

AD-A068 460

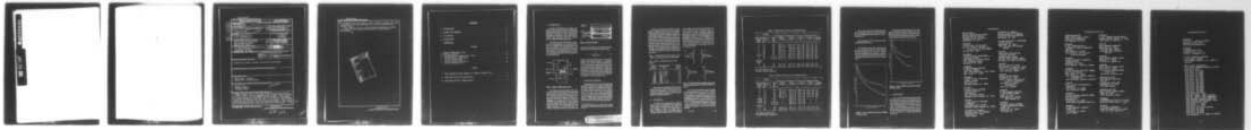
HARRY DIAMOND LABS ADELPHI MD  
NEUTRON-FLUX MAPPING OF AFRI EXPOSURE ROOMS.(U)  
NOV 78 C R HEIMBACH  
HDL-TM-78-19

F/G 18/9

UNCLASSIFIED

NL

1 OF 1  
ADA  
088480

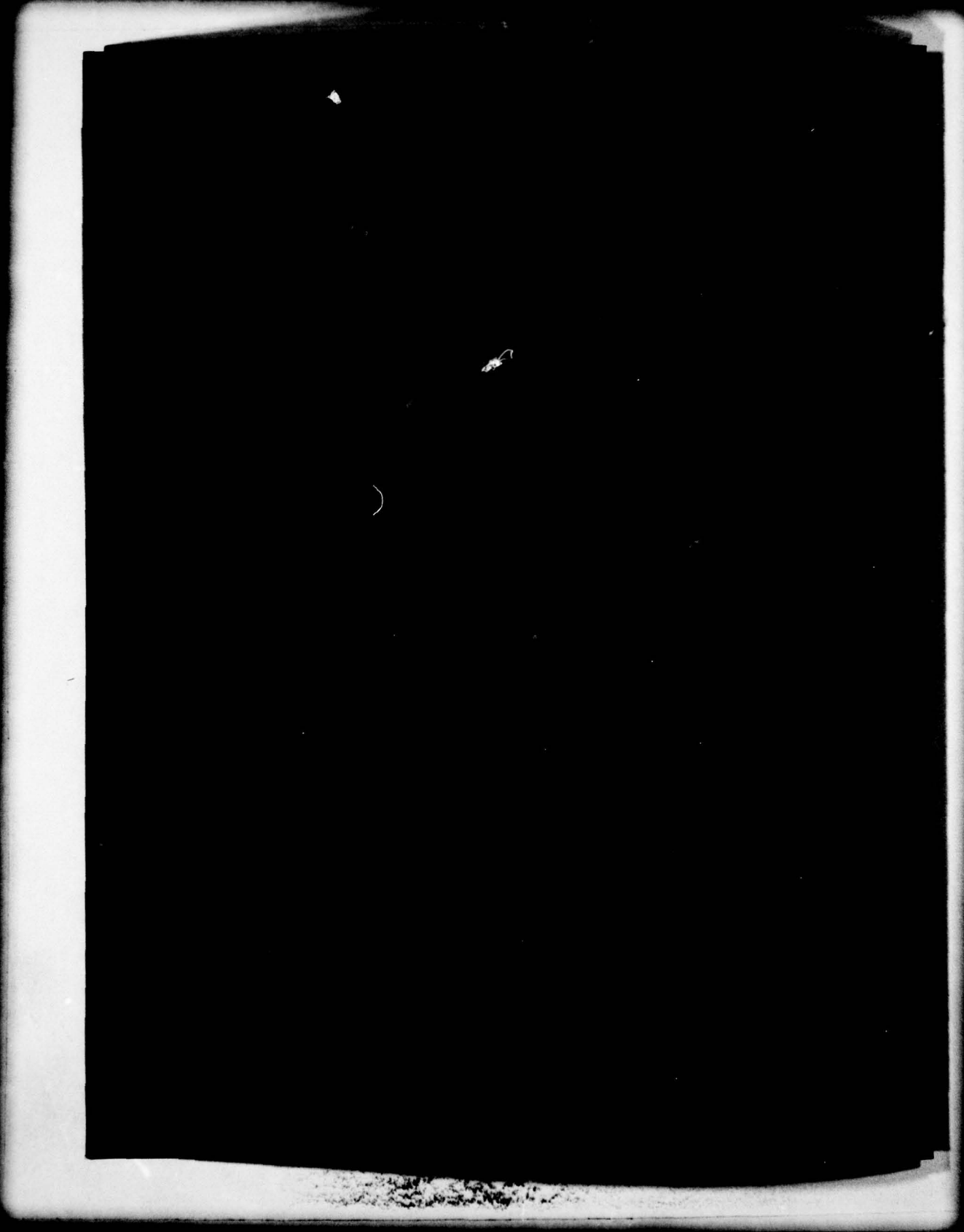


END  
DATE  
FILMED  
6-79  
DDC

**DDC FILE COPY**

**ADA068460**

1102



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER HDL-TM-78-19	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Neutron-Flux Mapping of AFRRI Exposure Rooms	5. TYPE OF REPORT & PERIOD COVERED Technical Memorandum	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Craig R. Heimbach	8. CONTRACT OR GRANT NUMBER(s) 1202	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Harry Diamond Laboratories 2800 Powder Mill Road Adelphi, MD 20783	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA: 1L162120AH2502 Prog. Ele: 6.21.20	
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Materiel Development and Readiness Command Alexandria, VA 22333	12. REPORT DATE Nov 78	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 124 P.	13. NUMBER OF PAGES 11	15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES HDL project: X75826 DRCMS Code: 612120.H250011		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Neutron flux Fission chambers Threshold foils greater than		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The neutron flux in the Armed Forces Radiobiology Research Institute (AFRRI) reactor exposure rooms has been mapped by means of a National Bureau of Standards fission chamber. The chamber contained loadings of both <sup>239</sup> Pu and <sup>237</sup> Np, so that the reported fluxes are for neutrons <math>\le 10</math> and <math>> 600</math> keV in energy. Most of the measurements were taken along the centerline height of the reactor core and perpendicular to the wall facing the reactor pool. A few		

DD FORM 1 JAN 78 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

1

163 050

nat

**UNCLASSIFIED**

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Measurements were also made at other heights and angles in order to establish the flux distribution in a wide volume in each exposure room.

This mapping will aid neutron damage experiments at AFRI by allowing a more precise determination of the neutron environment.

ACCESSION for

White Section

D-11 Section

NTIS

DDC

UNANNOUNCED

JUSTIFICATION

BY

DISTRIBUTION

Dis:

A

**UNCLASSIFIED**

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

## CONTENTS

1. INTRODUCTION . . . . .	5
2. POWER LEVEL MONITOR . . . . .	5
3. FLUX RESULTS . . . . .	6
4. CONCLUSIONS . . . . .	8
DISTRIBUTION . . . . .	9

## FIGURES

1. Design of AFRR1 exposure rooms . . . . .	5
2. NBS fission chambers. . . . .	5
3. Off-angle positions in exposure rooms 1 and 2 . . . . .	6
4. >10 and >600 keV neutron flux at 1000 W in exposure room 1 . . . . .	8
5. >10 and >600 keV neutron flux at 1000 W in exposure room 2 . . . . .	8

## TABLES

I. Power Indicated by Fission Chambers as a Function of Reactor Power . . . . .	6
II. Fission Rates and Flux in Exposure Room 1 . . . . .	7
III. Fission Rates and Flux in Exposure Room 2 . . . . .	7

## 1. INTRODUCTION

A series of measurements was taken in the exposure rooms of the Armed Forces Radiobiology Research Institute (AFRRI) to better characterize the fast-neutron environment. These measurements were taken in anticipation of Harry Diamond Laboratories (HDL) personnel using these exposure rooms for radiation-damage experiments.

The AFRRI reactor is a TRIGA Mark F reactor, and can be operated either at a steady-state power level or in a pulsed mode. All measurements for this report were taken in the steady-state mode. The AFRRI reactor has two exposure rooms which differ in size (see fig. 1). The larger exposure room (ER1) has a movable lead shield which may be positioned in front of the reactor.

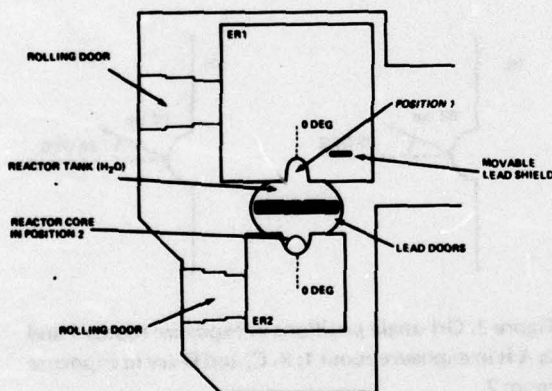


Figure 1. Design of AFRRI exposure rooms.

Fast neutrons were detected by means of a boron-covered National Bureau of Standards (NBS) fission chamber, as pictured in figure 2. The chamber consists of two back-to-back ionization chambers; one chamber had a deposit of 0.000472 g of plutonium-239 and the other had a deposit of 0.000604 g of neptunium-237. When neutrons enter the chamber, they cause the neptunium and plutonium to fission. The fission fragments are detected, and give rise to an electronic pulse. The number of pulses per second is equal, after some

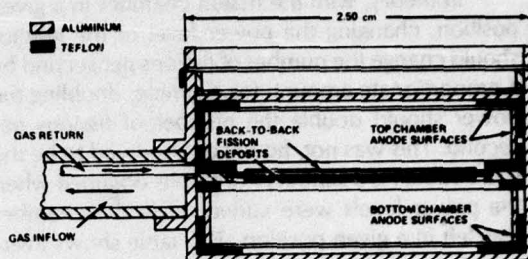


Figure 2. NBS fission chambers.

corrections are applied,<sup>1</sup> to the number of fissions per second. This is related to the neutron flux by

$$\phi = \frac{A}{N_A M \langle \sigma \rangle} f \quad (1)$$

where  $\phi$  is the total neutron flux,  $A$  is the atomic weight of the fissionable isotope,  $N_A$  is Avogadro's number,  $M$  is the mass of the fissionable isotope,  $\langle \sigma \rangle$  is the spectrum-averaged cross section, and  $f$  is the number of fissions per second. Since there are actually two chambers, both the flux as determined by plutonium and that determined by neptunium may be found simultaneously. The chambers were covered with 2.21 g/cm<sup>2</sup> of boron-10 to eliminate any response to neutrons below 10 keV.

## 2. POWER LEVEL MONITOR

Operating the reactor in a pulsed mode would saturate the chamber, so all data were taken with the reactor operating in the steady-state mode. In the taking of data, the reactor was run at various power levels. Close to the reactor, the chambers were run at lower levels to minimize dead-time corrections. Farther back into the room, the reactor was run at higher power levels to obtain sufficient statistics in a reasonably short time. At many positions, the reactor was run at several power levels.

<sup>1</sup>J. A. Grundl, D. M. Gilliam, N. D. Dudgey, and R. J. Popok, *Measurement of Absolute Fission Rates*, Nucl. Tech. 25 (1975), 237-257.

In theory, with the fission chamber in a given position, changing the power level of the reactor should change the number of fissions per second by a proportionate amount; for example, doubling the power should double the number of fissions per second. This was not, however, observed to be the case. Table I is a summary of results obtained when the power levels were varied while the chamber was left in a given position. This table shows averages found from several different positions of the chamber in both exposure rooms. All the data in this table are normalized under the assumption that the 1000 W indicated by reactor instrumentation was correct.

TABLE I. POWER INDICATED BY FISSION CHAMBERS AS A FUNCTION OF REACTOR POWER

Note: 1000 W is calibration point for fission chamber.

Reactor power (W)	Indicated power (W)	Percent deviation
15.	15.1 ± 0.05	+0.6
50.	50.9 ± 0.08	+1.8
100.	104.7 ± 0.6	+4.7
500.	488.0 ± 3.	-2.4
1000.	1000.	0.0
2000.	1980. ± 13	-1.0
5000.	4750. ± 40	-5.0

Table I shows that the fission-chamber and the reactor power-level monitors differ by as much as 5 percent in the range from 15 to 5000 W. One should be especially cautious in trying to extrapolate these results beyond 5000 W.

### 3. FLUX RESULTS

The results of the experiment are listed in tables II and III. Measurements were taken from various places in the exposure rooms, specified in the "Location" columns. The dotted lines in figure 1, labelled "0 deg." are parallel to the left and right walls of the exposure rooms, and originate

at the height of the center of the reactor core (120 cm from the floor in exposure room 2—ER2—and 92 cm in ER1). Distances are measured from the tank wall surface; off-angle positions are diagrammed in figure 3. The only positions not at the height of the reactor core are labelled "up." Measurements were also taken in ER2 with the reactor moved back into the water an extra 6 in. (15.24 cm) and an extra 12 in. (30.48 cm). Distance measurements in the exposure rooms are accurate to ±0.5 cm.

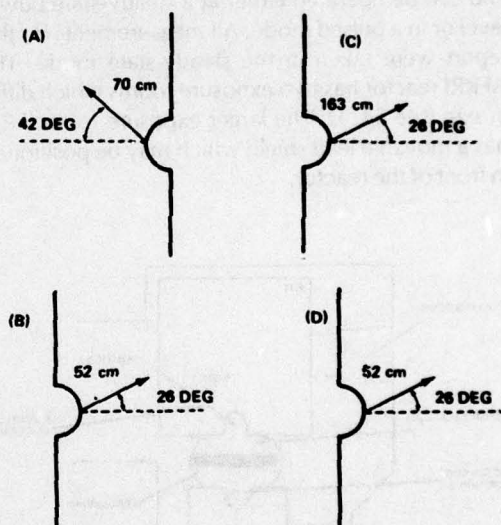


Figure 3. Off-angle positions in exposure rooms 1 and 2; A is in exposure room 1; B, C, and D are in exposure room 2.

The results are given both in terms of fissions per second and flux ( $n/cm^2-s$ ) in order to separate out the effect of the uncertainty in the boron-covered spectrum-averaged cross section, which is the largest source of error. This will affect only the normalization of the flux. The values used to convert from fissions per second to flux are  $K = 4.43 \times 10^3 \pm 5$  percent for neptunium-237 (giving  $>600$  keV flux) and  $5.64 \times 10^3 \pm 7$  percent for plutonium-239 (giving  $>10$  keV flux), using the equation

$$\phi = Kf. \quad (2)$$

TABLE II. FISSION RATES AND FLUX IN EXPOSURE ROOM 1

Location			Neptunium-237 fissions/s at 1000 W	Plutonium-239 fissions/s at 1000 W	10-keV flux at 1000 W (n/cm <sup>2</sup> -s)	600-keV flux at 1000 W (n/cm <sup>2</sup> -s)	Ratio <u>&gt;10 keV</u> <u>&gt;600 keV</u>
Angle from centerline (deg)	Distance from core (cm)	Height from floor					
0	6	HC <sup>a</sup>	983 ± 15	1323.9 ± 20	7.47 × 10 <sup>6</sup>	4.35 × 10 <sup>6</sup>	1.72
0	11.5	HC	710.8 ± 40	963 ± 20	5.43 × 10 <sup>6</sup>	3.15 × 10 <sup>6</sup>	1.72
0	28	HC	335.2 ± 6	498 ± 65	2.81 × 10 <sup>6</sup>	1.48 × 10 <sup>6</sup>	1.90
0	72	HC	99.2 ± 3	150 ± 6	8.46 × 10 <sup>7</sup>	4.39 × 10 <sup>7</sup>	1.91
0	160	HC	28.3 ± 0.7	73.5 ± 1.6	4.14 × 10 <sup>7</sup>	1.25 × 10 <sup>7</sup>	3.31
0	247	HC	14.1 ± 0.5	45.7 ± 2	2.58 × 10 <sup>7</sup>	6.25 × 10 <sup>6</sup>	4.13
42 (A) <sup>b</sup>	70	HC	110.4 ± 2	173.4 ± 4	9.78 × 10 <sup>7</sup>	4.89 × 10 <sup>7</sup>	2.0
0	78	41 cm up	29.4 ± 1.0	68.0 ± 1.0	3.83 × 10 <sup>7</sup>	1.30 × 10 <sup>7</sup>	2.95
0	79	70 cm up	54.2 ± 1.5	97.1 ± 3	5.48 × 10 <sup>7</sup>	2.40 × 10 <sup>7</sup>	2.28
(with lead shield)							
0	72	HC	74.3 ± 1.5	123.2 ± 4	6.95 × 10 <sup>7</sup>	3.29 × 10 <sup>7</sup>	2.11
0	160	HC	19.9 ± 0.5	53.7 ± 1.2	3.03 × 10 <sup>6</sup>	8.81 × 10 <sup>6</sup>	3.44

<sup>a</sup>HC = height at core (92 cm in ER1)

<sup>b</sup>See figure 3 for diagrams of angle positions

TABLE III. FISSION RATES AND FLUX IN EXPOSURE ROOM 2

Location			Neptunium-237 fissions/s at 1000 W	Plutonium-239 fissions/s at 1000 W	10-keV flux at 1000 W (n/cm <sup>2</sup> -s)	600-keV flux at 1000 W (n/cm <sup>2</sup> -s)	Ratio <u>&gt;10 keV</u> <u>&gt;600 ke</u>
Angle from centerline (deg)	Distance from core (cm)	Height from floor					
0	8	HC <sup>a</sup>	851.8 ± 30	1432.2 ± 30	8.08 × 10 <sup>6</sup>	3.77 × 10 <sup>6</sup>	2.14
0	11.5	HC	642.3 ± 9	1116 ± 18	6.29 × 10 <sup>6</sup>	2.84 × 10 <sup>6</sup>	2.21
0	30	HC	301.0 ± 5	519.5 ± 8	2.93 × 10 <sup>6</sup>	1.33 × 10 <sup>6</sup>	2.20
0	71.5	HC	98.7 ± 2.5	217.6 ± 5	1.23 × 10 <sup>6</sup>	4.37 × 10 <sup>7</sup>	2.81
0	158	HC	29.0 ± 1.8	104.9 ± 4	5.92 × 10 <sup>7</sup>	1.28 × 10 <sup>7</sup>	4.62
26 (B) <sup>b</sup>	52	HC	—	282.0 ± 6	1.59 × 10 <sup>6</sup>	—	—
26 (C) <sup>b</sup>	163	HC	—	93.0 ± 2.5	5.24 × 10 <sup>7</sup>	—	—
26 (D) <sup>b</sup>	52	61 cm up	—	282.0 ± 6	1.59 × 10 <sup>6</sup>	—	—
0	49	61 cm up	—	239.4 ± 6	1.35 × 10 <sup>6</sup>	—	—
(with H <sub>2</sub> O)							
0	30	HC	24.23 ± 2.2	44.9 ± 1.5	2.53 × 10 <sup>7</sup>	1.07 × 10 <sup>7</sup>	2.36
0	30	HC	3.48 ± 0.15	9.1 ± 0.3	5.13 × 10 <sup>6</sup>	1.54 × 10 <sup>6</sup>	3.33

<sup>a</sup>HC = height at core (120 cm in ER2)

<sup>b</sup>See figure 3 for diagrams of angle positions

Some of the results of the neptunium flux for ER2 are missing because one of the preamplifiers necessary for taking data failed during the course of the experiment.

The 0-deg data for the two exposure rooms are plotted in figures 4 and 5.

The two exposure rooms have about the same flux out to a distance of 40 cm from the tank wall. Beyond that distance, ER2 has more >10-keV neutrons and about the same number of >600-keV neutrons, indicating a softening of the spectrum as one approaches the back wall of the exposure room.

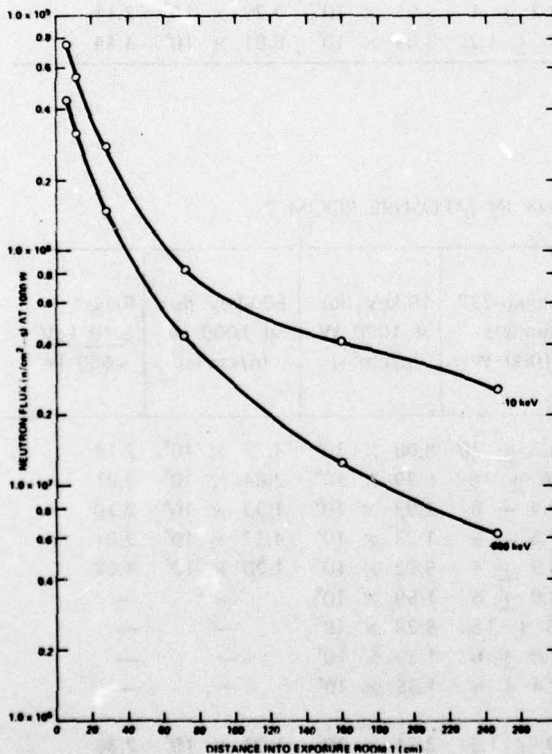


Figure 4. > 10 and > 600 keV neutron flux at 1000 W in exposure room 1.

The effect of the lead shield in ER1 is to cause about a 25-percent decrease in total fast flux and a slight softening of the spectrum. Moving the reactor back into the water significantly reduces neutron flux and greatly softens the neutron spectrum.

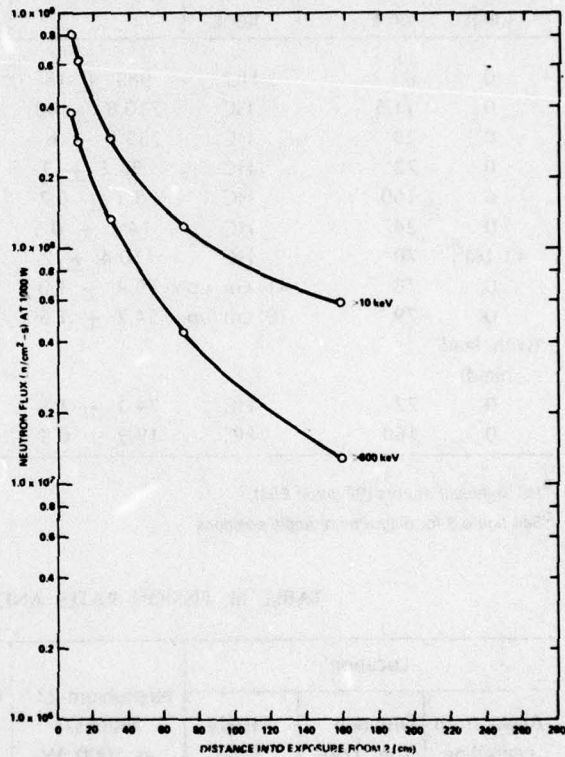


Figure 5. > 10 and > 600 keV neutron flux at 1000 W in exposure room 2.

#### 4. CONCLUSIONS

The > 10 and > 600 keV neutron fluxes have been measured in the two AFRR1 exposure rooms with emphasis in the direction along the 0-deg line at the height of the center of the reactor core. The results are reported in terms of 1000 W of reactor power. The positioning errors are  $\pm 0.5$  cm, the relative point-to-point fission rate errors are about 3 percent, and the absolute normalization uncertainty is 7 and 5 percent for > 10 and > 600 keV flux, respectively.

**DISTRIBUTION**

**ADMINISTRATOR**  
DEFENSE DOCUMENTATION CENTER  
ATTN DDC-TCA (12 COPIES)  
CAMERON STATION, BUILDING 5  
ALEXANDRIA, VA 22314

**COMMANDER**  
US ARMY RSCH & STD GP (EUR)  
ATTN LTC JAMES M. KENNEDY, JR.  
CHIEF, PHYSICS & MATH BRANCH  
FPO NEW YORK 09510

**COMMANDER**  
US ARMY MATERIEL DEVELOPMENT &  
READINESS COMMAND  
ATTN DRXAM-TL, HQ TECH LIBRARY  
5001 EISENHOWER AVENUE  
ALEXANDRIA, VA 22333

**COMMANDER**  
US ARMY ARMAMENT MATERIEL  
READINESS COMMAND  
ATTN ATTN DR SAR-LEP-L, TECH LIBRARY  
ROCK ISLAND, IL 61299

**COMMANDER**  
US ARMY MISSILE & MUNITIONS  
CENTER & SCHOOL  
ATTN ATSK-CTD-F  
REDSTONE ARSENAL, AL 35809

**DIRECTOR**  
US ARMY MATERIEL SYSTEMS  
ANALYSIS ACTIVITY  
ATTN DRXSY-MP  
ATTN TECHNICAL LIBRARY  
ABERDEEN PROVING GROUND, MD 21005

**DIRECTOR**  
US ARMY BALLISTIC RESEARCH  
LABORATORY  
ATTN DRDAR-TSB-S (STINFO)  
ABERDEEN PROVING GROUND, MD 21005

**DEPARTMENT OF COMMERCE**  
NATIONAL BUREAU OF STANDARDS  
WASHINGTON, DC 20234  
ATTN LIBRARY

**DEPARTMENT OF COMMERCE**  
NATIONAL BUREAU OF STANDARDS  
CENTER FOR RADIATION RESEARCH  
WASHINGTON, DC 20234

**US ENERGY RESEARCH & DEVELOPMENT**  
ADMINISTRATION  
WASHINGTON, DC 20545  
ATTN ASST ADMIN FOR NUCLEAR  
ENERGY

**DIRECTOR**  
ARMED FORCES RADIOBIOLOGY  
RESEARCH INSTITUTE  
DEFENSE NUCLEAR AGENCY  
NATIONAL NAVAL MEDICAL CENTER  
BETHESDA, MD 20014 (20 COPIES)

**DIRECTOR**  
NATIONAL SECURITY AGENCY  
FORT GEORGE G. MEADE, MD 20755  
ATTN O. D. VAN GUNTEN, R-425  
ATTN TECHNICAL LIBRARY

**DIRECTOR**  
DEFENSE NUCLEAR AGENCY  
WASHINGTON, DC 20305  
ATTN E. CONRAD, ASST DEP DIR,  
SCIENTIFIC TECHNOLOGY  
ATTN RAEV, ELECTRONIC  
VULNERABILITY  
ATTN TITL, LIBRARY

**COMMANDER**  
US ARMY ARMAMENT RESEARCH  
& DEVELOPMENT COMMAND  
DOVER, NJ 07801  
ATTN DRDAR-LCN, NUCLEAR  
APPLICATIONS DIV

**COMMANDER**  
BALLISTIC MISSILE DEFENSE  
ADVANCED TECHNOLOGY CENTER  
PO BOX 1500  
HUNTSVILLE, AL 35807  
ATTN TECH LIB

DISTRIBUTION (Cont'd)

COMMANDER/DIRECTOR  
COMBAT SURVEILLANCE & TARGET  
ACQUISITION LABORATORY  
FORT MONMOUTH, NJ 07703

COMMANDER  
US ARMY COMMUNICATIONS &  
ELECTRONICS MATERIEL READINESS  
COMMAND  
FORT MONMOUTH, NJ 07703  
ATTN SELEM-ES, DIR FOR ELECT  
SYSTEM MAINTENANCE

COMMANDER  
US ARMY MATERIALS & MECHANICS  
RESEARCH CENTER  
WATERTOWN, MA 02172  
ATTN DRXMR-PL, TECHNICAL LIBRARY

COMMANDER  
US ARMY MATERIEL READINESS COMMAND  
ROCK ISLAND ARSENAL  
ROCK ISLAND, IL 61299  
ATTN DRSAR-ASN, NUCLEAR, CHEMICAL  
& WARHEADS DIV  
ATTN DRSAR-MMN, NUCLEAR & CHEM DIV

DIRECTOR  
NIGHT VISION & ELECTRO-OPTICS  
LABORATORY  
FORT BELVOIR, VA 22060  
ATTN TECHNICAL LIBRARY

COMMANDER  
US ARMY NUCLEAR & CHEMICAL AGENCY  
7500 BACKLICK RD  
BUILDING 2073  
SPRINGFIELD, VA 22150  
ATTN ATCN-W, WEAPONS EFFECTS DIV

COMMANDER  
US ARMY NUCLEAR & CHEMICAL  
SURETY GRP  
FT. BELVOIR, VA 22060  
ATTN LIBRARY

COMMANDER  
US ARMY ABERDEEN PROVING GROUND  
ABERDEEN PROVING GROUND, MD 21005  
ATTN STEAP-TL, TECH LIB

DIRECTOR  
NAVAL RESEARCH LABORATORY  
WASHINGTON, DC 20375  
ATTN CODE 2620, LIBRARY  
ATTN CODE 6600, RADIATION  
TECH DIV

COMMANDER  
NAVAL SURFACE WEAPONS CENTER  
DAHLGREN, VA 22448  
ATTN DX-21, LIBRARY DIV

COMMANDER  
NAVAL SURFACE WEAPONS CENTER  
WHITE OAK, MD 20910  
ATTN WA-50, NUCLEAR WEAPONS  
EFFECTS DIV  
ATTN WX-40, TECHNICAL LIB

COMMANDING OFFICER  
NAVAL WEAPONS EVALUATION  
FACILITY  
KIRTLAND AIR FORCE BASE  
ALBUQUERQUE, NM 87117  
ATTN TECH LIBRARY

COMMANDING OFFICER  
NAVAL WEAPONS SUPPORT CENTER  
CRANE, IN 47522  
ATTN TECHNICAL LIBRARY

COMMANDER  
HQ AERONAUTICAL SYSTEMS DIV (AFSC)  
WRIGHT-PATTERSON AFB, OH 45433

DIRECTOR  
AF AVIONICS LABORATORY  
WRIGHT-PATTERSON AFB, OH 45433  
ATTN LDF (TSR), STINFO BR

DISTRIBUTION (Cont'd)

COMMANDER  
HQ AF TEST & EVALUATION CENTER  
KIRTLAND AFB, NM 87115  
ATTN TEK, ELECTRONICS DIV

COMMANDER  
AF WEAPONS LAB, AFSC  
KIRTLAND AFB, NM 87117  
ATTN EL, ELECTRONICS DIV

US ARMY ELECTRONICS RESEARCH  
& DEVELOPMENT COMMAND  
ATTN WISEMAN, ROBERT S., DR., DRDEL-CT  
ATTN PAO

HARRY DIAMOND LABORATORIES  
ATTN 00100, COMMANDER/TECHNICAL DIR/TSO  
ATTN CHIEF, 00210  
ATTN CHIEF, DIV 10000  
ATTN CHIEF, DIV 20000  
ATTN CHIEF, DIV 30000  
ATTN CHIEF, DIV 40000  
ATTN CHIEF, LAB 11000  
ATTN CHIEF, LAB 13000  
ATTN CHIEF, LAB 15000  
ATTN CHIEF, LAB 22000  
ATTN CHIEF, LAB 21000  
ATTN CHIEF, LAB 34000  
ATTN CHIEF, LAB 36000  
ATTN CHIEF, LAB 47000  
ATTN CHIEF, LAB 48000  
ATTN RECORD COPY, 94100  
ATTN HDL LIBRARY, 41000 (5 COPIES)  
ATTN HDL LIBRARY, 41000 (WOODBRIDGE)  
ATTN CHAIRMAN, EDITORIAL COMMITTEE  
ATTN TECHNICAL REPORTS BRANCH, 41300  
ATTN LEGAL OFFICE, 97000  
ATTN LANHAM, C., 00210  
ATTN WILLIS, B., 47400  
ATTN CHIEF, BR 22800 (5 COPIES)  
ATTN CHIEF, BR 22900  
ATTN CHIEF, BR 22300  
ATTN CHIEF, BR 22100  
ATTN HEIMBACH, C. R., 22900 (10 COPIES)