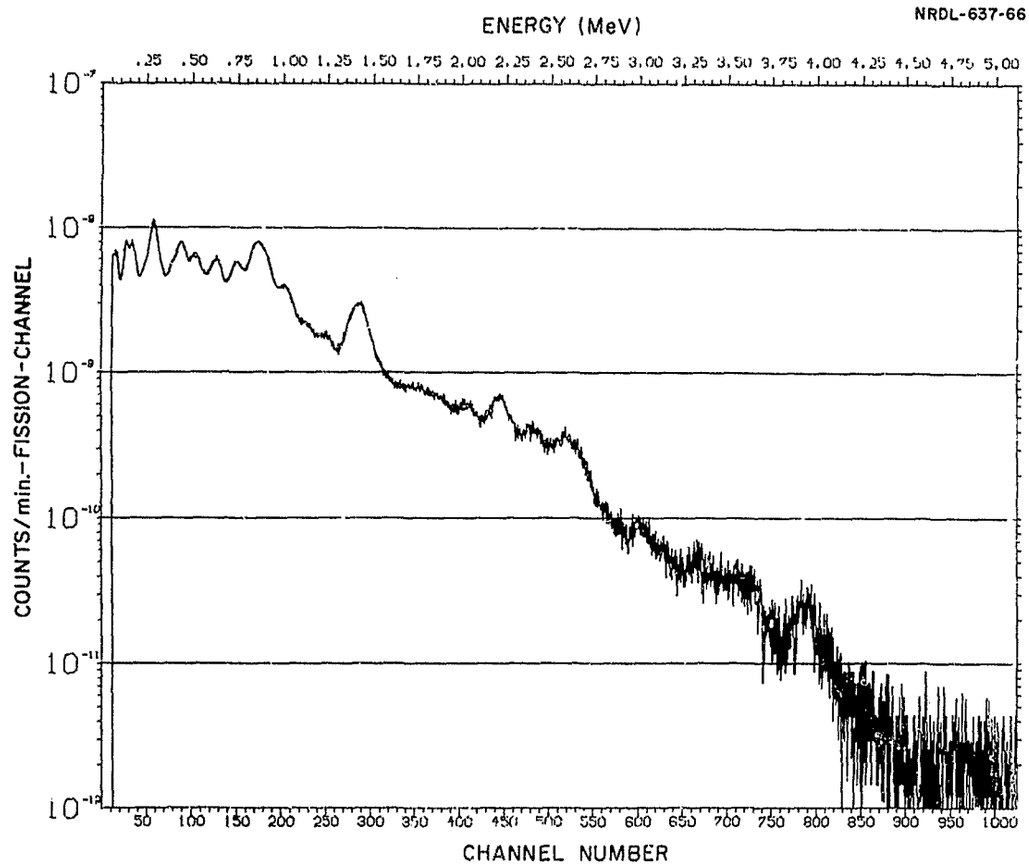


Fig. 1 Duplicate Pulse-Height Distributions from Products of U^{235} Fission at 1 Hour after Fission

TABLE 2

Unfolding of Known Amounts of Individual Gamma-Rays

Gamma-Ray Energy (MeV)	Radionuclide	Calculated/Added
0.145	Ce^{141}	1.192
0.279	Hg^{203}	0.946
0.325	Cr^{51}	1.095
0.514	Sr^{85}	1.013
0.662	Cs^{137}	1.072
0.768	Nb^{95}	1.047
1.12	Zn^{65}	1.123
1.38	Na^{24}	1.129
1.52	K^{42}	0.958
2.75	Na^{24}	1.158
	Average	1.073 ± 0.082

TABLE 3

Unfolding of Known Mixtures of Equally Abundant Gamma-Rays

Mixture No. 1		Mixture No. 2	
Gamma-Ray Energy (MeV)	Calculated/Added	Gamma-Ray Energy (MeV)	Calculated/Added
0.279	1.104	0.279	1.105
0.325	1.072	0.325	1.056
1.38	1.104	0.662	1.070
1.52	0.896	1.38	1.091
2.75	1.148	1.52	0.888
		2.75	1.140
Average	1.065 ± 0.098	Average	1.058 ± 0.088

Table 4

Energy and Width of Energy Bins

Bin No.	Mid-bin Energy (MeV)	Width (MeV)	Bin No.	Mid-bin Energy (MeV)	Width (MeV)
1	0.07	0.01	51	1.470	0.05
2	0.08	0.01	52	1.520	0.05
3	0.09	0.01	53	1.570	0.05
4	0.10	0.01	54	1.620	0.05
5	0.11	0.01	55	1.670	0.05
6	0.12	0.01	56	1.720	0.05
7	0.13	0.01	57	1.770	0.05
8	0.14	0.01	58	1.820	0.05
9	0.15	0.01	59	1.870	0.05
10	0.16	0.01	60	1.925	0.06
11	0.17	0.01	61	1.985	0.06
12	0.18	0.01	62	2.045	0.06
13	0.19	0.01	63	2.105	0.06
14	0.20	0.01	64	2.165	0.06
15	0.215	0.02	65	2.225	0.06
16	0.235	0.02	66	2.285	0.06
17	0.255	0.02	67	2.345	0.06
18	0.275	0.02	68	2.405	0.06
19	0.295	0.02	69	2.465	0.06
20	0.315	0.02	70	2.525	0.06
21	0.335	0.02	71	2.585	0.06
22	0.355	0.02	72	2.645	0.06
23	0.375	0.02	73	2.705	0.06
24	0.395	0.02	74	2.770	0.07
25	0.420	0.03	75	2.840	0.07
26	0.450	0.03	76	2.910	0.07
27	0.480	0.03	77	2.980	0.07
28	0.510	0.03	78	3.050	0.07
29	0.540	0.03	79	3.120	0.07
30	0.570	0.03	80	3.190	0.07
31	0.600	0.03	81	3.265	0.08
32	0.630	0.03	82	3.345	0.08
33	0.665	0.04	83	3.425	0.08
34	0.705	0.04	84	3.505	0.08
35	0.745	0.04	85	3.[illegible]5	0.08
36	0.785	0.04	86	3.665	0.08
37	0.825	0.04	87	3.750	0.09
38	0.865	0.04	88	3.840	0.09
39	0.905	0.04	89	3.930	0.09
40	0.945	0.04	90	4.020	0.09
41	0.985	0.04	91	4.115	0.10
42	1.025	0.04	92	4.215	0.10
43	1.070	0.05	93	4.315	0.10
44	1.120	0.05	94	4.415	0.10
45	1.170	0.05	95	4.515	0.10
46	1.220	0.05	96	4.615	0.10
47	1.270	0.05	97	4.715	0.10
48	1.320	0.05	98	4.820	0.11
49	1.370	0.05	99	4.930	0.11
50	1.420	0.05	100	5.040	0.11

TABLE 5

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 15 MINUTES AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.1117E-04	51	0.9833E-05
2	0.6068E-05	52	0.6198E-05
3	0.1169E-04	53	0.5045E-05
4	0.4261E-05	54	0.5722E-05
5	0.4381E-05	55	0.7218E-05
6	0.2036E-05	56	0.7471E-05
7	0.3234E-05	57	0.6741E-05
8	0.9105E-05	58	0.4971E-05
9	0.5964E-05	59	0.4319E-05
10	0.5686E-05	60	0.4552E-05
11	0.1185E-04	61	0.7633E-05
12	0.1407E-04	62	0.6976E-05
13	0.8255E-05	63	0.4093E-05
14	0.7082E-05	64	0.7638E-05
15	0.8669E-05	65	0.8494E-05
16	0.1200E-04	66	0.3500E-05
17	0.2422E-04	67	0.2435E-05
18	0.8911E-05	68	0.2357E-05
19	0.3622E-04	69	0.2380E-05
20	0.2338E-04	70	0.3637E-05
21	0.1228E-04	71	0.4967E-05
22	0.1297E-04	72	0.4036E-05
23	0.6950E-05	73	0.2671E-05
24	0.8454E-05	74	0.1656E-05
25	0.2004E-04	75	0.1077E-05
26	0.2512E-04	76	0.7178E-06
27	0.1328E-04	77	0.6858E-06
28	0.3209E-04	78	0.8314E-06
29	0.1075E-04	79	0.8552E-06
30	0.1809E-04	80	0.8357E-06
31	0.2405E-04	81	0.8752E-06
32	0.1308E-04	82	0.8354E-06
33	0.1418E-04	83	0.7146E-06
34	0.1801E-04	84	0.8331E-06
35	0.2053E-04	85	0.8758E-06
36	0.1969E-04	86	0.6102E-06
37	0.2364E-04	87	0.4429E-06
38	0.3671E-04	88	0.4211E-06
39	0.3734E-04	89	0.4571E-06
40	0.2711E-04	90	0.4737E-06
41	0.1182E-04	91	0.4166E-06
42	0.2939E-04	92	0.3320E-06
43	0.1482E-04	93	0.2778E-06
44	0.1279E-04	94	0.2496E-06
45	0.1139E-04	95	0.2224E-06
46	0.1850E-04	96	0.2216E-06
47	0.2112E-04	97	0.2322E-06
48	0.7712E-05	98	0.2422E-06
49	0.1170E-04	99	0.2574E-06
50	0.1755E-04	100	0.3217E-06
		TOTAL	0.9083E-03

TABLE 6

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 30 MINUTES AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.5999E-05	51	0.7531E-05
2	0.3175E-05	52	0.3191E-05
3	0.5710E-05	53	0.3160E-05
4	0.2261E-05	54	0.2663E-05
5	0.1920E-05	55	0.2668E-05
6	0.1048E-05	56	0.3459E-05
7	0.3007E-05	57	0.3422E-05
8	0.5213E-05	58	0.2640E-05
9	0.3541E-05	59	0.2293E-05
10	0.3406E-05	60	0.2384E-05
11	0.6111E-05	61	0.3646E-05
12	0.7207E-05	62	0.3733E-05
13	0.4735E-05	63	0.2027E-05
14	0.4093E-05	64	0.3215E-05
15	0.3524E-05	65	0.5121E-05
16	0.5347E-05	66	0.2324E-05
17	0.1068E-04	67	0.1302E-05
18	0.5090E-05	68	0.1370E-05
19	0.2434E-04	69	0.1434E-05
20	0.1448E-04	70	0.1859E-05
21	0.5914E-05	71	0.2731E-05
22	0.6977E-05	72	0.2386E-05
23	0.3191E-05	73	0.1239E-05
24	0.5314E-05	74	0.5694E-06
25	0.8993E-05	75	0.3947E-06
26	0.1621E-04	76	0.3382E-06
27	0.6098E-05	77	0.3448E-06
28	0.1701E-04	78	0.3853E-06
29	0.8823E-05	79	0.3683E-06
30	0.6653E-05	80	0.3250E-06
31	0.8186E-05	81	0.2934E-06
32	0.9983E-05	82	0.2504E-06
33	0.9404E-05	83	0.2334E-06
34	0.5020E-05	84	0.2724E-06
35	0.1366E-04	85	0.2852E-06
36	0.9727E-05	86	0.2151E-06
37	0.9595E-05	87	0.1513E-06
38	0.2010E-04	88	0.1392E-06
39	0.2114E-04	89	0.1542E-06
40	0.1534E-04	90	0.1566E-06
41	0.5412E-05	91	0.1369E-06
42	0.1599E-04	92	0.1093E-06
43	0.8424E-05	93	0.9293E-07
44	0.5580E-05	94	0.8682E-07
45	0.6054E-05	95	0.8275E-07
46	0.8233E-05	96	0.8469E-07
47	0.1038E-04	97	0.8924E-07
48	0.3505E-05	98	0.9332E-07
49	0.5168E-05	99	0.1019E-06
50	0.1431E-04	100	0.1309E-06
		TOTAL	0.4830E-03

TABLE 7

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 1 HOUR AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.2211E-05	51	0.4130E-05
2	0.1180E-05	52	0.1319E-05
3	0.2264E-05	53	0.1113E-05
4	0.6790E-06	54	0.9455E-06
5	0.6184E-06	55	0.9115E-06
6	0.3512E-06	56	0.1089E-05
7	0.1463E-05	57	0.1199E-05
8	0.3239E-05	58	0.1166E-05
9	0.1857E-05	59	0.1091E-05
10	0.1460E-05	60	0.9079E-06
11	0.2339E-05	61	0.1004E-05
12	0.2773E-05	62	0.1130E-05
13	0.1579E-05	63	0.6802E-06
14	0.1456E-05	64	0.1144E-05
15	0.1243E-05	65	0.2119E-05
16	0.1690E-05	66	0.9387E-06
17	0.2957E-05	67	0.6671E-06
18	0.2283E-05	68	0.9551E-06
19	0.9301E-05	69	0.8055E-06
20	0.5156E-05	70	0.7788E-06
21	0.2001E-05	71	0.1053E-05
22	0.1790E-05	72	0.9600E-06
23	0.1196E-05	73	0.5114E-06
24	0.2638E-05	74	0.2128E-06
25	0.3323E-05	75	0.1481E-06
26	0.7692E-05	76	0.1451E-06
27	0.2860E-05	77	0.1590E-06
28	0.4169E-05	78	0.1644E-06
29	0.4835E-05	79	0.1386E-06
30	0.2025E-05	80	0.1091E-06
31	0.1748E-05	81	0.9384E-07
32	0.5388E-05	82	0.8655E-07
33	0.4482E-05	83	0.7540E-07
34	0.1305E-05	84	0.7069E-07
35	0.7501E-05	85	0.6550E-07
36	0.4096E-05	86	0.5542E-07
37	0.4875E-05	87	0.4601E-07
38	0.1193E-04	88	0.4635E-07
39	0.8802E-05	89	0.4953E-07
40	0.4717E-05	90	0.4496E-07
41	0.2373E-05	91	0.3741E-07
42	0.5806E-05	92	0.3209E-07
43	0.2781E-05	93	0.3089E-07
44	0.2585E-05	94	0.3134E-07
45	0.2088E-05	95	0.3062E-07
46	0.2134E-05	96	0.3118E-07
47	0.2554E-05	97	0.3315E-07
48	0.1000E-05	98	0.3524E-07
49	0.2706E-05	99	0.3877E-07
50	0.8691E-05	100	0.4964E-07
		TOTAL	0.1949E-03

TABLE 8

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 2 HOURS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.7464E-06	51	0.8776E-06
2	0.3831E-06	52	0.4290E-06
3	0.7148E-06	53	0.3570E-06
4	0.1767E-06	54	0.2797E-06
5	0.1500E-06	55	0.2978E-06
6	0.1478E-06	56	0.3833E-06
7	0.6166E-06	57	0.4484E-06
8	0.1188E-05	58	0.5292E-06
9	0.8264E-06	59	0.4803E-06
10	0.6607E-06	60	0.2874E-06
11	0.5867E-06	61	0.2620E-06
12	0.5753E-06	62	0.3019E-06
13	0.4758E-06	63	0.2267E-06
14	0.4688E-06	64	0.4013E-06
15	0.3939E-06	65	0.5094E-06
16	0.7427E-06	66	0.2160E-06
17	0.8192E-06	67	0.3179E-06
18	0.6251E-06	68	0.6701E-06
19	0.1669E-05	69	0.3885E-06
20	0.1060E-05	70	0.2912E-06
21	0.4594E-06	71	0.3458E-06
22	0.2085E-06	72	0.2487E-06
23	0.3805E-06	73	0.1202E-06
24	0.1313E-05	74	0.6001E-07
25	0.9874E-06	75	0.5354E-07
26	0.2149E-05	76	0.6027E-07
27	0.7560E-06	77	0.6726E-07
28	0.1064E-05	78	0.6120E-07
29	0.1971E-05	79	0.4164E-07
30	0.6687E-06	80	0.3028E-07
31	0.5053E-06	81	0.2701E-07
32	0.2716E-05	82	0.2546E-07
33	0.1853E-05	83	0.2232E-07
34	0.5191E-06	84	0.1933E-07
35	0.3452E-05	85	0.1714E-07
36	0.1210E-05	86	0.1540E-07
37	0.2662E-05	87	0.1352E-07
38	0.6217E-05	88	0.1304E-07
39	0.2558E-05	89	0.1266E-07
40	0.1126E-05	90	0.1115E-07
41	0.8930E-06	91	0.9852E-08
42	0.1475E-05	92	0.9213E-08
43	0.9574E-06	93	0.9108E-08
44	0.1325E-05	94	0.9177E-08
45	0.5762E-06	95	0.9177E-08
46	0.4542E-06	96	0.9683E-08
47	0.5071E-06	97	0.1060E-07
48	0.2769E-06	98	0.1138E-07
49	0.2024E-05	99	0.1260E-07
50	0.3183E-05	100	0.1631E-07
		TOTAL	0.6680E-04

TABLE 9

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 5 HOURS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.2098E-06	51	0.7823E-07
2	0.1972E-06	52	0.1377E-06
3	0.3232E-06	53	0.1524E-06
4	0.7822E-07	54	0.8378E-07
5	0.6725E-07	55	0.1119E-06
6	0.6489E-07	56	0.1515E-06
7	0.2418E-06	57	0.1660E-06
8	0.4409E-06	58	0.2480E-06
9	0.2647E-06	59	0.2436E-06
10	0.1146E-06	60	0.9791E-07
11	0.1150E-06	61	0.6746E-07
12	0.2177E-06	62	0.1019E-06
13	0.1509E-06	63	0.8998E-07
14	0.1028E-06	64	0.1161E-06
15	0.2308E-06	65	0.1310E-06
16	0.8559E-06	66	0.5845E-07
17	0.3526E-06	67	0.8945E-07
18	0.2277E-06	68	0.3501E-06
19	0.3852E-06	69	0.2370E-06
20	0.1765E-06	70	0.8280E-07
21	0.1281E-06	71	0.6548E-07
22	0.7063E-07	72	0.5297E-07
23	0.9087E-07	73	0.3217E-07
24	0.3288E-06	74	0.1859E-07
25	0.2689E-06	75	0.1549E-07
26	0.2393E-06	76	0.1724E-07
27	0.1582E-06	77	0.1878E-07
28	0.5808E-06	78	0.1780E-07
29	0.1461E-05	79	0.1241E-07
30	0.2243E-06	80	0.8468E-08
31	0.4830E-07	81	0.7074E-08
32	0.1024E-05	82	0.6240E-08
33	0.1432E-05	83	0.5434E-08
34	0.1109E-06	84	0.4933E-08
35	0.1636E-05	85	0.4692E-08
36	0.4564E-06	86	0.4328E-08
37	0.6254E-06	87	0.3682E-08
38	0.1393E-05	88	0.3248E-08
39	0.7280E-06	89	0.2958E-08
40	0.5033E-06	90	0.2737E-08
41	0.2083E-06	91	0.2693E-08
42	0.5385E-06	92	0.2661E-08
43	0.3426E-06	93	0.2592E-08
44	0.5493E-06	94	0.2559E-08
45	0.2821E-06	95	0.2610E-08
46	0.1420E-06	96	0.2875E-08
47	0.3833E-06	97	0.3288E-08
48	0.5844E-07	98	0.3688E-08
49	0.1034E-05	99	0.4188E-08
50	0.1144E-05	100	0.5357E-08
		TOTAL	0.2414E-04

TABLE 10

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 10 HOURS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.1092E-06	51	0.4620E-07
2	0.1425E-06	52	0.4018E-07
3	0.1778E-06	53	0.2823E-07
4	0.2634E-07	54	0.3102E-07
5	0.2861E-07	55	0.6089E-07
6	0.6667E-07	56	0.6862E-07
7	0.2228E-06	57	0.6545E-07
8	0.1508E-06	58	0.8139E-07
9	0.3146E-07	59	0.5788E-07
10	0.2045E-07	60	0.2561E-07
11	0.4248E-07	61	0.2068E-07
12	0.8590E-07	62	0.2274E-07
13	0.4282E-07	63	0.2179E-07
14	0.3757E-07	64	0.2699E-07
15	0.2152E-06	65	0.2524E-07
16	0.8636E-06	66	0.2152E-07
17	0.1365E-06	67	0.4098E-07
18	0.1661E-06	68	0.7271E-07
19	0.1726E-06	69	0.3382E-07
20	0.4632E-07	70	0.1122E-07
21	0.6459E-07	71	0.6750E-08
22	0.6209E-07	72	0.5853E-08
23	0.2536E-07	73	0.5158E-08
24	0.3650E-07	74	0.4147E-08
25	0.8773E-07	75	0.3787E-08
26	0.9399E-07	76	0.3530E-08
27	0.3005E-07	77	0.2915E-08
28	0.5730E-06	78	0.2330E-08
29	0.8675E-06	79	0.1916E-08
30	0.3607E-07	80	0.1644E-08
31	0.5838E-08	81	0.1467E-08
32	0.5351E-06	82	0.1271E-08
33	0.7897E-06	83	0.1139E-08
34	0.1097E-06	84	0.1076E-08
35	0.1052E-05	85	0.1012E-08
36	0.1487E-06	86	0.9568E-09
37	0.2044E-06	87	0.8956E-09
38	0.1233E-06	88	0.8603E-09
39	0.2131E-06	89	0.8434E-09
40	0.1995E-06	90	0.8356E-09
41	0.9192E-07	91	0.8441E-09
42	0.2901E-06	92	0.8532E-09
43	0.1026E-06	93	0.8839E-09
44	0.2380E-06	94	0.9199E-09
45	0.8232E-07	95	0.9764E-09
46	0.1007E-06	96	0.1101E-08
47	0.2094E-06	97	0.1281E-08
48	0.4706E-07	98	0.1449E-08
49	0.3429E-06	99	0.1655E-08
50	0.2669E-06	100	0.2080E-08
		TOTAL	0.1068E-04

TABLE 11

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 1 DAY AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.8751E-07	51	0.1712E-07
2	0.8377E-07	52	0.8185E-08
3	0.8239E-07	53	0.9643E-08
4	0.1144E-07	54	0.1517E-07
5	0.3030E-07	55	0.1734E-07
6	0.1221E-06	56	0.1629E-07
7	0.8859E-07	57	0.1321E-07
8	0.1336E-07	58	0.1029E-07
9	0.7216E-08	59	0.7547E-08
10	0.1557E-07	60	0.5823E-08
11	0.1221E-07	61	0.4631E-08
12	0.1965E-07	62	0.3450E-08
13	0.2093E-07	63	0.2649E-08
14	0.2490E-07	64	0.2346E-08
15	0.2355E-06	65	0.2247E-08
16	0.4578E-06	66	0.1996E-08
17	0.3758E-07	67	0.1884E-08
18	0.1206E-06	68	0.1905E-08
19	0.5970E-07	69	0.1630E-08
20	0.2115E-07	70	0.1205E-08
21	0.5148E-07	71	0.9031E-09
22	0.3382E-07	72	0.7409E-09
23	0.7120E-08	73	0.6361E-09
24	0.8118E-08	74	0.5464E-09
25	0.2068E-07	75	0.5210E-09
26	0.2393E-07	76	0.4871E-09
27	0.1468E-07	77	0.4475E-09
28	0.3407E-06	78	0.4103E-09
29	0.3356E-06	79	0.3846E-09
30	0.5354E-08	80	0.3656E-09
31	0.1250E-08	81	0.3526E-09
32	0.2550E-06	82	0.3400E-09
33	0.4727E-06	83	0.3297E-09
34	0.2827E-07	84	0.3253E-09
35	0.5489E-06	85	0.3167E-09
36	0.9908E-07	86	0.3147E-09
37	0.3829E-07	87	0.3161E-09
38	0.4142E-07	88	0.3214E-09
39	0.3491E-07	89	0.3270E-09
40	0.3845E-07	90	0.3302E-09
41	0.3222E-07	91	0.3368E-09
42	0.9549E-07	92	0.3459E-09
43	0.3168E-07	93	0.3560E-09
44	0.5613E-07	94	0.3694E-09
45	0.3591E-07	95	0.3886E-09
46	0.1889E-07	96	0.4290E-09
47	0.6538E-07	97	0.4899E-09
48	0.1871E-07	98	0.5517E-09
49	0.1860E-07	99	0.6262E-09
50	0.3288E-07	100	0.7510E-09
		TOTAL	0.4516E-05

TABLE 12

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 2 DAYS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.5475E-07	51	0.2098E-08
2	0.4477E-07	52	0.1561E-08
3	0.5884E-07	53	0.9998E-08
4	0.5754E-08	54	0.2020E-07
5	0.3666E-08	55	0.3943E-08
6	0.9133E-07	56	0.1305E-08
7	0.7248E-07	57	0.1174E-08
8	0.1086E-08	58	0.1224E-08
9	0.4906E-09	59	0.1326E-08
10	0.1019E-07	60	0.1516E-08
11	0.8983E-08	61	0.1349E-08
12	0.5241E-08	62	0.1010E-08
13	0.7497E-08	63	0.7490E-09
14	0.2826E-07	64	0.5786E-09
15	0.1078E-06	65	0.5027E-09
16	0.1092E-06	66	0.4390E-09
17	0.1136E-07	67	0.3895E-09
18	0.6161E-07	68	0.3718E-09
19	0.3127E-07	69	0.3653E-09
20	0.9983E-08	70	0.3396E-09
21	0.3057E-07	71	0.2764E-09
22	0.3056E-07	72	0.2150E-09
23	0.2881E-08	73	0.1786E-09
24	0.1584E-08	74	0.1556E-09
25	0.5317E-08	75	0.1471E-09
26	0.1426E-07	76	0.1356E-09
27	0.8191E-08	77	0.1285E-09
28	0.1531E-06	78	0.1225E-09
29	0.9464E-07	79	0.1175E-09
30	0.2195E-09	80	0.1151E-09
31	0.2075E-09	81	0.1134E-09
32	0.8333E-07	82	0.1092E-09
33	0.2368E-06	83	0.1061E-09
34	0.7385E-08	84	0.1068E-09
35	0.2064E-06	85	0.1054E-09
36	0.8476E-07	86	0.1054E-09
37	0.7538E-08	87	0.1075E-09
38	0.1953E-07	88	0.1114E-09
39	0.9689E-08	89	0.1158E-09
40	0.1456E-07	90	0.1198E-09
41	0.1324E-07	91	0.1219E-09
42	0.1433E-07	92	0.1246E-09
43	0.7665E-08	93	0.1293E-09
44	0.1274E-07	94	0.1343E-09
45	0.1089E-07	95	0.1416E-09
46	0.5125E-08	96	0.1552E-09
47	0.9578E-08	97	0.1748E-09
48	0.6939E-08	98	0.1941E-09
49	0.7757E-08	99	0.2158E-09
50	0.7739E-08	100	0.2541E-09
		TOTAL	0.1887E-05

TABLE 13

GAMMA RAY SPECTRUM OF URANIUM-235 FISSION PRODUCTS
AT 3 DAYS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.4971E-07	51	0.9704E-09
2	0.3193E-07	52	0.6062E-09
3	0.4729E-07	53	0.9802E-08
4	0.4016E-08	54	0.2700E-07
5	0.1759E-08	55	0.1959E-08
6	0.7027E-07	56	0.3840E-09
7	0.6153E-07	57	0.3948E-09
8	0.4909E-09	58	0.5332E-09
9	0.1761E-09	59	0.6694E-09
10	0.7130E-08	60	0.7914E-09
11	0.8477E-08	61	0.7435E-09
12	0.3514E-08	62	0.5830E-09
13	0.4039E-08	63	0.4313E-09
14	0.2718E-07	64	0.3163E-09
15	0.7876E-07	65	0.2746E-09
16	0.2347E-07	66	0.2509E-09
17	0.5879E-08	67	0.2359E-09
18	0.3773E-07	68	0.2307E-09
19	0.2170E-07	69	0.2349E-09
20	0.7224E-08	70	0.2456E-09
21	0.2250E-07	71	0.2138E-09
22	0.3159E-07	72	0.1490E-09
23	0.1653E-08	73	0.1095E-09
24	0.7731E-09	74	0.9491E-10
25	0.3622E-08	75	0.9444E-10
26	0.1103E-07	76	0.8870E-10
27	0.1388E-07	77	0.8482E-10
28	0.8343E-07	78	0.8288E-10
29	0.4062E-07	79	0.7907E-10
30	0.7456E-10	80	0.7467E-10
31	0.1960E-09	81	0.7376E-10
32	0.3636E-07	82	0.7214E-10
33	0.1502E-06	83	0.6996E-10
34	0.5992E-08	84	0.7000E-10
35	0.1028E-06	85	0.7031E-10
36	0.7641E-07	86	0.7164E-10
37	0.4123E-08	87	0.7256E-10
38	0.1204E-07	88	0.7459E-10
39	0.5598E-08	89	0.7757E-10
40	0.1306E-07	90	0.8031E-10
41	0.8089E-08	91	0.8327E-10
42	0.2828E-08	92	0.8424E-10
43	0.2709E-08	93	0.8559E-10
44	0.6978E-08	94	0.8763E-10
45	0.6313E-08	95	0.9255E-10
46	0.2544E-08	96	0.1012E-09
47	0.3662E-08	97	0.1117E-09
48	0.3827E-08	98	0.1215E-09
49	0.5897E-08	99	0.1356E-09
50	0.5683E-08	100	0.158[illegible]E-09
		TOTAL	0.1206E-05

TABLE 14

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 15 MINUTES AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.1973E-04	51	0.8678E-05
2	0.5825E-05	52	0.5851E-05
3	0.1675E-04	53	0.6373E-05
4	0.5232E-05	54	0.6366E-05
5	0.6026E-05	55	0.6046E-05
6	0.1931E-05	56	0.7591E-05
7	0.6194E-05	57	0.7707E-05
8	0.9057E-05	58	0.5113E-05
9	0.5696E-05	59	0.3853E-05
10	0.6720E-05	60	0.4371E-05
11	0.1215E-04	61	0.7875E-05
12	0.1358E-04	62	0.8235E-05
13	0.6751E-05	63	0.4540E-05
14	0.1086E-04	64	0.5252E-05
15	0.7448E-05	65	0.6792E-05
16	0.1286E-04	66	0.4181E-05
17	0.2381E-04	67	0.2536E-05
18	0.7626E-05	68	0.2049E-05
19	0.4530E-04	69	0.2015E-05
20	0.2382E-04	70	0.2761E-05
21	0.1385E-04	71	0.4070E-05
22	0.1714E-04	72	0.3751E-05
23	0.5578E-05	73	0.2206E-05
24	0.8160E-05	74	0.1328E-05
25	0.2379E-04	75	0.1066E-05
26	0.2184E-04	76	0.8067E-06
27	0.1893E-04	77	0.6952E-06
28	0.6255E-04	78	0.7959E-06
29	0.8567E-05	79	0.8370E-06
30	0.1861E-04	80	0.7447E-06
31	0.1935E-04	81	0.7057E-06
32	0.1332E-04	82	0.6515E-06
33	0.1435E-04	83	0.5582E-06
34	0.1748E-04	84	0.6011E-06
35	0.1985E-04	85	0.6479E-06
36	0.2075E-04	86	0.5269E-06
37	0.2050E-04	87	0.3830E-06
38	0.3091E-04	88	0.3220E-06
39	0.3028E-04	89	0.3246E-06
40	0.2605E-04	90	0.3297E-06
41	0.1513E-04	91	0.3067E-06
42	0.2259E-04	92	0.2581E-06
43	0.1340E-04	93	0.2188E-06
44	0.1293E-04	94	0.1991E-06
45	0.1171E-04	95	0.1839E-06
46	0.1540E-04	96	0.1860E-06
47	0.1597E-04	97	0.1984E-06
48	0.9849E-05	98	0.2101E-06
49	0.1009E-04	99	0.2307E-06
50	0.1383E-04	100	0.2925E-06
		TOTAL	0.9690E-03

TABLE 15

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 30 MINUTES AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
51	0.6553E-05	1	0.1021E-04
52	0.3108E-05	2	0.2906E-05
53	0.3131E-05	3	0.8427E-0[illegible]
54	0.2600E-05	4	0.1670E-05
55	0.2652E-05	5	0.3264E-05
56	0.3102E-05	6	0.1154E-05
57	0.3109E-05	7	0.2727E-05
58	0.2515E-05	8	0.5846E-05
59	0.1990E-05	9	0.2927E-05
60	0.2030E-05	10	0.2858E-05
61	0.3310E-05	11	0.6221E-05
62	0.3982E-05	12	0.7045E-05
63	0.1926E-05	13	0.3830E-05
64	0.2460E-05	14	0.5239E-05
65	0.4028E-05	15	0.3292E-05
66	0.2041E-05	16	0.5422E-05
67	0.1088E-05	17	0.1012E-04
68	0.1103E-05	18	0.4829E-05
69	0.1146E-05	19	0.2862E-04
70	0.1370E-05	20	0.1273E-04
71	0.1814E-05	21	0.6875E-05
72	0.1856E-05	22	0.8155E-05
73	0.1182E-05	23	0.2980E-05
74	0.5713E-06	24	0.3924E-05
75	0.3765E-06	25	0.1063E-04
76	0.3035E-06	26	0.1425E-04
77	0.2936E-06	27	0.6597E-05
78	0.3223E-06	28	0.3006E-04
79	0.3363E-06	29	0.7977E-05
80	0.3083E-06	30	0.6810E-05
81	0.2550E-06	31	0.7271E-05
82	0.2127E-06	32	0.8080E-05
83	0.1930E-06	33	0.7758E-05
84	0.2045E-06	34	0.4878E-05
85	0.2265E-06	35	0.1206E-04
86	0.1899E-06	36	0.8983E-05
87	0.1345E-06	37	0.7956E-05
88	0.1180E-06	38	0.1636E-04
89	0.1194E-06	39	0.1700E-04
90	0.1212E-06	40	0.1333E-04
91	0.1122E-06	41	0.5201E-05
92	0.9228E-07	42	0.1221E-04
93	0.8122E-07	43	0.6135E-05
94	0.7565E-07	44	0.5019E-05
95	0.7257E-07	45	0.5594E-05
96	0.7382E-07	46	0.6188E-05
97	0.7814E-07	47	0.8005E-05
98	0.8334E-07	48	0.3522E-05
99	0.9251E-07	49	0.4019E-05
100	0.1197E-06	50	0.1184E-04
		TOTAL	0.4623E-03

TABLE 16

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 1 HOUR AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.3806E-05	51	0.4128E-05
2	0.1184E-05	52	0.1190E-05
3	0.3250E-05	53	0.1146E-05
4	0.9245E-06	54	0.9330E-06
5	0.7967E-06	55	0.8890E-06
6	0.3838E-06	56	0.1110E-05
7	0.1674E-05	57	0.1143E-05
8	0.3274E-05	58	0.1007E-05
9	0.1439E-05	59	0.8619E-06
10	0.1576E-05	60	0.7721E-06
11	0.2284E-05	61	0.9430E-06
12	0.2367E-05	62	0.1005E-05
13	0.1747E-05	63	0.5622E-06
14	0.2118E-05	64	0.8773E-06
15	0.1250E-05	65	0.1689E-05
16	0.1180E-05	66	0.8367E-06
17	0.3248E-05	67	0.5364E-06
18	0.2335E-05	68	0.6637E-06
19	0.1053E-04	69	0.5895E-06
20	0.4317E-05	70	0.5945E-06
21	0.2230E-05	71	0.7798E-06
22	0.2187E-05	72	0.7483E-06
23	0.1055E-05	73	0.4383E-06
24	0.1904E-05	74	0.2006E-06
25	0.3621E-05	75	0.1362E-06
26	0.7908E-05	76	0.1263E-06
27	0.2534E-05	77	0.1367E-06
28	0.7656E-05	78	0.1385E-06
29	0.4515E-05	79	0.1193E-06
30	0.2085E-05	80	0.9981E-07
31	0.1890E-05	81	0.8891E-07
32	0.4694E-05	82	0.7695E-07
33	0.3598E-05	83	0.6395E-07
34	0.1422E-05	84	0.5985E-07
35	0.6726E-05	85	0.5773E-07
36	0.3761E-05	86	0.5112E-07
37	0.3677E-05	87	0.4316E-07
38	0.1135E-04	88	0.4051E-07
39	0.7245E-05	89	0.4060E-07
40	0.4426E-05	90	0.3749E-07
41	0.2311E-05	91	0.3271E-07
42	0.4727E-05	92	0.2919E-07
43	0.2175E-05	93	0.2771E-07
44	0.2390E-05	94	0.2747E-07
45	0.2063E-05	95	0.2698E-07
46	0.1561E-05	96	0.2777E-07
47	0.2089E-05	97	0.2988E-07
48	0.9828E-06	98	0.3224E-07
49	0.1893E-05	99	0.3584E-07
50	0.7207E-05	100	0.4597E-07
		TOTAL	0.1868E-03

TABLE 17

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 2 HOURS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.1167E-05	51	0.1082E-05
2	0.6635E-06	52	0.3753E-06
3	0.1634E-05	53	0.3262E-06
4	0.4464E-06	54	0.3222E-06
5	0.3420E-06	55	0.3178E-06
6	0.1610E-06	56	0.3699E-06
7	0.6428E-06	57	0.4395E-06
8	0.1153E-05	58	0.4703E-06
9	0.7975E-06	59	0.3771E-06
10	0.6526E-06	60	0.2432E-06
11	0.5847E-06	61	0.2192E-06
12	0.6205E-06	62	0.2431E-06
13	0.6475E-06	63	0.1929E-06
14	0.9922E-06	64	0.3051E-06
15	0.4321E-06	65	0.4697E-06
16	0.5211E-06	66	0.2253E-06
17	0.9042E-06	67	0.2185E-06
18	0.7718E-06	68	0.4209E-06
19	0.1686E-05	69	0.3316E-06
20	0.1102E-05	70	0.2385E-06
21	0.5023E-06	71	0.2591E-06
22	0.2653E-06	72	0.2178E-06
23	0.3250E-06	73	0.1223E-06
24	0.9946E-06	74	0.5897E-07
25	0.1190E-05	75	0.4562E-07
26	0.2316E-05	76	0.4988E-07
27	0.9076E-06	77	0.5806E-07
28	0.1390E-05	78	0.5611E-07
29	0.2003E-05	79	0.4015E-07
30	0.7419E-06	80	0.2934E-07
31	0.6296E-06	81	0.2490E-07
32	0.2392E-05	82	0.2289E-07
33	0.1777E-05	83	0.2028E-07
34	0.5575E-06	84	0.1769E-07
35	0.3288E-05	85	0.1582E-07
36	0.1176E-05	86	0.1455E-07
37	0.2352E-05	87	0.1271E-07
38	0.7228E-05	88	0.1196E-07
39	0.2700E-05	89	0.1153E-07
40	0.1188E-05	90	0.1041E-07
41	0.8028E-06	91	0.9527E-08
42	0.1416E-05	92	0.8899E-08
43	0.1009E-05	93	0.8613E-08
44	0.1349E-05	94	0.8694E-08
45	0.6206E-06	95	0.8838E-08
46	0.3866E-06	96	0.9374E-08
47	0.5587E-06	97	0.1022E-07
48	0.2842E-06	98	0.1102E-07
49	0.1278E-05	99	0.1233E-07
50	0.2999E-05	100	0.1594E-07
		TOTAL	0.6894E-04

TABLE 18

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 5 HOURS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.3818E-06	51	0.1656E-06
2	0.5337E-06	52	0.1263E-06
3	0.1839E-05	53	0.1269E-06
4	0.5713E-06	54	0.8704E-07
5	0.3169E-06	55	0.1347E-06
6	0.8175E-07	56	0.1819E-06
7	0.1539E-06	57	0.1687E-06
8	0.2773E-06	58	0.2248E-06
9	0.3216E-06	59	0.2193E-06
10	0.1918E-06	60	0.1083E-06
11	0.7441E-07	61	0.6904E-07
12	0.1463E-06	62	0.8965E-07
13	0.4183E-06	63	0.7946E-07
14	0.7322E-06	64	0.7949E-07
15	0.2494E-06	65	0.9802E-07
16	0.6964E-06	66	0.5635E-07
17	0.5226E-06	67	0.5517E-07
18	0.2675E-06	68	0.1870E-06
19	0.2970E-06	69	0.2379E-06
20	0.3089E-06	70	0.8845E-07
21	0.1498E-06	71	0.5520E-07
22	0.6575E-07	72	0.4461E-07
23	0.5835E-07	73	0.2900E-07
24	0.3018E-06	74	0.1933E-07
25	0.3136E-06	75	0.1716E-07
26	0.2849E-06	76	0.1711E-07
27	0.2033E-06	77	0.1684E-07
28	0.4535E-06	78	0.1759E-07
29	0.1428E-05	79	0.1397E-07
30	0.3593E-06	80	0.8717E-08
31	0.1009E-06	81	0.6809E-08
32	0.6062E-06	82	0.6499E-08
33	0.1634E-05	83	0.5876E-08
34	0.1788E-06	84	0.5423E-08
35	0.1567E-05	85	0.5028E-08
36	0.5136E-06	86	0.4708E-08
37	0.3661E-06	87	0.4293E-08
38	0.1798E-05	88	0.3818E-08
39	0.8699E-06	89	0.3527E-08
40	0.5361E-06	90	0.3366E-08
41	0.2188E-06	91	0.3348E-08
42	0.4184E-06	92	0.3389E-08
43	0.4070E-06	93	0.3397E-08
44	0.5790E-06	94	0.3358E-08
45	0.4063E-06	95	0.3391E-08
46	0.6918E-07	96	0.3711E-08
47	0.5022E-06	97	0.4220E-08
48	0.1271E-06	98	0.4646E-08
49	0.4913E-06	99	0.5302E-08
50	0.1288E-05	100	0.6757E-08
		TOTAL	0.2761E-04

TABLE 19

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 10 HOURS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.1374E-06	51	0.5950E-07
2	0.1062E-05	52	0.4506E-07
3	0.1524E-05	53	0.3363E-07
4	0.2103E-06	54	0.2866E-07
5	0.1911E-06	55	0.5577E-07
6	0.5885E-07	56	0.8945E-07
7	0.1446E-06	57	0.7692E-07
8	0.1404E-06	58	0.7086E-07
9	0.7846E-07	59	0.5145E-07
10	0.1394E-07	60	0.2807E-07
11	0.7325E-08	61	0.2112E-07
12	0.1089E-06	62	0.1981E-07
13	0.5090E-06	63	0.1515E-07
14	0.3987E-06	64	0.1613E-07
15	0.2002E-06	65	0.2038E-07
16	0.8458E-06	66	0.1550E-07
17	0.2403E-06	67	0.1832E-07
18	0.1861E-06	68	0.4338E-07
19	0.1697E-06	69	0.3945E-07
20	0.1136E-06	70	0.1368E-07
21	0.8225E-07	71	0.5967E-08
22	0.4977E-07	72	0.4472E-08
23	0.4477E-07	73	0.4421E-08
24	0.3775E-07	74	0.4008E-08
25	0.5911E-07	75	0.3594E-08
26	0.1179E-06	76	0.3453E-08
27	0.3466E-07	77	0.3078E-08
28	0.4979E-06	78	0.2542E-08
29	0.9097E-06	79	0.2122E-08
30	0.4438E-07	80	0.1904E-08
31	0.6283E-08	81	0.1840E-08
32	0.3240E-06	82	0.1723E-08
33	0.9609E-06	83	0.1579E-08
34	0.8255E-07	84	0.1487E-08
35	0.1017E-05	85	0.1379E-08
36	0.1727E-06	86	0.1377E-08
37	0.1515E-06	87	0.1364E-08
38	0.1398E-06	88	0.1392E-08
39	0.1541E-06	89	0.1440E-08
40	0.1773E-06	90	0.1414E-08
41	0.8239E-07	91	0.1411E-08
42	0.2507E-06	92	0.1422E-08
43	0.1145E-06	93	0.1473E-08
44	0.2459E-06	94	0.1501E-08
45	0.1491E-06	95	0.1541E-08
46	0.3714E-07	96	0.1691E-08
47	0.2933E-06	97	0.1915E-08
48	0.5224E-07	98	0.2099E-08
49	0.1907E-06	99	0.2361E-08
50	0.3391E-06	100	0.2878E-08
		TOTAL	0.1399E-04

TABLE 20

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 1 DAY AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.6689E-07	51	0.1607E-07
2	0.1075E-06	52	0.6982E-08
3	0.2498E-06	53	0.6833E-08
4	0.4130E-07	54	0.1097E-07
5	0.4506E-07	55	0.1528E-07
6	0.4524E-07	56	0.1551E-07
7	0.1375E-06	57	0.1254E-07
8	0.1690E-07	58	0.9194E-08
9	0.6285E-08	59	0.5803E-08
10	0.1271E-07	60	0.4178E-08
11	0.1406E-09	61	0.3220E-08
12	0.4116E-10	62	0.2440E-08
13	0.4246E-08	63	0.1943E-08
14	0.8920E-07	64	0.1734E-08
15	0.1110E-06	65	0.1586E-08
16	0.4421E-06	66	0.1377E-08
17	0.1221E-06	67	0.1257E-08
18	0.6167E-07	68	0.1225E-08
19	0.8921E-07	69	0.1028E-08
20	0.1738E-07	70	0.7510E-09
21	0.4367E-07	71	0.5673E-09
22	0.3813E-07	72	0.4732E-09
23	0.7492E-08	73	0.4094E-09
24	0.4494E-08	74	0.3566E-09
25	0.1564E-07	75	0.3434E-09
26	0.1854E-07	76	0.3222E-09
27	0.3342E-08	77	0.2972E-09
28	0.2401E-06	78	0.2724E-09
29	0.3285E-06	79	0.2561E-09
30	0.3695E-08	80	0.2454E-09
31	0.1376E-08	81	0.2398E-09
32	0.1289E-06	82	0.2310E-09
33	0.4580E-06	83	0.2226E-09
34	0.1304E-07	84	0.2206E-09
35	0.4225E-06	85	0.2175E-09
36	0.1156E-06	86	0.2190E-09
37	0.1334E-07	87	0.2222E-09
38	0.3458E-07	88	0.2282E-09
39	0.2498E-07	89	0.2343E-09
40	0.2837E-07	90	0.2408E-09
41	0.2383E-07	91	0.2488E-09
42	0.6551E-07	92	0.2541E-09
43	0.2684E-07	93	0.2612E-09
44	0.4758E-07	94	0.2705E-09
45	0.3281E-07	95	0.2841E-09
46	0.1253E-07	96	0.3115E-09
47	0.6234E-07	97	0.3496E-09
48	0.1766E-07	98	0.3879E-09
49	0.1284E-07	99	0.4367E-09
50	0.2583E-07	100	0.5259E-09
		TOTAL	0.4067E-05

TABLE 21

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 2 DAYS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.3300E-07	51	0.2350E-08
2	0.1433E-06	52	0.1577E-08
3	0.1666E-06	53	0.7484E-08
4	0.3496E-08	54	0.1653E-07
5	0.1616E-07	53	0.4179E-08
6	0.4177E-07	56	0.1397E-08
7	0.1085E-06	57	0.1195E-08
8	0.3787E-08	58	0.1213E-08
9	0.1798E-08	59	0.1198E-08
10	0.5233E-08	60	0.1285E-08
11	0.7934E-11	61	0.1125E-08
12	0.2389E-10	62	0.8607E-09
13	0.1039E-07	63	0.6516E-09
14	0.6413E-07	64	0.5191E-09
15	0.8427E-07	65	0.4384E-09
16	0.1213E-06	66	0.3778E-09
17	0.2315E-07	67	0.3262E-09
18	0.5430E-07	68	0.2957E-09
19	0.3933E-07	69	0.2820E-09
20	0.1295E-07	70	0.2629E-09
21	0.2741E-07	71	0.2174E-09
22	0.3006E-07	72	0.1719E-09
23	0.3463E-08	73	0.1425E-09
24	0.8085E-09	74	0.1242E-09
25	0.3515E-08	75	0.1203E-09
26	0.1054E-07	76	0.1140E-09
27	0.4255E-08	77	0.1096E-09
28	0.1312E-06	78	0.1051E-09
29	0.1012E-06	79	0.1007E-09
30	0.1297E-09	80	0.9756E-10
31	0.2044E-09	81	0.9678E-10
32	0.5103E-07	82	0.9553E-10
33	0.2297E-06	83	0.9398E-10
34	0.6729E-08	84	0.9469E-10
35	0.1705E-06	85	0.9488E-10
36	0.8510E-07	86	0.9681E-10
37	0.3150E-08	87	0.9947E-10
38	0.1377E-07	88	0.1033E-09
39	0.8875E-08	89	0.1075E-09
40	0.1203E-07	90	0.1123E-09
41	0.1201E-07	91	0.1166E-09
42	0.9594E-08	92	0.1181E-09
43	0.5979E-08	93	0.1202E-09
44	0.9050E-08	94	0.1234E-09
45	0.8831E-08	95	0.1287E-09
46	0.3714E-08	96	0.1401E-09
47	0.8527E-08	97	0.1551E-09
48	0.6878E-08	98	0.1686E-09
49	0.6521E-08	99	0.1848E-09
50	0.7198E-08	100	0.2145E-09
		TOTAL	0.1953E-05

TABLE 22

GAMMA RAY SPECTRUM OF URANIUM-238 FISSION PRODUCTS
AT 3 DAYS AFTER FISSION

ENERGY BIN NO.	PHOTONS/ FISSION-SEC	ENERGY BIN NO.	PHOTONS/ FISSION-SEC
1	0.7417E-08	51	0.8966E-09
2	0.2380E-06	52	0.7583E-09
3	0.1374E-06	53	0.8579E-08
4	0.3568E-16	54	0.2129E-07
5	0.1471E-16	55	0.2053E-08
6	0.2812E-07	56	0.3677E-09
7	0.9060E-07	57	0.2988E-09
8	0.3334E-09	58	0.3475E-09
9	0.6660E-09	59	0.4459E-09
10	0.2579E-08	60	0.6389E-09
11	0.9481E-10	61	0.4289E-09
12	0.2665E-08	62	0.3178E-09
13	0.5332E-07	63	0.2488E-09
14	0.1261E-07	64	0.1701E-09
15	0.7095E-07	65	0.1451E-09
16	0.2866E-07	66	0.1401E-09
17	0.8284E-08	67	0.1445E-09
18	0.3853E-07	68	0.1567E-09
19	0.2129E-07	69	0.1759E-09
20	0.1233E-07	70	0.1918E-09
21	0.2026E-07	71	0.1618E-09
22	0.2656E-07	72	0.1194E-09
23	0.2613E-08	73	0.9712E-10
24	0.3977E-09	74	0.8547E-10
25	0.2082E-08	75	0.8363E-10
26	0.8483E-08	76	0.7930E-10
27	0.1233E-07	77	0.7717E-10
28	0.7763E-07	78	0.7386E-10
29	0.3934E-07	79	0.6909E-10
30	0.5347E-10	80	0.6487E-10
31	0.1345E-09	81	0.6283E-10
32	0.2917E-07	82	0.6081E-10
33	0.1354E-06	83	0.5879E-10
34	0.[illegible]47E-08	84	0.5792E-10
35	0.8616E-07	85	0.5703E-10
36	0.6488E-07	86	0.5703E-10
37	0.2565E-08	87	0.5774E-10
38	0.8121E-08	88	0.5906E-10
39	0.5269E-08	89	0.6037E-10
40	0.1098E-07	90	0.6192E-10
41	0.6990E-08	91	0.6251E-10
42	0.1972E-08	92	0.6203E-10
43	0.1517E-08	93	0.6293E-10
44	0.4929E-08	94	0.6480E-10
45	0.4519E-08	95	0.6777E-10
46	0.1692E-08	96	0.7389E-10
47	0.2789E-08	97	0.8191E-10
48	0.3266E-08	98	0.8844E-10
49	0.5139E-08	99	0.9565E-10
50	0.4437E-08	100	0.1103E-09
		TOTAL	0.1371E-05

Figure 2 shows a comparison of the spectral density from the products of the fast neutron fission of U^{235} and U^{238}. It can be seen that the differences are generally small. They may be ascribed to differences in the yields of individual products in the two fission processes.

Figure 3 compares the spectral density obtained at 15 minutes after fast neutron fission of U^{235} in this work with that obtained at 16.67 minutes after slow neutron fission of U^{235} by Maienschein et al.[2] The resolution of the present work has been reduced to fit the scale by combination of some of the energy bins. The general agreement in shape and magnitude is very good. The reason for the relatively high results at the highest energies in the present work is not known.

The present work was compared with the latest calculated spectra[5] at 1, 2, 5, 24, 48 and 72 hours post-fission for both types of fission. Table 23 gives the ratios of the experimental to calculated number of photons per fission per second for both types of fission studied in this work.

TABLE 23

Comparison of Experimental and Calculated Photon Emission Rates

Time After Fission (hr)	Experimental Photons/fission-sec	Calculated[5] Photons/fission-sec	Experimental / Calculated
	U^{235} (Fast Fission)		
1	1.95×10^{-4}	1.36×10^{-4}	1.43
2	6.68×10^{-5}	5.74×10^{-5}	1.16
5	2.41×10^{-5}	1.85×10^{-5}	1.30
24	4.52×10^{-6}	3.87×10^{-6}	1.17
48	1.89×10^{-6}	1.83×10^{-6}	1.03
72	1.21×10^{-6}	1.18×10^{-6}	1.02
	U^{238} (Fast Fission)		
1	1.37×10^{-4}	1.38×10^{-4}	1.35
2	6.89×10^{-5}	5.95×10^{-5}	1.16
5	2.76×10^{-5}	1.84×10^{-5}	1.50
24	4.07×10^{-6}	3.74×10^{-6}	1.09
48	1.95×10^{-6}	1.74×10^{-6}	1.12
72	1.37×10^{-6}	1.12×10^{-6}	1.22

The agreement, as shown, is reasonably good. However, it is actually somewhat poorer; the photons below 0.065 MeV were not included in the experimental results and the calculated results do include them. Moderate differences also can be noticed in the spectral distributions obtained by the two methods. For example, at 1 hour after U^{235} fission the experimental results show significantly more photons in the energy ranges of 0 to 0.3 MeV and 3 to 5 MeV. The specific reasons for these spectral differences are not known but might be ascribed, in part, to unknown decay schemes and to experimental errors.

The gamma-ray spectra determined in this work will be used to calculate the exposure rate per deposited fission per unit area for each spectrum. Such calculations will permit further comparison of the experimental data with calculated results.

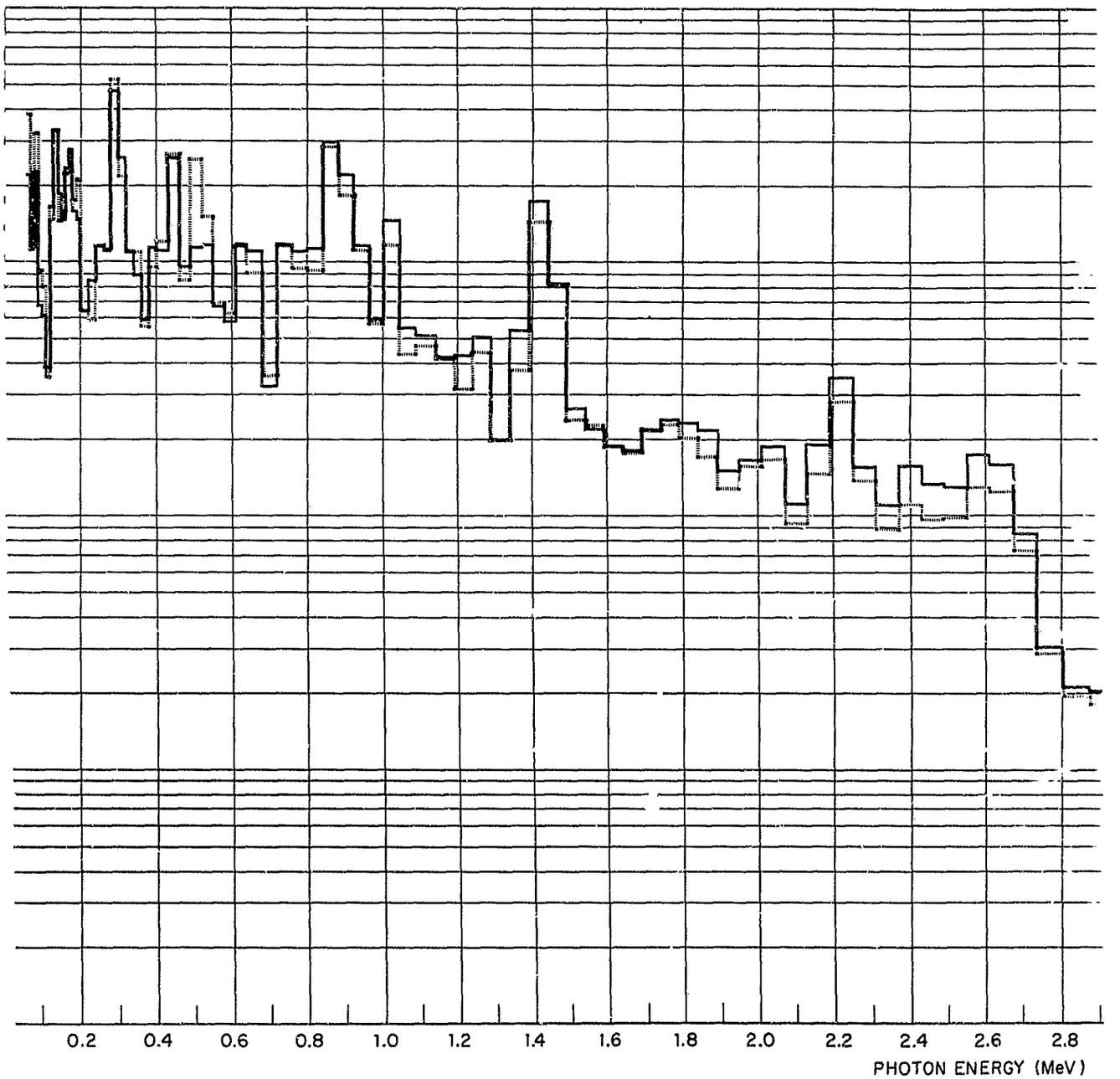
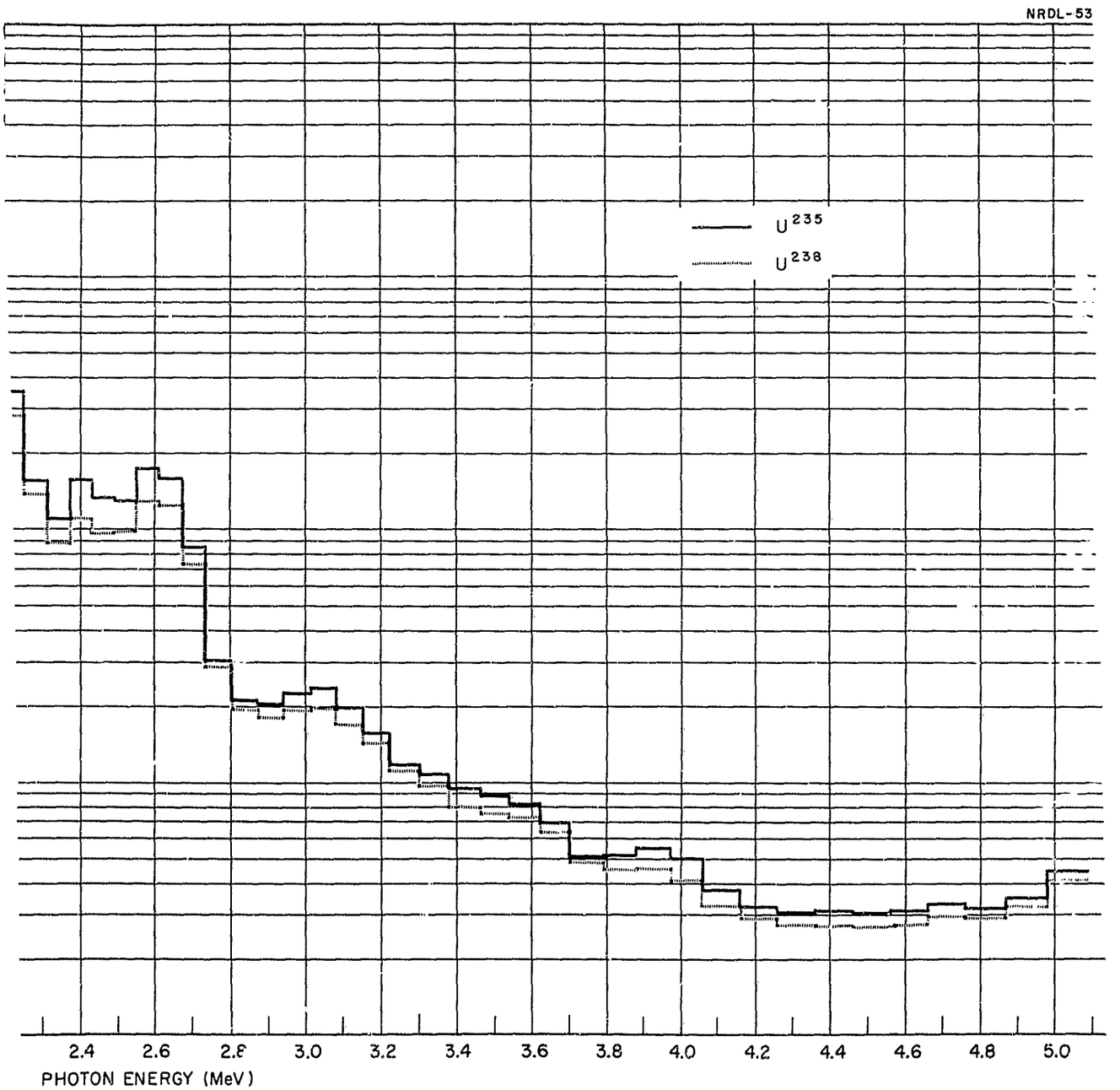


Fig. 2 Comparison of the Gamma-Ray Spectral Density from U^{235} and U

A



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8

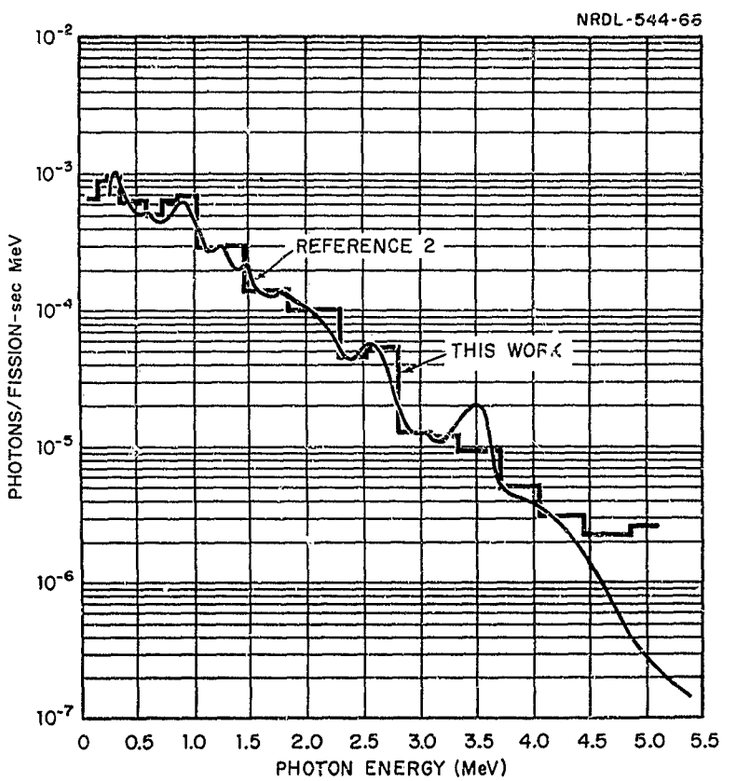

Fig. 3 Comparison of Experimental Gamma-Ray Spectral Densities

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APPENDIX A

CALIBRATION OF THE PULSE-HEIGHT ANALYZER

The pulse-height analysis system was calibrated with standardized gamma-ray sources. These sources were standardized by 4-π beta-ray counting, alpha-ray counting with a known geometry, or gamma-ray measurements in counters whose efficiencies for the respective radionuclides had previously been determined by 4-π beta-ray counting or from standard sources. The efficiency of the system for the 4.08 MeV gamma-ray of Ca^{49} was estimated by an extrapolation of efficiencies of lower energy gamma-rays. The gamma-ray sources and the corresponding methods of standardization are given in Table A.1. Ideally, monoenergetic gamma-ray sources are used for the calibration at convenient intervals of

TABLE A.1

Radionuclides Used for the Calibration of the Spectrometer

Radionuclide	Half-life	Energy (MeV)	Method of Calibration
Am^{241}	458 y	0.060	alpha counting
Tm^{170}	129 d	0.084	4-π beta counting
Ce^{141}	32.5 d	0.145	4-π beta counting
Hg^{203}	45 d	0.279	calibrated gamma counter
Cr^{51}	27.8 d	0.325	" " "
Sr^{85}	64 d	0.514	" " "
Cs^{137}	30.4 y	0.662	" " "
Nb^{95}	35.3 d	0.768	" " "
Rb^{86}	18.7 d	1.084	4-π beta counting
Zn^{65}	246.4 d	1.12	calibrated gamma counter
K^{42}	12.37 h	1.52	" " "
Na^{24}	15 h	2.75	" " "
Ca^{49}	8.8 m	4.08	efficiency estimated by extrapolation of above data

gamma-ray energy. In practice, some of the available sources have more than one gamma-ray. In these cases the part of the pulse height distribution that could be ascribed unambiguously to one gamma-ray was used, and the remainder was removed from the response with the aid of the response function of the nearest monoenergetic gamma-ray. In this manner, the contribution of their lower energy gamma-rays to the response were removed from the distributions from Na^{24}, Zn^{65} and Ca^{49}.

The gamma-ray calibration sources were usually prepared from aliquots of commercially available solutions. Each aliquot was deposited on 0.004 inch thick polyethylene. The solution was confined to a circle with a diameter of 3/8 inch by placing the polyethylene film in a mold. The liquid was evaporated slowly under an infrared lamp. After drying, an identical thickness of polyethylene film was placed over the deposit, and the two plastic sheets were heat-sealed in the same manner as the uranium samples used to obtain the pulse-height distribution measurements. There was one exception to this method of calibration source preparation. The Ca^{49} activity was produced by thermal neutron irradiation of $CaCO_3$ enriched in the Ca^{48} isotope. Consequently, the source prepared from this irradiated material was not evaporated but prepared by the sealing of a few milligrams of the $CaCO_3$ powder in polyethylene. The self-absorption of the high energy gamma-rays of Ca^{49} was negligible. All of the other sources were so prepared as to minimize the mass of material in and around the source.

The measured pulse height distributions of the calibration standards were used to construct a matrix expressing the response of the collimated 5" x 5" NaI(Tl) detector and its associated pulse height analysis system to axially incident monoenergetic gamma-rays. This response matrix was arbitrarily chosen to have an energy-pulse height grid with a non-uniform energy bin width. The width of each energy bin was selected to be approximately one half the resolution of the detector at the midpoint energy of the bin. This gave a grid covering an energy range of 0.065 to approximately 5.0 MeV having 100 energy bins. Consequently, after unfolding, the pulse height distributions which have 1024 channels are converted to gamma-ray spectra with 100 energy bins. The essential steps in the construction of the response matrix are given by Hubbell and Scofield.[8]

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Experimental measurements of the gamma-ray pulse height distributions due to the products of fast-neutron-induced fission of U^{235} and U^{238} are presented. The measurements were made at nine selected times after fission from 15 minutes to 3 days. Irradiation times and counting intervals were chosen to minimize saturation and decay effects.

The experimental data were used to calculate 100 energy bin distributions of the absolute number of photons/fission-sec. by means of absolute calibrations of the collimated NaI(Tl) detector. The number of fissions in each sample was determined radiochemically. Machine computation was used extensively.

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