LIQUID METAL REACTOR PROGRAM

JASPER

USDOE/PNC Shielding Research Program

Technical Progress Report

August 1 - September 30, 1986

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INTRODUCTION

The first two reports, ORNL/LMR/AC-86/3 and 4, cover the measurements in phases I, II, III and V. This report contains the measurements in phases VI and VII, a graphite benchmark study and an alternate loop type shield design study for the LMR respectively. For these measurements the spectrum modifier remained the same as in I, II and III. This report also includes the results of analyses for phases I, II, III, V, and VI.

EXPERIMENTAL PROGRAM

Schematics of the mockups in phases VI and VII of the program plan are given in Figs. 1 through 4. In Fig. 1, 7.62 cm of lead was placed behind the graphite to attenuate the gamma-rays so that neutron spectral measurements could be made with the NE-213 spectrometer. For the spectral measurements in VI-F it was necessary to add 15.24 cm of lead as shown in Fig. 2. The lead was removed for the Bonner ball measurements on centerline at 30 cm behind the configuration and at 304.8 cm from the reactor centerline as shown in Figs. 3 and 4.

Measurements

Data obtained with the NE-213 spectrometer behind the mockups for VI-A and VI-F are listed in Tables 1 and 2, and plotted in Figures 5 and 6 respectively. Accompanying low neutron energy spectra obtained with the hydrogen counter are given in Tables 3 and 4, and plotted in Figures 7 and 8. Integral neutron flux measurements with the Bonner balls on centerline at 30 cm behind the configurations are given in Table 5 for both phases. Similar measurements at 304.8 cm from the reactor centerline are given in Table 6. Several traverses through the horizontal midplane were made with the 5-in. Bonner ball 30 cm behind selected configurations and these data are listed in Table 7. Table 8 contains the results from measurements with the three Bonner balls at the NE-213 locations.

ANALYSIS

Calculations were performed for all the configurations listed under Roman numerals I, II, III, V, and VI of the Experimental Program Plan. Calculations were performed with the DOT-IV (version 4.4) two-dimensional discrete ordinates radiation transport computer code in R-Z geometry using a 51-neutron-group cross-section library developed at ORNL for fast reactor shield analysis. The basic cross-section data came mainly from ENDF/B-IV. A symmetric S_{12} quadrature (96 directions) was used and is felt to be adequate since little if any narrow-gap void streaming would be encountered. Higher order quadratures up to S_{32} did not result in significant changes in the neutron flux levels behind 1-D mockups of thick-shield configurations.

The source for a particular calculation was either an external disk boundary flux incident on the spectrum modifier (following the Tower Shielding Reactor collimator) or an external disk boundary flux at some intermediate location in the larger configurations. For Configurations I.A, II.A, III.A, III.B, III.C, V.A, and VI.A, the source was incident on the spectrum modifier and during calculations for Configurations II.A, III.C, V.A, and VI.A boundary fluxes were saved at intermediate locations for use in follow-on calculations. For Configurations V.B through V. J the source was incident on the fourth sodium tank. For the remaining configurations the source was incident on the aluminum slab which followed the UO_2 radial blankets, thus eliminating the need for multiple outer iterations to converge the fission source in these cases.

Calculated detector responses were obtained either by (1) calculating with DOT-IV the flux in the void region behind the configuration and using the DOTWRTPN code to weight the detector count rate over the detector's hemispherical surface which faces the configuration or (2) using the DISK-TRAN code to calculate responses at the centers of detection for the detectors. The calculated spectrum at the specified measurement location was compared directly with the measured spectrum (i.e. no spatial smearing of the calculated result).

Results

Results for Configuration V.A were reported in the last reporting period, although some of those are repeated for comparison. Calculation-to-experiment ratios (C/E) for the 5-in. Bonner ball at two or three positions behind each configuration calculated are presented in Table 9. Similar ratios were obtained for the 3-, 8-, and 10-in. Bonner balls. The ratios for the bare and Cd-covered BF_3 detectors ranged from "similar to" to "very different from" the 5-in. Bonner ball ratios depending on the configuration. The agreement is generally good for Configurations I, V, and the smaller configurations of sections II, III, and VI. There is some overprediction for section V configurations containing B_4C . Configurations in section VI are underpredicted more than any others. The steadily declining C/E's with increasing shield thickness suggests an underprediction of (1) the fast-neutron flux leaving the UO_2 blankets or (2) the fission neutron source in the blankets. Possible reasons for the calculational discrepancies are being examined and hopefully will be identified prior to the initiation of a new round of calculations for the remaining configurations.

Calculated versus measured fast-neutron spectra for Configurations I.A, II.D, VI.A, and VI.F are shown in Figs. 9-12. The calculational underprediction is about the same as that for the 5-in. Bonner ball (last column of Table 9).

ORNL - DWG 86 - 15295

Figure 1. Schematic of SM + 1.26 cm Al + 15.53 cm SS + 10.16 cm SS + 10.16 cm graphite + 7.62 cm lead (Item VI-A). Note: Lithiated paraffin covers lateral sides of configuration.

ORNL - DWG 86 - 15294

Figure 2. Schematic of SM + 1.26 cm Al + 15.53 cm SS + 61 cm graphite + 6.50 cm B₄C + 15.24 cm lead (Item VI-F). Note: Lithiated paraffin covers lateral sides of configuration.

ORNL - DWG 86 - 15296

Figure 3. Schematic of SM + 1.26 cm Al + 15.53 cm SS + 61 cm graphite (Items VI-A - F). Note: Lithiated paraffin covers lateral sides of configuration.

ORNL DWG 86-15297

Figure 4. Schematic of SM + 1.26 cm Al + 15.53 cm SS + 1.26 cm Al + 15.74 cm SS + 1.26 cm Al + 15.68 cm SS + 1.26 cm Al + 16.95 cm B₄C + 2.59 cm SS + 34.2 cm Na (Items VII-A - D). Note: Lithiated paraffin covers lateral sides of configuration.

22-AUG-86

Figure 5. Fast neutron fluxes (>0.8 MeV) on centerline at 51.1 cm beyond the graphite (36.4 cm behind the lead) (Item VI-A): Run 7858A.

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Figure 6. Spectrum of high-energy neutrons (>0.8 MeV) on centerline 63.2 cm beyond the graphite in the configuration (Item VI-F): Run 7859A.

Figure 7. Neutron fluxes (50 keV to 1.4 MeV) on centerline at 51.1 cm behind the graphite (36.4 cm behind the lead) (Item VI-A): Runs 1542A, 1541B, 1541A.

Figure 8. Neutron spectrum (50 keV to 1.4 MeV) on centerline 63.2 cm beyond the graphite in the configuration (Item VI-F): Runs 1544A, 1544B, 1545A.

Figure 9. Calculated versus measured $E > 0.09$ MeV neutron spectra on centerline 178.8 cm behind Configuration I.A.

Figure 10. Calculated versus measured $E > 0.09$ MeV neutron spectra on centerline 33.6 cm behind Configuration II.D + 7.62 cm Pb.

Figure 11. Calculated versus measured $E > 0.09$ MeV neutron spectra on centerline 36.4 cm behind Configuration VI.A + 7.62 cm Pb.

Figure 12. Calculated versus measured $E > 0.09$ MeV neutron spectrum on centerline 36.3 cm behind Configuration VI.F + 6.5 cm B_4C + 15.24 cm Pb.

Table 1. Fast neutron fluxes (>0.8 MeV) on centerline at 51.1 cm behind the graphite (36.4 cm behind the lead) (Item VI A): Run 7858A.

Neutron Energy (MeV)	Flux (neutrons $\text{cm}^{-2}\text{MeV}^{-1}\text{kw}^{-1}\text{s}^{-1}$)		Neutron Energy (MeV)	Flux (neutrons $\text{cm}^{-2}\text{MeV}^{-1}\text{kw}^{-1}\text{s}^{-1}$)	
	Lower Limit	Upper Limit		Lower Limit	Upper Limit
8.11E (-1)	3.47E (3)	3.51E (3)	5.94E (0)	2.44E (1)	2.58E (1)
9.07E (-1)	3.73E (3)	3.75E (3)	6.25E (0)	2.05E (1)	2.23E (1)
1.01E (0)	3.28E (3)	3.29E (3)	6.56E (0)	1.74E (1)	1.90E (1)
1.11E (0)	2.70E (3)	2.71E (3)	6.84E (0)	1.50E (1)	1.60E (1)
1.20E (0)	2.25E (3)	2.26E (3)	7.24E (0)	1.22E (1)	1.31E (1)
1.31E (0)	1.91E (3)	1.92E (3)	7.74E (0)	9.32E (0)	1.03E (1)
1.41E (0)	1.65E (3)	1.66E (3)	8.24E (0)	6.79E (0)	7.54E (0)
1.51E (0)	1.44E (3)	1.44E (3)	8.76E (0)	5.63E (0)	6.16E (0)
1.61E (0)	1.23E (3)	1.23E (3)	9.26E (0)	5.25E (0)	5.70E (0)
1.71E (0)	1.03E (3)	1.04E (3)	9.74E (0)	4.33E (0)	4.70E (0)
1.81E (0)	8.56E (2)	8.63E (2)	1.03E (1)	3.07E (0)	3.34E (0)
1.93E (0)	6.97E (2)	7.04E (2)	1.08E (1)	2.29E (0)	2.49E (0)
2.10E (0)	5.29E (2)	5.35E (2)	1.12E (1)	2.02E (0)	2.17E (0)
2.30E (0)	3.85E (2)	3.90E (2)	1.18E (1)	1.88E (0)	2.02E (0)
2.50E (0)	2.76E (2)	2.80E (2)	1.24E (1)	1.52E (0)	1.64E (0)
2.70E (0)	1.95E (2)	1.99E (2)	1.32E (1)	8.02E (-1)	8.79E (-1)
2.90E (0)	1.45E (2)	1.49E (2)	1.40E (1)	2.69E (-1)	3.03E (-1)
3.10E (0)	1.08E (2)	1.12E (2)	1.48E (1)	6.35E (-2)	7.73E (-2)
3.30E (0)	8.24E (1)	8.56E (1)	1.56E (1)	3.62E (-3)	8.88E (-3)
3.50E (0)	6.55E (1)	6.92E (1)	1.65E (1)	-5.46E (-3)	-3.91E (-3)
3.71E (0)	5.51E (1)	5.81E (1)	1.75E (1)	-5.09E (-3)	-4.53E (-3)
3.91E (0)	4.92E (1)	5.18E (1)	1.85E (1)	-4.29E (-3)	-3.81E (-3)
4.15E (0)	4.75E (1)	5.01E (1)	1.95E (1)	-3.49E (-3)	-3.01E (-3)
4.45E (0)	5.03E (1)	5.25E (1)	2.06E (1)	-2.53E (-3)	-2.06E (-3)
4.75E (0)	4.96E (1)	5.16E (1)	2.16E (1)	-1.60E (-3)	-1.14E (-3)
5.04E (0)	4.24E (1)	4.41E (1)	2.26E (1)	-9.71E (-4)	-5.14E (-4)
5.35E (0)	3.41E (1)	3.57E (1)	2.35E (1)	-5.87E (-4)	-1.01E (-4)
5.65E (0)	2.85E (1)	3.01E (1)			

E1 (MeV)	E2 (MeV)	Integral (neutrons $\text{cm}^{-2}\text{kw}^{-1}\text{s}^{-1}$)	Error (neutrons $\text{cm}^{-2}\text{kw}^{-1}\text{s}^{-1}$)
0.811	1.000	6.85E (2)	1.97E (0)
1.000	1.200	5.53E (2)	1.33E (0)
1.200	1.600	6.83E (2)	1.99E (0)
1.600	2.000	3.60E (2)	1.40E (0)
2.000	3.000	3.09E (2)	2.31E (0)
3.000	4.000	7.39E (1)	1.66E (0)
4.000	6.000	8.25E (1)	1.89E (0)
6.000	8.000	3.01E (1)	1.21E (0)
8.000	10.000	1.15E (1)	5.23E (-1)
10.000	12.000	4.86E (0)	1.92E (-1)
12.000	16.000	2.23E (0)	9.86E (-2)
16.000	20.000	-1.56E (-2)	1.72E (-3)
1.500	15.000	1.01E (3)	9.71E (0)
3.000	12.000	2.03E (2)	5.47E (0)

Table 2. Fast Neutron fluxes (>0.8 MeV) on centerline at 63.2 cm beyond the graphite in the configuration (Item VI-F): Run 7859A

Neutron Energy (MeV)	Flux (neutrons $\text{cm}^{-2}\text{MeV}^{-1}\text{kW}^{-1}\text{s}^{-1}$)		Neutron Energy (MeV)	Flux (neutrons $\text{cm}^{-2}\text{MeV}^{-1}\text{kW}^{-1}\text{s}^{-1}$)	
	Lower Limit	Upper Limit		Lower Limit	Upper Limit
8.11E (-1)	4.48E (0)	4.54E (0)	5.94E (0)	1.06E (-1)	1.10E (-1)
9.07E (-1)	4.93E (0)	4.97E (0)	6.25E (0)	1.00E (-1)	1.06E (-1)
1.01E (0)	4.36E (0)	4.38E (0)	6.56E (0)	9.36E (-2)	9.81E (-2)
1.11E (0)	3.54E (0)	3.57E (0)	6.84E (0)	8.23E (-2)	8.53E (-2)
1.20E (0)	2.97E (0)	2.99E (0)	7.24E (0)	6.04E (-2)	6.27E (-2)
1.31E (0)	2.61E (0)	2.63E (0)	7.74E (0)	3.59E (-2)	3.83E (-2)
1.41E (0)	2.38E (0)	2.40E (0)	8.24E (0)	2.15E (-2)	2.33E (-2)
1.51E (0)	2.16E (0)	2.18E (0)	8.76E (0)	1.45E (-2)	1.58E (-2)
1.61E (0)	1.93E (0)	1.95E (0)	9.26E (0)	1.13E (-2)	1.24E (-2)
1.71E (0)	1.69E (0)	1.70E (0)	9.74E (0)	8.35E (-3)	9.30E (-3)
1.81E (0)	1.45E (0)	1.47E (0)	1.03E (1)	5.17E (-3)	5.94E (-3)
1.93E (0)	1.22E (0)	1.23E (0)	1.08E (1)	3.21E (-3)	3.87E (-3)
2.10E (0)	9.49E (-1)	9.61E (-1)	1.12E (1)	2.53E (-3)	3.11E (-3)
2.30E (0)	6.86E (-1)	6.97E (-1)	1.18E (1)	2.13E (-3)	2.66E (-3)
2.50E (0)	4.87E (-1)	4.96E (-1)	1.24E (1)	1.48E (-3)	1.91E (-3)
2.70E (0)	3.53E (-1)	3.62E (-1)	1.32E (1)	7.20E (-4)	1.07E (-3)
2.90E (0)	2.70E (-1)	2.79E (-1)	1.40E (1)	4.31E (-4)	7.24E (-4)
3.10E (0)	2.09E (-1)	2.19E (-1)	1.48E (1)	3.31E (-4)	7.40E (-4)
3.30E (0)	1.66E (-1)	1.74E (-1)	1.56E (1)	2.70E (-4)	7.29E (-4)
3.50E (0)	1.46E (-1)	1.55E (-1)	1.65E (1)	1.52E (-4)	4.96E (-4)
3.71E (0)	1.41E (-1)	1.48E (-1)	1.75E (1)	-8.63E (-5)	3.49E (-4)
3.91E (0)	1.36E (-1)	1.42E (-1)	1.85E (1)	-2.33E (-4)	2.52E (-4)
4.15E (0)	1.30E (-1)	1.37E (-1)	1.95E (1)	-2.31E (-4)	2.21E (-4)
4.45E (0)	1.32E (-1)	1.38E (-1)	2.06E (1)	-2.53E (-4)	2.05E (-4)
4.75E (0)	1.28E (-1)	1.34E (-1)	2.16E (1)	-1.82E (-4)	2.64E (-4)
5.04E (0)	1.17E (-1)	1.22E (-1)	2.26E (1)	-1.91E (-4)	2.63E (-4)
5.35E (0)	1.11E (-1)	1.15E (-1)	2.35E (1)	-2.00E (-4)	2.93E (-4)
5.65E (0)	1.09E (-1)	1.14E (-1)			

E1 (MeV)	E2 (MeV)	Integral (neutrons $\text{cm}^{-2}\text{kW}^{-1}\text{s}^{-1}$)	Error (neutrons $\text{cm}^{-2}\text{kW}^{-1}\text{s}^{-1}$)
0.811	1.000	9.04E (-1)	3.44E (-3)
1.000	1.200	7.31E (-1)	2.45E (-3)
1.200	1.600	9.73E (-1)	3.81E (-3)
1.600	2.000	6.02E (-1)	2.81E (-3)
2.000	3.000	5.55E (-1)	5.05E (-3)
3.000	4.000	1.64E (-1)	4.08E (-3)
4.000	6.000	2.45E (-1)	5.26E (-3)
6.000	8.000	1.44E (-1)	3.34E (-3)
8.000	10.000	2.93E (-2)	1.29E (-3)
10.000	12.000	7.25E (-3)	6.39E (-4)
12.000	16.000	3.37E (-3)	7.78E (-4)
16.000	20.000	4.74E (-4)	8.68E (-4)
1.500	15.000	1.96E (0)	2.39E (-2)
3.000	12.000	5.89E (-1)	1.46E (-2)

Table 3. Neutron fluxes (50 keV to 1.4 MeV) on centerline
at 51.1 cm behind the graphite (36.4 cm behind the lead)
(Item VI-A): Runs 1542A, 1541B, 1541A.

N	Energy Boundary (MeV)		Flux (Neutron cm ⁻² MeV ⁻¹ kW ⁻¹ s ⁻¹)	Error (%)
<u>Run 1542A</u>				
1	0.0542	0.0633	2.77E (5)	1.32
2	0.0633	0.0762	1.92E (5)	1.42
3	0.0762	0.0890	1.64E (5)	1.82
4	0.0890	0.1037	1.35E (5)	2.06
5	0.1037	0.1221	1.14E (5)	2.03
6	0.1221	0.1441	9.98E (4)	2.03
7	0.1441	0.1698	7.69E (4)	2.39
8	0.1698	0.1992	6.51E (4)	2.61
9	0.1992	0.2359	5.45E (4)	2.52
<u>Run 1541B</u>				
1	0.1672	0.1993	6.13E (4)	0.85
2	0.1993	0.2359	5.22E (4)	0.93
3	0.2359	0.2771	4.19E (4)	1.10
4	0.2771	0.3230	3.46E (4)	1.27
5	0.3230	0.3825	2.70E (4)	1.26
6	0.3825	0.4466	2.04E (4)	1.64
7	0.4466	0.5291	1.73E (4)	1.48
<u>Run 1541A</u>				
1	0.3793	0.4448	2.14E (4)	0.82
2	0.4448	0.5291	1.78E (4)	0.77
3	0.5291	0.6227	1.30E (4)	0.95
4	0.6227	0.7258	9.39E (3)	1.21
5	0.7258	0.8569	5.83E (3)	1.49
6	0.8569	1.0067	4.16E (3)	1.86
7	1.0067	1.1846	3.07E (3)	2.09
8	1.1846	1.4000	2.17E (3)	2.33

Table 4. Neutron fluxes (50 keV to 1.4 MeV) on centerline at 63.2 cm beyond the graphite in the configuration (Item VI-F): Runs 1544A, 1544B, 1545A.

N	Energy Boundary (MeV)		Flux (Neutron cm ⁻² MeV ⁻¹ kW ⁻¹ s ⁻¹)	Error (%)
<u>Run 1544A</u>				
1	0.0536	0.0630	3.62E (1)	7.65
2	0.0630	0.0743	3.43E (1)	7.46
3	0.0743	0.0875	3.28E (1)	7.37
4	0.0875	0.1026	2.52E (1)	9.25
5	0.1026	0.1214	1.94E (1)	10.55
6	0.1214	0.1421	1.84E (1)	11.39
7	0.1421	0.1666	1.62E (1)	12.06
8	0.1666	0.1967	1.53E (1)	11.27
9	0.1967	0.2324	1.32E (1)	11.96
<u>Run 1544B</u>				
1	0.1696	0.1989	1.37E (1)	5.47
2	0.1989	0.2324	1.34E (1)	5.45
3	0.2324	0.2743	1.17E (1)	5.50
4	0.2743	0.3204	1.09E (1)	6.06
5	0.3204	0.3790	9.24E (0)	6.06
6	0.3790	0.4460	7.88E (0)	6.94
7	0.4460	0.5256	8.69E (0)	5.72
<u>Run 1545A</u>				
1	0.3767	0.4512	7.81E (0)	2.20
2	0.4512	0.5256	8.32E (0)	2.34
3	0.5256	0.6186	7.31E (0)	2.26
4	0.6186	0.7302	6.66E (0)	2.19
5	0.7302	0.8605	5.48E (0)	2.40
6	0.8605	1.0093	4.43E (0)	2.70
7	1.0093	1.1860	3.33E (0)	3.04
8	1.1860	1.4000	2.36E (0)	3.50

Table 5. Bonner Ball measurements on centerline at 30 cm behind a series of configurations (Items VI-A - VI-F, VII-A - VII-D).

Configuration ^a	Bonner Ball count rates (s ⁻¹ , w ⁻¹)											
	bare detector		CD-covered detector		3-inch diam ball		5-inch diam ball		8-inch diam ball		10-inch diam ball	
VI-A	2.87	(1) ^b	1.25	(1)	2.01	(2)	5.15	(2)	2.61	(2)	1.10	(2)
VI-A	2.48	(1) ^c										
VI-B	8.40	(1)	1.30	(1)	1.35	(2)	2.46	(2)	1.03	(2)	4.25	(1)
VI-B	7.65	(1) ^c										
VI-C	1.19	(2)	7.42	(0)	6.30	(1)	9.45	(1)	3.62	(1)	1.47	(1)
VI-C	1.08	(2) ^c										
VI-D	1.13	(2)	3.09	(0)	2.23	(1)	2.97	(1)	1.06	(1)	4.32	(0)
VI-D	1.05	(2) ^c										
VI-E	9.70	(1)	1.08	(0)	7.44	(0)	9.04	(0)	3.08	(0)	1.25	(0)
VI-E	9.19	(1) ^c										
VI-F	7.52	(1)	3.39	(-1)	2.10	(0)	2.42	(0)	8.44	(-1)	3.58	(-1)
VI-F	7.49	(1) ^c										
VII-A					6.57	(1)	2.61	(2)	1.69	(2)	7.77	(1)
VII-B					1.92	(1)	7.69	(1)	4.64	(1)	2.13	(1)
VII-C					3.04	(-1)	1.61	(0)	1.08	(0)	5.03	(-1)
VII-D	1.01	(-2)	4.00	(-3)	1.52	(-1)	5.46	(-1)	3.11	(-1)	1.37	(-1)
VII-D	6.39	(-3) ^c										

^aSee experimental program plan on Appendix A for description of configurations.

^bRead: 2.87×10^1 .

^cCadmium enclosure that surrounded the detector except on the side of the last slab in the configuration.

Table 6. Bonner Ball measurements on centerline at 304.8 cm from the center of the reactor (Items VI-A - VI-F, VII-A - VII-D).

Configuration ^a	Bonner Ball count rates ($s^{-1}w^{-1}$)											
	Bare Counter		CD-Covered Counter		3-inch Diam Ball		5-inch Diam Ball		8-inch Diam Ball		10-inch Diam Ball	
	Foreground ^b	Background ^c	Foreground	Background	Foreground	Background	Foreground	Background	Foreground	Background	Foreground	Background
VI-A	8.44 (0) ^d	3.46 (0)	2.62 (0)	3.53 (-1)	4.06 (1)	3.77 (0)	1.00 (2)	7.07 (0)	5.10 (1)	2.89 (0)	2.22 (1)	1.25
VI-A	5.51 (0) ^e											
VI-B	2.10 (1)	4.06 (0)	2.95 (0)	2.33 (-1)	2.98 (1)	2.00 (0)	5.42 (1)	3.17 (0)	2.26 (1)	1.14 (0)	9.41 (0)	4.88 (-1)
VI-B	5.54 (0) ^e											
VI-C	3.11 (1)	3.17 (0)	1.88 (0)	9.00 (-1)	1.57 (1)	6.65 (-1)	2.34 (1)	9.55 (-1)	9.00 (0)	3.45 (-1)	3.64 (0)	1.45 (-1)
VI-C	3.08 (0) ^e											
VI-D	3.33 (1)	2.60 (0)	8.80 (-1)	3.22 (-2)	6.27 (0)	2.20 (-1)	8.23 (0)	2.87 (-1)	3.02 (0)	9.41 (-2)	1.21 (0)	3.98 (-2)
VI-D	1.42 (0) ^e											
VI-E	3.28 (1)	1.80 (0)	3.60 (-1)	8.97 (-3)	2.44 (0)	5.63 (-2)	2.96 (0)	7.08 (-2)	1.02 (0)	2.30 (-2)	4.13 (-1)	1.10 (-2)
VI-E	6.21 (-1) ^e											
VI-F	2.98 (1)	1.10 (0)	1.29 (-1)	2.03 (-3)	8.05 (-1)	1.28 (-2)	9.86 (-1)	1.56 (-2)	3.23 (-1)	5.42 (-3)	1.37 (-1)	2.54 (-3)
VI-F	2.62 (-1) ^e											
VII-A					1.55 (1)	1.78 (0)	5.90 (1)	4.18 (0)	3.74 (1)	2.40 (0)	1.70 (1)	8.98 (-1)
VII-B					5.81 (0)	5.03 (-1)	2.12 (1)	1.21 (0)	1.30 (1)	5.33 (-1)	5.89 (0)	2.55 (-1)
VII-C					1.26 (-1)	8.11 (-3)	6.27 (-1)	2.04 (-1)	4.26 (-1)	9.81 (-3)	2.02 (-1)	4.39 (-3)
VII-D	9.12 (-3)	2.68 (-3)	3.05 (-3)	2.81 (-4)	1.04 (-1)	3.25 (-3)	3.71 (-1)	6.98 (-3)	2.08 (-1)	2.98 (-3)	9.17 (-2)	1.40 (-3)
VII-D	6.39 (-3) ^e											

^aSee experimental program plan in Appendix A for description of configurations.

^bNeutron flux without shadow shield between detector and configuration.

^cNeutron flux with shadow shield between detector and configuration.

^dRead: 8.44×10^4

^eCadmium over face of last slab in configuration.

^fBackground taken at 311.5 cm.

Table 7. 5-inch Bonner Ball horizontal traverses through midplane at 30 cm behind a series of configurations (Items VI-A, VI-B, VI-D, VI-F, VII-A - VII-C).

Distance from centerline (cm)	Bonner Ball count rates ($s^{-1}w^{-1}$)						
	Item VI-A ^a	Item VI-B ^a	Item VI-D ^a	Item VI-F ^a	Item VII-A ^a	Item VII-B ^a	Item VII-C ^a
76.2S	1.78 (2) ^b	7.99 (1)	9.60 (0)	7.63 (-1)	9.63 (1)	2.58 (1)	6.24 (-1)
60	2.79 (2)	1.26 (2)	1.55 (1)	1.24 (0)	1.43 (2)	4.01 (1)	9.62 (-1)
45	3.80 (2)	1.69 (2)	2.13 (1)	1.71 (0)	1.89 (2)	5.39 (1)	1.27 (0)
30	4.55 (2)	2.08 (2)	2.66 (1)	2.11 (0)	2.26 (2)	6.52 (1)	1.50 (0)
15	5.12 (2)	2.34 (2)	2.99 (1)	2.37 (0)	2.51 (2)	7.24 (1)	1.64 (0)
0	5.38 (2)	2.43 (2)	3.10 (1)	2.45 (0)	2.64 (2)	7.53 (1)	1.65 (0)
15	5.06 (2)	2.36 (2)	2.98 (1)	2.34 (0)	2.51 (2)	7.05 (1)	1.57 (0)
30	4.50 (2)	2.08 (2)	2.63 (1)	2.05 (0)	2.19 (2)	6.28 (1)	1.39 (0)
45	3.53 (2)	1.67 (2)	2.12 (1)	1.64 (0)	1.79 (2)	5.09 (1)	1.14 (0)
60	2.58 (2)	1.23 (2)	1.53 (1)	1.16 (0)	1.32 (2)	3.74 (1)	8.44 (-1)
76.2N	1.62 (2)	7.93 (1)	9.48 (0)	7.31 (-1)	8.90 (1)	2.36 (1)	5.62 (-1)

^aSee experimental program plan in Appendix A for description of experiments.

^bRead: 1.78×10^2 .

Table 8. Bonner Ball measurements on
centerline at NE-213 location (Items VI-A, F)

Configuration ^a	Bonner Ball	Bonner Ball count rates ($s^{-1}w^{-1}$)
VI-A	4-inch	2.56 (2)
VI-F	3-inch	4.51 (-3)
VI-A	5-inch	2.82 (2)
VI-F	5-inch	2.22 (-2)
VI-A	10-inch	6.00 (1)
VI-F	10-inch	1.12 (-2)

^aSee experimental program plan in Appendix A for description of configurations.

Table 9. Calculation-to-Experiment Ratios for the 5-in. Bonner ball
on Centerline Behind Various JASPER Configurations

Configuration	Calculation-to-Experiment Ratios		At Spectrum Location
	at 30 cm	at 304.8 cm from Core	
I.A	1.03	0.96	0.97
II.A	0.92	0.85	
II.B	0.83	0.83	
II.C	0.69	0.63	
II.D	0.59	0.56	
II.E	0.60	0.67	0.51
III.A	0.99	0.95	
III.B	0.91	0.83	
III.C	0.89	0.82	
III.D	0.83	0.78	
III.E	0.83	0.75	0.75
V.A	1.08	0.90	
V.B	1.02	0.97	
V.C	1.04	0.90	
V.D	1.07	1.00	
V.E	1.14	0.98	
V.F	1.06	0.97	
V.G	1.13	1.04	
V.H	1.19	1.01	
V.I	1.24	1.09	
V.J	1.28	1.23	
VI.A	0.86	0.76	0.39
VI.B	0.78	0.72	
VI.C	0.70	0.63	
VI.D	0.62	0.59	
VI.E	0.54	0.49	
VI.F	0.47	0.41	