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EBR-II 75D
HIGH POWER DOSIMETRY TEST

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EBR-11 75D
HIGH POWER DOSIMETRY TEST

E. P. Lippincott, J. A. Ulseth,
L. S. Kellogg, A. I. Davis,
and W. N. McElroy

December, 1975

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ABSTRACT

Preliminary analysis has been completed for twelve midplane sets irradiated in the EBR-II Run 75D high power dosimetry test. Results indicate changes that have occurred in the EBR-II core environment since previous dosimetry test measurements made before the substitution of the stainless steel reflector for the depleted uranium blanket. Large flux variations were also noted outside the core depending on the composition (fuel vs. structural) of neighboring core subassemblies.

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I. INTRODUCTION

Preliminary results of the EBR-II Run 75D high power dosimetry test are presented in this report. This dosimetry test is a part of the continuing efforts of the Fast Reactor Materials Dosimetry Center (FRMDC) and the FTR and EBR-II Projects to achieve and maintain high accuracy neutronics characterization of fast test reactor environments for the LMFBR development program.

Goal accuracy requirements in the 1-3% (1σ) range for neutronics characterization of FTR and EBR-II have been requested based on the needs of LMFBR fuels and materials experimenters. Realistically, however, accuracies ultimately will probably reach the 2-5% (1σ) range^(1,2). Based on this and previous work⁽¹⁻⁶⁾, current accuracies are estimated to be in the 5-15% (1σ) range.

Previous EBR-II full power dosimetry experiments were conducted during EBR-II Runs 31F and 50H^(3,4). Measurements from these tests provided a means of predicting irradiation conditions for fuels, materials, and absorber experiments that were inserted in reactor locations similar to those characterized. In addition, neutron environment characterization for experiment planning could be reasonably approximated from the flux-spectra maps generated from the measured reaction rate data of these dosimetry tests.

The replacement after Run 55 of the radial depleted uranium blanket with a stainless steel reflector in rows 7 to 10 appreciably altered the nuclear environment of the core and reflector regions of the EBR-II. In addition, driver fuel and experimental fuel subassemblies now occupy approximately one-half of the row 7 subassembly positions and high worth B_4C control rods have been introduced in row 5. Therefore, a new high power dosimetry experiment was designed and irradiated in Run 75D to measure the effects of these changes on the reactor environment.

The primary objective of the 75D experiment is to provide more complete and accurate neutron flux and neutron energy descriptions in specific regions of EBR-II where fuel, absorber, and structural material irradiations are performed. Due to the changes in reactor configuration mentioned above,

calculated flux-spectra in certain regions, especially at boundary positions and irradiation locations in the axial and radial reflectors, have rather large uncertainties and must be adjusted by multiple foil measurements. The multiple foil adjusted flux-spectral data derived from this experiment, therefore, provide more reliable neutronics characterization of EBR-II for experimental design and analysis. The 75D test will also help to improve the accuracy of the transposition of point "test sample" results to pins to subassemblies to total core configurations.

A second objective of the full power dosimetry test is to provide timely data on experimental dosimetry methods such as the feasibility of utilizing FTR wire wrap directly as a dosimeter material for the analysis of fuel irradiations. Of particular interest will be its use in establishing more accurate reaction rate axial distributions for fuel pins. In this regard, FTR wire wrap and FTR mixed oxide fuel encapsulated as if it were a fission dosimeter itself, were irradiated along with encapsulated ^{240}Pu , and ^{241}Pu . These special dosimeters, in addition to the standard fission and non-fission dosimeters were located in specific axial positions in a row 4 subassembly. Boron and lithium helium generation monitors were also used. This portion of the irradiation test will provide a basis for developing dosimeter concepts specifically relevant for determining higher accuracy burnup, fission rates,⁽²⁾ and boron absorber capture rates⁽⁷⁾ for LMFBR components, drivers, experimental fuel pins, and control rods.

An additional, but future, objective of this experiment is the assessment of the degree of correlation among present FTR calculational procedures and (1) dosimetry measurement results and (2) ANL calculational results. An early assessment of such correlation is required in view of expected syntheses of EBR-II and FTR irradiation data and results, and because of the need for improved accuracy in the extrapolation of "test sample" results to more complex configurations.

Both ANL-Chicago and Atomics International (AI) participated in this experiment. ANL irradiated one container of candidate CTR dosimetry materials and AI had five containers of He production monitors. AI included both bare and encapsulated (sealed gold or platinum capsules) candidate

fluence monitors to determine if and to what extent the irradiation produced helium escapes from the monitors. Also FTR reference clad constituents and FTR wire wrap samples have been irradiated to determine helium production rates.

This report presents preliminary flux-spectral results from twelve HEDL midplane sets only. These data, the first analyzed in detail, are intended to provide necessary information for experimental design in rows 7 and 8 and some information on flux-spectral changes in rows 2 and 4. Results for the off-midplane sets and additional analyses to meet the other objectives discussed above will be reported in the future.

II. SUMMARY AND CONCLUSIONS

The 75D dosimetry experiment was irradiated for 583 Mwd in January 1975 in order to characterize the EBR-II neutron environment with the stainless steel reflector. Analysis of twelve dosimetry sets located at axial mid-plane in rows 2, 4, 7, and 8 has been completed in order to obtain radial reaction rate and flux traverses to assist in design and analysis of experimental irradiations. Results agree with an ANL calculation for Run 56 in predicting higher total flux in rows 7 and 8, relative to rows 2-4, than existed before the reflector change. However, the absolute value of the total flux appears to be about 10% below the calculated value.

The neutron environment in row 8 was found to be affected by the type of neighboring subassemblies. Row 8 subassemblies next to fuel in row 7, as opposed to structurals in row 7, had about a 10% higher total flux, but the higher energy flux (neutrons with energy greater than 1 MeV) was about 50% higher. Such effects may also be expected in other rows, indicating the necessity of dosimetry for accurate characterization of not only the flux intensity, but the neutron spectrum.

The above, as well as previous results, demonstrate the need for the adjustment of reactor physics calculations by multiple foil measurements to achieve higher accuracy neutronics characterization of EBR-II and subsequently FTR. Present uncertainties for this characterization are estimated to be in the 5 to 15% (1σ) range and this must be reduced to the 2 to 5% (1σ) range to meet current and future LMFBR fuels, materials, and absorber development program needs⁽²⁻⁷⁾. The estimated ranges of past, present, and future characterization uncertainties are shown in Figure 1.

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FIGURE 1. Uncertainty Ranges for Neutron Environmental Characterization.

III. TEST DESCRIPTION AND DATA ANALYSIS

The dosimetry experiment consisted of six Mark B-19 EBR-II subassemblies containing from one to three dosimeter elements with the remaining subassembly positions occupied by solid 304L stainless steel B-19 dummy elements.

The reactor locations for the test subassemblies are shown in Figure 2, together with an indication of the type of surrounding subassemblies. The dosimeter element locations within the subassemblies are also shown in Figure 2, and the twelve sets used for the analysis described in this report are indicated by the darkened circles. The dosimeter data from these locations is the basis for radial reaction rate and flux traverses. In addition, the row 2 location provides a direct comparison with the Run 50H high power dosimetry experiment results. The row 4 locations will provide an estimate of the perturbation due to the high worth B_4C EBR-II control rods. The rows 7 and 8 locations provide an estimate of the differences between adjacent structural subassemblies located in rows 7 and 8 as compared with a structural subassembly in row 8 which is adjacent to a fueled subassembly in row 7. Comparison of data from these locations with similar measurements in Run 50H indicate the changes in neutron flux due to the replacement of the depleted U blanket by stainless steel. In Figure 3, the axial distribution of the dosimeters in each pin is indicated by the rectangles. The letters in each box refer to the type of dosimeter set and Table I lists the number and types of monitors at each dosimeter set location. The vertical lines in Figure 3 represent gradient wire dosimeters which are utilized to interpolate axial reaction rate distributions. Also included are the locations of the capsules containing the helium generation materials which were provided by Atomics International and the location of the capsule containing candidate CTR dosimeter materials provided by ANL. Approximately 1200 monitors (including iron gradient monitors) will be analyzed. As with the previous 31F and 50H dosimetry tests, assistance in the radiometric analysis of this test has been provided by the Atlantic Richfield Hanford Company's Radiochemistry Laboratory^(8,9).

FIGURE 2. Plan View of Location of Subassemblies With Dosimetry Elements.

LETTERED BOXES A THRU K REFER TO SPECTRAL SET LOCATIONS AND NUMBER AND TYPES OF DOSIMETERS INCLUDED IN EACH SPECTRAL SET (SEE TABLE 1 FOR A THRU K TYPES)

ANL BOX INDICATES TEST MATERIALS SUPPLIED BY ANL

AI BOXES INDICATE TEST MATERIALS SUPPLIED BY AI

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FIGURE 3. Dosimetry Element Loading Diagram.

TABLE 1
HIGH POWER DOSIMETRY TEST
SPECTRAL SET CLASSIFICATION AND IDENTIFICATION

<u>No.</u>	<u>Material</u>	Type:	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>Total Number of Dosimeters</u>
1	Enriched U_3O_8 in V		1	1	3	3	1	1	1	1	1	1	1	60
2	Depleted U_3O_8 in V		1	1	3	3	1	1	1			1	1	48
3	NpO_2 in V		1	1	3	3	1	1	1	1	1	1	1	60
4	$^{239}PuO_2$ in V		1	1	3	3	1	1	1	1	1	1	1	60
5	$^{240}PuO_2$ in V				3	3								9
6	$^{241}PuO_2$ in V				3	3								9
7	FTR Fuel in V				3	3								9
8	Sc Wire in V		1	1	1	1	1	1	1	1	1	1	1	54
9	Natural B in V		1		2	2	1	1	1	1		1		26
10	6Li in V		1		1	1	1	1				1		19
11	7Li in V				1		1							4
12	Mn Wire		1	1	1	1	1	1	1	1	1	1	1	54
13	Fe Wire		1	1	1	1	1	1	1	1	1	1	1	54
14	Ni Wire		1	1	1	1	1	1	1	1	1	1	1	54
15	Ti Wire		1	1	1	1	1	1	1	1	1	1	1	54
16	Cu Wire		1	1	1	1	1	1	1	1	1	1	1	54
17	Cu Foil		1	1	1	1	1	1	1	1	1	1	1	54
18	Al Wire		1	1	1	1	1	1	1	1	1	1	1	54
19	Al-0.1% Co Wire		1	1	1	1	1	1	1	1	1	1	1	54
20	Au Foil		1	1	1	1	1	1	1	1	1	1	1	54
21	Al-0.1% Ta Wire		1	1	1	1	1	1	1	1	1	1	1	54
22	SS (FTR) Wire Wrap		1		3	3	1							16
23	V Blank				1		1							4
Total Number of Sets of Each Type			5	10	2	1	2	4	2	2	10	5	11	918 Dosimeters
Total Sets = 54														

The 75D dosimetry experiment was irradiated for a total of 583 Mwd at a nominal reactor power of 62.5 Mw. The irradiation was not continuous but had a shutdown in the middle for a period of 4 hours. The calculation of foil activity saturation factors for this run was carried out using the program TIMWH⁽¹⁰⁾. Power level information from the EBR-II Data Acquisition System were entered every 10 minutes during shutdown and startup, enabling an accurate calculation of reaction rates for even the shortest half-life products (12.7 hr ⁶⁴Cu and 15 hr ²⁴Na).

Reaction rate measurements were made using various radiochemistry techniques. Foils were counted on Ge(Li) and NaI(Tl) counter systems, as appropriate, and statistical errors were generally kept below 1%. The nuclear data used to derive reaction rates from the radiochemical measurements are given in Appendix A. The measured reaction rates were then used as input to the SAND-II program for spectral unfolding^(1,11-13). The reactions available for the preliminary midplane analysis are listed in Table II. Future results will include additional reactions for which radiochemical measurements are not yet available or which require helium mass spectrographic measurement. Weighted SAND-II solutions with uncertainty estimates will also be provided by use of a new and improved SAND-II Monte Carlo code^(1,14-15).

TABLE 2
REACTIONS USED IN THE RUN 75D SAND-II UNFOLDING

	Energy Range (a), MeV	
	Lower	Upper
$^{197}\text{Au}(n,\gamma)^{198}\text{Au}$	4.7×10^{-6}	.58
$^{181}\text{Ta}(n,\gamma)^{182}\text{Ta}^{(b)}$	8.0×10^{-5}	.66
$^{59}\text{Co}(n,\gamma)^{60}\text{Co}^{(b)}$	1.2×10^{-4}	.30
$^{235}\text{U}(n,f)^{140}\text{Ba}$	9.6×10^{-4}	2.3
$^{45}\text{Sc}(n,\gamma)^{46}\text{Sc}$	1.3×10^{-3}	.80
$^{239}\text{Pu}(n,f)^{140}\text{Ba}$	1.2×10^{-3}	2.8
$^{58}\text{Fe}(n,\gamma)^{59}\text{Fe}$	3.2×10^{-4}	1.2
$^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$	5.7×10^{-4}	.76
$^{237}\text{Np}(n,f)^{140}\text{Ba}$	0.42	4.4
$^{238}\text{U}(n,f)^{140}\text{Ba}$	1.4	6.1
$^{58}\text{Ni}(n,p)^{58}\text{Co}$	2.0	7.2
$^{54}\text{Fe}(n,p)^{54}\text{Mn}$	2.1	7.6
$^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$	2.7	11.0
$^{27}\text{Al}(n,\alpha)^{24}\text{Na}^{(b)}$	6.4	11.9

(a) Energy range above which 5% and below which 5% of reactions occur at the 28.2 cm. radius.

(b) Not available for row 2 and 4 positions for calculations in this report.

IV. DISCUSSION OF RESULTS

Total flux distributions at midplane are shown in Figure 4. The Run 75D plotted points are compared with curves for the previous Run 50H multiple foil derived results and a calculated curve for the Run 56 loading. The 50H curve was based on measurements with the depleted uranium radial blanket and thus has lower flux in rows 7 and 8 than the calculation. The Run 56 calculation has been lowered by a 9% power calibration correction^(5,6). If the curve were lowered by about an additional 10% it would agree quite closely with the 75D measurement, as it predicts the shape of the measured traverse quite accurately.

The multiple foil derived flux-spectral data, Figure 4, are based on both fission and non-fission foil results. For the fission foils, the fission rates were determined by measurement of the ^{140}Ba fission product. Preliminary measurements were also obtained for the ^{235}U fission rate as determined by ^{137}Cs , ^{103}Ru , and ^{95}Zr . The ^{137}Cs results are less accurate at this time, because of counting interferences from the shorter half-life fission products, but agree within error with the ^{140}Ba . The ^{103}Ru and ^{95}Zr results are 6% higher than the ^{140}Ba , which if used instead of the ^{140}Ba would move the total flux determined from the experimental numbers in the direction of the calculation. However, it is felt that the fission rate as determined by the ^{140}Ba should be used at this time in preference to other estimates because of the greater standardization effort on this isotope. Future calibration checks and additional measurements for ^{137}Cs , ^{103}Ru , and ^{95}Zr will help to eliminate or reduce the present discrepancies between measured fission rates for the different fission products. An important observation here is that the high and low power EBR-II dosimetry tests as well as individual fuels, materials, and absorber tests, have shown that the analysis of multiple fission products is essential for obtaining higher accuracy fission rate and burnup measurements, and the subsequent multiple foil derived values of flux-fluence-spectra.

Curves are shown for the flux greater than 0.1 MeV and 1 MeV in Figures 5 and 6. Figure 7 compares the mean neutron energy and good agreement is observed with the 50H measurements except for the row 8 subassemblies next to fuel in row 7.

FIGURE 4. Total Flux Radial Distribution at EBR-II Midplane - Run 75D.

FIGURE 5. Flux ($E > 0.1$ MeV) Radial Distribution at EBR-II Midplane - Run 75D.

FIGURE 6. Flux ($E > 1.0$ MeV) Radial Distribution at EBR-II Midplane - Run 75D.

FIGURE 7. Mean Neutron Energy at EBR-II Midplane - Run 75D.

The comparisons between row 8 subassemblies next to fuel and next to structurals in row 7 are expanded in Figures 8 and 9. It is seen that fuel in row 7 increases the row 8 total flux by 8-14% and the flux greater than 1 MeV by about 50%. This difference can be significant for effects caused primarily by the high energy neutrons, such as helium production. For such cases, detailed account of neighboring subassembly effects is mandatory. Such flux differences can also be expected at positions inside the core but high energy flux perturbations will usually be less than 20%. Reduction of total flux by as much as 20% may be expected next to absorber subassemblies.

FIGURE 8. Expanded View of Rows 7 and 8 Total Flux - Run 75D.

FIGURE 9. Expanded View of Rows 7 and 8 Flux $E > 1.0 \text{ MeV}$ - Run 75D.

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APPENDIX A

Tables A-1 through A-3 present the basic constants and factors used to calculate reaction rates from measured gamma ray intensities. These tables represent an updated version of those values used in previous dosimetry tests^(3,4).

Table A-1 presents branching ratios and decay constants for the various radioactive species measured. Most of these constants are from the compilation in Reference 16.

Table A-2 presents the atomic mass and abundance factors used to convert from d/s/mg to d/s/atom. For the fissionable isotopes, the abundance of the principal isotope in the particular mixture is used. Thus, the numbers in Table A-2 are for 100% abundance of these isotopes and must be adjusted for an actual case.

Table A-3 presents fission yields as recommended in References 1 and 2. These values are identical to the ENDF/B-IV recommendation except for ²³⁷Np fission yields which are presently not contained in the ENDF/B file.

TABLE A-1
BASIC CONSTANTS AND FACTORS FOR RADIOCHEMICAL ANALYSES

Reactions	γ Energy Kev	γ -Ray Branching Intensity, %	$t_{1/2}$	λ (sec ⁻¹)
$^{27}\text{Al}(n,\alpha)^{24}\text{Na}$	1368.6 2753.98	99.993 (2)* 99.84 (3)	15.00 (2)*h	1.28361-5
$^4_5\text{Sc}(n,\gamma)^{46}\text{Sc}$	889.26	99.984 (6)	83.85 (10) d	9.56772-8
$^{46}\text{Ti}(n,p)^{46}\text{Sc}$	1120.52	99.987 (6)		
$^4_7\text{Ti}(n,p)^{47}\text{Sc}$	159.39	69.0 (25)	3.39 (4) d	2.36653-6
$^{48}\text{Ti}(n,p)^{48}\text{Sc}$	983.4 1037.4 1311.8	99.987 (2) 97.5 (3) 99.992 (2)	43.8 (1) h	4.39591-6
$^{54}\text{Fe}(n,p)^{54}\text{Mn}$	834.827	99.97 (2)	312.6 (3) d	2.56639-8
$^{55}\text{Mn}(n,2n)^{54}\text{Mn}$				
$^{58}\text{Ni}(n,p)^{58}\text{Co}$	810.757	99.44 (5)	71.23 (15) d	1.12629-7
$^{58}\text{Fe}(n,\gamma)^{59}\text{Fe}$	1099.224 1291.564 Sum	55.5 (17) 44.1 (12) 99.6 (1)	44.6 (1) d	1.79878-7
$^{59}\text{Co}(n,\gamma)^{60}\text{Co}$	1173.208	99.86 (2)	5.268 (5) y	4.16953-9
$^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$	1332.46	99.986 (2)		
$^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$	511.002 1345.7	36.8 (16) 0.48	12.701 (7)	1.51595-5
$^{127}\text{I}(n,2n)^{126}\text{I}$	388.5 666.2	34.73 32.6	13.02 (7) d	6.16170-7
$^{181}\text{Ta}(n,\gamma)^{182}\text{Ta}$	1121.3 1189.1 1221.4	35.3 16.2 27.45	115.1 d	6.97006-8
$^{197}\text{Au}(n,\gamma)^{198}\text{Au}$	411.794	95.48 (10)	2.696 (2) d	2.97572-6
$^{235}\text{U}(n,f)$	^{140}Ba - ^{140}La 1596.18	- 95.33 (16)	12.79 (1) d 40.26 (2) h	6.27251-7 4.78244-6
$^{238}\text{U}(n,f)$	^{95}Zr 724.18	44.2 (5)	64.4 (5) d	1.24574-7
$^{237}\text{Np}(n,f)$	756.72	54.8 (5)		
$^{239}\text{Pu}(n,f)$	Sum	99.0 (5)		
	^{103}Ru 497.08	89.0 (30)	39.43 (10) d	2.03463-7
	^{137}Cs 661.64	85.0 (3)	30.174 (34) y	7.27948-10
$^{238}\text{U}(n,\gamma)^{239}\text{Np}$	228.19 (1) 277.60 (3)	11.3 (2) 14.3 (2)	2.355 (4) d	3.40660-6

* Numbers in parentheses after the half-lives and X-ray branching intensities are the 1 σ assigned errors in the last digits.

TABLE A-2

BASIC CONSTANTS AND FACTORS FOR REACTION RATE DETERMINATIONS

<u>Reaction</u>	<u>Atomic Mass</u>	<u>Isotopic Abundance</u>	<u>K x 10¹⁹</u>
$^{27}\text{Al}(n,\alpha)^{24}\text{Na}$	26.9815	1.00	0.44804
$^{45}\text{Sc}(n,\gamma)^{46}\text{Sc}$	44.9559	1.00	0.74652
$^{46}\text{Ti}(n,p)^{46}\text{Sc}$	47.90	0.0799	9.9550
$^{47}\text{Ti}(n,p)^{47}\text{Sc}$	47.90	0.0732	10.866
$^{48}\text{Ti}(n,p)^{48}\text{Sc}$	47.90	0.7399	1.0750
$^{54}\text{Fe}(n,p)^{54}\text{Mn}$	55.847	0.0584	15.880
$^{55}\text{Mn}(n,2n)^{54}\text{Mn}$	54.938	1.00	.91227
$^{58}\text{Ni}(n,p)^{58}\text{Co}$	58.71	0.6788	1.4362
$^{58}\text{Fe}(n,\gamma)^{59}\text{Fe}$	55.847	0.0033	281.02
$^{59}\text{Co}(n,\gamma)^{60}\text{Co}$	58.9332	1.00	0.97862
$^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$	63.546	0.6909	1.5273
$^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$	63.546	0.6909	1.5273
$^{127}\text{I}(n,2n)^{126}\text{I}$	126.9045	1.00	2.75657
$^{181}\text{Ta}(n,\gamma)^{182}\text{Ta}$	180.948	.99988	3.0051
$^{197}\text{Au}(n,\gamma)^{198}\text{Au}$	196.9665	1.00	3.2707
$^{235}\text{U}(n,f)^{140}\text{Ba}$	235.0439	1.00	3.9030
$^{238}\text{U}(n,f)^{140}\text{Ba}$	238.0508	1.00	3.9530
$^{237}\text{Np}(n,f)^{140}\text{Ba}$	237.0482	1.00	3.9363
$^{239}\text{Pu}(n,f)^{140}\text{Ba}$	239.0522	1.00	3.9696

TABLE A-3
FISSION YIELDS

	<u>^{140}Ba</u>	<u>^{137}Cs</u>	<u>^{95}Zr</u>	<u>^{103}Ru</u>
^{235}U	6.020	6.159	6.383	3.290
^{238}U	5.889	6.194	5.324	6.336
^{239}Pu	5.319	6.389	4.742	6.710
^{237}Np	5.79	6.67	5.85	5.75

APPENDIX B

SELECTED REACTION RATE TRAVERSES

Measured radial reaction rate traverses are presented in Figures B-1 to B-5. These traverses are presented to illustrate the relationship between measurements and the derived flux spectrum.

Figure B-1 shows the $\text{Au}(n,\gamma)$ reaction rate which is sensitive to low energy neutrons. The reaction rate drops from row 2 to 5 and then rises rapidly outside the core. For comparison, the gold traverse from Run 31F (depleted U blanket instead of stainless steel reflector in rows 7-10) is plotted and shows no increase outside the core. In rows 7 and 8 the reaction rate (and therefore the low energy flux) also depending greatly on whether or not fuel is present in row 7.

The $^{235}\text{U}(n,f)$ and $^{239}\text{Pu}(n,f)$ reaction rate traverses are shown in Figures B-2 and B-3, respectively. These reactions sample neutrons of all energies and thus approximately represent the total flux. The ^{235}U fission rate does indicate a slight rise outside the core since this reaction is more sensitive to low energy neutrons, but the effect is much less than for the gold capture reaction. The effect of rows 7-8 subassembly geometry is also much less for the fission reactions with the plutonium exhibiting essentially no variation. Reaction rate curves from Run 50H are also plotted and illustrate the effect of the enhanced flux in rows 7-8 with the stainless steel reflector in Run 75D.

The high energy flux is illustrated by the $^{238}\text{U}(n,f)$ and $^{63}\text{Cu}(n,\alpha)$ reaction rate in Figures B-4 and B-5. The reaction rates are relatively unaffected by the blanket change, but large effects are seen in rows 7-8 due to fuel placement.

FIGURE B-1. Comparison of Run 75D and 31F $^{197}\text{Au}(n,\gamma)$ Reaction Rate Distribution at EBR-II Midplane.

B-3

FIGURE B-2. Comparison of Runs 75D and 50H ²³⁵(n,f) Fission Rate Distribution at EBR-II Midplane.

FIGURE B-3. Comparison of Runs 75D and 50H $^{239}\text{Pu}(n,f)$ Fission Rate Distribution at EBR-II Midplane.

FIGURE B-4. Comparison of Runs 75D and 50H ²³⁸U(n,f) Fission Rate Distribution at EBR-II Midplane.

FIGURE B-5. Comparison of Runs 75D and 50H $^{63}\text{Cu}(n,\alpha)$ Reaction Rate Distribution at EBR-II Midplane.

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