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Intrinsic Radiation Measurements of the B61 and W76 Weapon Systems (U)

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INTRINSIC RADIATION MEASUREMENTS OF THE B61 AND W76 WEAPON SYSTEMS (U)

by

R. E. Anderson, C. A. Goulding, M. C. Lucas, J. J. Malanify, A. A. Robba, and L. E. Ussery

ABSTRACT (~~CRD~~)

Gamma-ray and neutron spectra and integral neutron and gamma-ray dose rates were obtained at points around the B61-0, B61-5, and B61-7 bombs and around the W76 warhead.

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We also report gamma-ray line identifications and intensities that were determined with a high-resolution germanium detector.

I. INTRODUCTION

In January of 1988 the Intrinsic Radiation (INRAD) Measurement Team traveled to the Pantex Plant in Amarillo, Texas to measure the intrinsic radiation of the B61 and the W76 ballistic missile warhead. In a three-week period, we measured three modifications of the B61 (-0, -5, and -7) and one version of the W76. Both the photon and neutron flux from each device were measured, and the results are documented in this report. For reference with standard military dosimetry instruments, we also made some measurements using gamma-ray and neutron dosimetry instrumentation. Those data are available upon request.

II. NE 213 MEASUREMENTS

A. Equipment and Methods

The neutron spectrometer (NE 213) system that was used has been significantly altered since the last INRAD measurement. To increase portability, reliability, and flexibility, the LeCroy 3500 system was replaced by a CAMAC crate coupled to an IBM-AT computer, and all acquisition and analysis programs were converted to the IBM-AT. We also fielded two detectors: one was the standard Nuclear Enterprises cell, 2 in. in diameter and 2 in. long, and the other was a cell 1.875 in. in diameter and 2 in. long, constructed at Los Alamos National Laboratory (LANL), Group N-2.

The acquisition configuration consisted of five, 1024 histograms for one detector: high- and low-gain neutron spectra, a pulse-shape discrimination spectrum, and high- and low-gain gamma-ray spectra. Except for the high-gain gamma-ray spectrum, the same histograms were acquired for the second detector. Because of time constraints imposed by the Christmas holiday, only one detector system was completely configured before shipment to Pantex. The detector was set up as time allowed to prevent interference with other experiments. To check consistency, a ^{252}Cf spectrum was measured with both detectors; the results are shown in Table I and Fig. 1.

TABLE I

^{252}Cf CALIBRATION

E_n (MeV)	Detector A $\frac{n}{MeV\text{-}s}$	Detector B $\frac{n}{MeV\text{-}s}$	Theoretical $\frac{n}{MeV\text{-}s}$
0.52 - 0.76	9.24×10^5	1.08×10^6	7.29×10^5
0.76 - 1.05	8.56×10^5	9.81×10^5	7.27×10^5
1.05 - 1.41	7.84×10^5	8.81×10^5	6.85×10^5
1.41 - 1.92	6.87×10^5	7.45×10^5	6.02×10^5
1.92 - 2.74	5.40×10^5	5.46×10^5	4.59×10^5
2.74 - 3.74	3.22×10^5	2.98×10^5	2.79×10^5
3.74 - 4.58	1.60×10^5	1.47×10^5	1.61×10^5
4.58 - 5.47	8.32×10^4	7.04×10^4	1.11×10^5
5.47 - 6.53	3.04×10^4	2.52×10^4	5.80×10^4
6.53 - 7.53	2.42×10^4	4.92×10^4	3.17×10^4
7.53 - 9.01	1.73×10^4		1.71×10^4
9.01 - 11.0			4.88×10^3
Total n/s	2.16×10^6	2.24×10^6	2.23×10^6

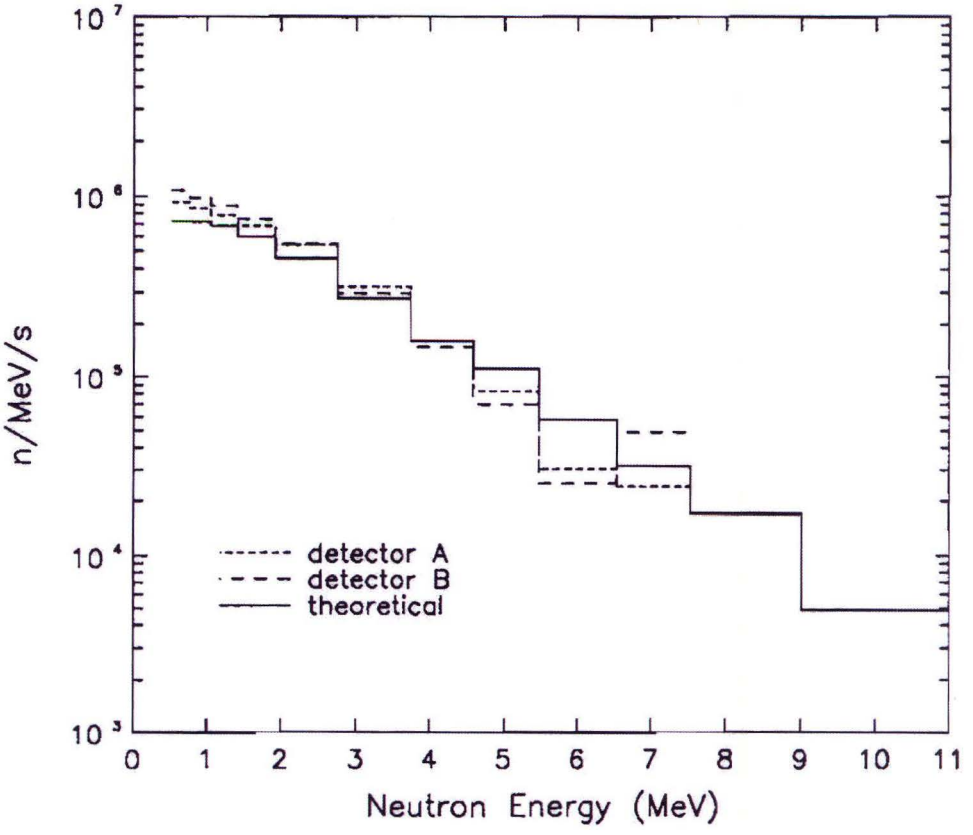

Fig. 1. Calibration results for ^{252}Cf.

B. Results

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TABLE II

B61-0 NEUTRON SPECTRA AND DOSE

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Fig. 2. Neutron spectra for the B61-0.

TABLE III

B61-5 NEUTRON SPECTRA AND DOSE

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Fig. 3. Neutron spectra for the B61-5.

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TABLE IV

B61-7 NEUTRON SPECTRA AND DOSE

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Fig. 4. Neutron spectra for the B61-7.

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TABLE V

W76 NEUTRON SPECTRA AND DOSE

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Fig. 5. Neutron spectra for the W76.

III. B61 MEASUREMENTS WITH THE ^{3}He NEUTRON SPECTROMETER

A. Equipment and Methods

During this same period in 1988, a second set of neutron spectral INRAD measurements of the B61-0, B61-5, and B61-7 weapons was made at Pantex with the ^{3}He Cuttler-Shalev spectrometer.

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Data were acquired with a CAMAC-based data acquisition system interfaced to a COMPAQ-III personal computer. The data acquisition code allowed the summation of short, individual runs that were then transferred manually into LOTUS 1-2-3 for analysis. While we hope to eventually transfer the data automatically, there were still significant improvements over the data acquisition and analysis system that was used in June 1987 for the W76.

In addition to the data runs on the B61, we took extensive background and ^{252}Cf calibration runs. For the energy calibration, we used a precision electronic pulse prior to our trip to Pantex.

Data reduction and analysis were similar to that used for the June 1987, W76 measurements. A background run of ~ 64 h confirmed the flat character of the background that we observed last June with poorer statistics. We acquired about 65 h of data in the ^{252}Cf calibration run to compare to the B61 data runs and accumulated over 33 h on the B61-0, about 50 h on the B61-5, and 33.5 h on the B61-7.

B. Results

The B61 data runs were compared with the ^{252}Cf calibration run, the spectrum was assumed to be characterized by the LANL T-2 model. Figure 6 shows the results of these analyses and compares them to the NE 213 results, which show the neutron spectra at the detector. Table VI lists the ^{3}He spectrometer data and the dose rate that was extracted using the ICRP-21 flux-to-dose conversion. Again, the NE 213 dose rate is given for comparison. Uncertainties associated with our results are estimated to be ± 20%.

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1. B61-5 and B61-7.

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TABLE VI

^{3}He SPECTROMETER MEASUREMENTS

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TABLE VI (cont.)

^{3}He SPECTROMETER MEASUREMENTS

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The need to analyze non-fission spectrum sources adds to our desire to obtain good response functions for the spectrometer as a function of energy. We hope to measure response functions at the Van de Graaff in the near future and will need to develop or adapt an unfolding technique. The Van de Graaff measurements will also permit us to examine the properties of the pulse-shape discrimination system.

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IV. GAMMA-RAY MEASUREMENTS FOR THE BGO AND HPGe DETECTORS

A. Equipment and Methods

1. BGO. The methods used for gamma-ray spectrometry were similar to those used in previous studies.[2] One bismuth germanate detector (BGO 8) was used for all measurements. The diameter and length of the BGO detector crystal were 7.62 cm each.

We acquired pulse-height distributions with the BGO detector at specified positions (see Tables VII-X). Data analysis was done using a computer code called GPEELC. This code runs on a CRAY computer and uses measured detector efficiencies[3] and response functions in a stripping procedure[4] to calculate the gamma-ray flux (photon/cm^2-s), as a function of energy, from the BGO pulse-height distributions. The resulting flux distribution is then converted to a dose-rate distribution. The integral over this dose-rate distribution is then reported as the total gamma-ray dose rate.

2. HPGe. Although the high-purity germanium (HPGe) spectra were obtained for some of the devices in this study, these measurements were important in determining the presence of impurities and isotopic ratios.

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B. Results

1. BGO. Tables VII-X list the total gamma-ray dose rates at each position measured; but Table X only contains data for three positions for a W76. The latter data are from a remeasurement of the W76 that had been measured in June of 1987. Note that the device type was the same but the specific device number was different. The device used for the most recent measurement is approximately 7-8 years newer than the earlier one.

TABLE VII

TOTAL DOSE RATES FOR THE B61-0 INTRINSIC RADIATION MEASUREMENTS

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TABLE VIII

TOTAL DOSE RATES FOR THE B61-5 INTRINSIC RADIATION MEASUREMENTS

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TABLE IX

TOTAL DOSE RATES FOR THE B61-7 INTRINSIC RADIATION MEASUREMENTS

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TABLE X

TOTAL DOSE RATES FROM REMEASUREMENT OF THE W76

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Fig. 7. Raw data (a), flux distribution (b), and dose distribution (c) for the B61-0 measured with the BGO.

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Fig. 8. Raw data (a), flux distribution (b), and dose distribution (c) for the B61-5 measured with the BGO.

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Fig. 9. Raw data (a), flux distribution (b), and dose distribution (c) for the B61-7 measured with the BGO.

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Fig. 10. Raw data (a), flux distribution (b), and dose distribution (c) for the W76 measured with the BGO.

2. HPGe. Table XI lists gamma-ray data for the W76. The second column shows gamma-ray intensities corrected for geometry and detector efficiency.

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TABLE XI

GAMMA RAYS FROM A W76 OBSERVED WITH THE HIGH-PURITY GERMANIUM DETECTOR

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TABLE XI (cont.)

GAMMA RAYS FROM A W76 OBSERVED WITH THE HIGH-PURITY GERMANIUM DETECTOR

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TABLE XI (cont.)

GAMMA RAYS FROM A W76 OBSERVED WITH THE HIGH-PURITY GERMANIUM DETECTOR

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TABLE XI (cont.)

GAMMA RAYS FROM A W76 OBSERVED WITH THE HIGH-PURITY GERMANIUM DETECTOR

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REFERENCES

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