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**Multidimensional Shielding
Analysis of the JASPER In-Vessel
Fuel Storage Experiments**

J. A. Bucholz

MASTER

**MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY**

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Engineering Physics and Mathematics Division

MULTIDIMENSIONAL SHIELDING ANALYSIS OF THE
JASPER IN-VESSEL FUEL STORAGE EXPERIMENTS

Date Published: March 1993

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ABSTRACT

The In-Vessel Fuel Storage (IVFS) experiments analyzed in this report were conducted at the Oak Ridge National Laboratory's Tower Shielding Reactor (TSR) as part of the Japanese-American Shielding Program for Experimental Research (JASPER). These IVFS experiments were designed to study source multiplication and three-dimensional effects related to in-vessel storage of spent fuel elements in liquid metal reactor (LMR) systems. The present report describes the 2-D and 3-D models, analyses, and calculated results corresponding to a limited subset of those IVFS experiments in which the U.S. LMR program has a particular interest.

Experimental measurements were made downstream of several different spectral modifiers including one composed of 2 iron slabs, 3 aluminum slabs, 1 boral slab, and 6 sodium-filled tanks (having a total of 205 cm of sodium), which then served as the basic spectral modifier for six additional LMR shielding configurations. These included a radial blanket assembly mockup, a homogeneous fuel assembly mockup containing 4.81 wt% enriched fuel pins dispersed more-or-less uniformly, or a heterogeneous fuel assembly mockup containing the same fuel pins dispersed in three widely separated compartments with 6 inches of aluminum between each compartment. The latter configuration was included to determine the importance of any 3-D effects that might be overlooked in a simplified 2-D shielding analysis. Results of a 3-D XYZ discrete ordinates analysis for the heterogeneous fuel slab were compared against measured results. Additional configurations were also included so as to study the relative effectiveness of placing a B_4C shield upstream vs downstream of the homogeneous fuel slab. [Placing the B_4C slab downstream of the IVFS fuel slab reduced the fast and intermediate flux by a factor of 3 relative to what it would have been without the B_4C slab, while placing the B_4C slab upstream of the IVFS slab reduced the fast and intermediate flux by an additional order of magnitude.]

Properly accounting for resonance self-shielding in the IVFS fuel slab (and the radial blanket assembly mockup) was found to be extremely important. Using infinitely dilute U-238 cross-section data, the calculated Bonner ball responses were 1.9 times too low relative to the measured responses. Once the resonance self-shielded data was used, the calculated Bonner ball responses were generally found to be within 5 to 7% of the measured responses.

The most reliable measurements of the fast, intermediate, and epithermal neutron fluxes were made with the 12, 10, 8, 5, 4, and 3-inch Bonner balls located along the centerline of the system, 30 cm downstream of the various configurations. Comparisons show that 55% of the 96 measurements were within 5% of the calculated values, while 90% of the 96 measurements were within 10% of the calculated values, and the remainder were within 17% of the calculated values. [Results for the case with the B_4C slab directly upstream of the IVFS fuel slab are an exception for some yet unexplained reason. There, the C/E ratios were generally between 1.30 and 1.35. Although the calculational uncertainty in this case is somewhat higher, this greater uncertainty is more than offset by the significantly lower fluxes actually present with the B_4C slab upstream of the IVFS fuel slab.]

While horizontal traverses 30 cm downstream of the heterogeneous IVFS fuel slab did not show any visible peaks or depressions in the flux, three-dimensional effects were still present as evidenced by the fact that the 12-inch Bonner ball response at the centerline was 16% lower than that for the homogeneous IVFS fuel slab, while the 3-inch Bonner ball response there was 55% higher, and the thermal flux as measured by the bare fission chamber 30 cm downstream of the IVFS fuel slab was 2.0 times higher than that for the homogeneous IVFS fuel slab.

Thermal and epithermal background radiation was a severe problem — both experimentally and calculationally. When care was taken to artificially simulate this background radiation in the

calculational models, the most reliable data at 0.7 cm downstream of the shield showed that 45% of the calculated bare and Cd-covered fission chamber responses were within 5% of the corresponding measured values, that 76% of the calculated values were within 10% of the measured values, and that 93% of the calculated values were within 15% of the corresponding measured values along the centerline. With no simulation of thermal neutron background radiation, the calculated bare and Cd-covered fission chamber responses sometimes underpredicted the measured responses by as much as a factor of 2 or 3. [Fortunately, this is only a problem for experimenters and experimental analysts, and is not a problem for shielding design engineers and analysts who seldom (if ever) have to worry about thermal neutron background radiation.] In those few cases where the measured thermal neutron background radiation appeared to be relatively negligible, the calculated values generally appeared to be within 5 to 15% of the measured values.

1.0 INTRODUCTION AND OVERVIEW OF THE EXPERIMENTS

The In-Vessel Fuel Storage (IVFS) experiments analyzed in this report were conducted at the Oak Ridge National Laboratory's Tower Shielding Reactor (TSR) during the first nine months of 1991 as part of a larger series of experiments planned for the Japanese-American Shielding Program for Experimental Research (JASPER), all of which were intended to provide support in the development of current reactor shield designs for proposed liquid metal reactor (LMR) systems in both Japan and the United States. This program was a cooperative effort between the United States Department of Energy (US DOE) and the Japanese Power Reactor and Nuclear Development Corporation (PNC). Experimental results for a large number of IVFS experiments were first reported in ORNL/TM-11989 in January, 1992. The present report describes the 2-D and 3-D models, analyses, and calculated results corresponding to a limited subset of those IVFS experiments in which the U.S. LMR program has a particular interest.

The IVFS experiments were designed to study source multiplication and three-dimensional effects related to in-vessel storage of spent fuel elements in liquid metal reactor systems. While the presence of fuel stored within the reactor vessel has created significant shielding and flux monitoring problems in earlier design studies, the concept of storing the fuel internally remains attractive. Two previous experiments performed much earlier at the Tower Shielding Reactor, but not as part of this program, demonstrated the difficulty in determining the neutron multiplication in a fuel pin array, and led to large uncertainties in earlier Fast Flux Test Facility (FFTF) design analyses. The present measurements and analyses were performed in an attempt to resolve these difficulties.

Experimental measurements were first made downstream of several different spectral modifiers placed in front of the Tower Shielding Reactor's wide-beam collimator. These are designated as Configurations IA, IA/PB, IB, IC, and IC/PB in Fig. 1.1. (A more detailed description of these will be given later in this report.) The first consisted of iron, aluminum, and boral slabs common to each of the other configurations. Configuration IB had, in addition, two 11.05-cm-thick slabs of natural UO_2 fuel pins simulating radial blanket assemblies, while Config. IC had six 34.2-cm-thick sodium-filled tanks (total thickness = 205 cm) in place of the radial blanket assemblies. Bonner ball and fission chamber measurements were made downstream of the five spectral modifiers, while spectral measurements based on an NE213 liquid scintillator spectrometer ($E > 0.8$ MeV) and a hydrogen-filled spectrometer ($E < 1.5$ MeV) were also made downstream of Configs. IA/PB, IB, and IC/PB.

OVERVIEW OF THE JASPER IVFS EXPERIMENTS RELATED TO THE U.S. LMR PROGRAM

CONFIG. IA

DETECTORS

1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IA/PB

DETECTORS

2 PB SLABS (7.62 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IB

DETECTORS

2 BLANKET ASSYS (22.10 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IC

DETECTORS

6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IC/PB

DETECTORS

2 PB SLABS (7.62 CM)
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIA

DETECTORS

HETEROG. (3-D) FUEL SLAB
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIB

DETECTORS

HOMOGENEOUS FUEL SLAB
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIC

DETECTORS

1 BLANKET ASSY (11.05 CM)
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIID

DETECTORS

1 B4C SLAB (6.90 CM)
HOMOGENEOUS FUEL SLAB
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIE

DETECTORS

HOMOGENEOUS FUEL SLAB
1 B4C SLAB (6.90 CM)
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIF

DETECTORS

1 ALUMINUM SLAB (2.57 CM)
1 B4C SLAB (6.90 CM)
1 STEEL SLAB (2.68 CM)
1 LARGE VOID (34.58 CM)
HOMOGENEOUS FUEL SLAB
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

Fig. 1.1. Overview of the JASPER In-Vessel Fuel Storage (IVFS) shielding experiments of direct interest to the US LMR program. Note that numerous other IVFS shielding experiments (not shown here) were also performed in support of the Japanese LMR program.

Configuration IC, with its 2 iron slabs, 3 aluminum slabs, 1 boron slab, and 6 sodium-filled tanks (having a total of 205 cm of sodium) then served as the basic spectral modifier for the six additional basic configurations of interest to the US LMR program. These are designated as Configurations IIIA, IIIB, IIIC, IIID, IIIE, and IIIF in Fig. 1.1. (All of these, as well as numerous variations of these, will be described in detail later in this report.) These configurations contained a radial blanket assembly mockup comprised of 522 natural UO_2 fuel pins (Config. IIIC), a homogeneous fuel assembly mockup containing 536 low enriched (4.81 wt% U-235) SPERT reactor fuel pins dispersed more-or-less uniformly (cf. Configs. IIIB, IIID, IIIE, and IIIF), or a heterogeneous fuel assembly mockup containing 564 low enriched (4.81 wt% U-235) SPERT reactor fuel pins dispersed in three widely separated compartments with 6 inches of aluminum between each compartment to allow for neutron streaming between compartments (cf. Config. IIIA). The latter configuration, which best simulates individual fuel assemblies stored in a liquid metal reactor vessel, was included to experimentally determine the importance of any three-dimensional effects that might be overlooked in a simplified (homogeneous) 2-D shielding analysis. To investigate this analytically, the results of a 3-D XYZ discrete ordinates analysis of Config. IIIA were compared against the experimentally measured results as well as the results of a 2-D RZ discrete ordinates analysis of Config. IIIB using the homogeneous IVFS fuel slab. In addition to Config. IIIB (using the homogeneous IVFS fuel slab), Configs. IIID, IIIE, and IIIF were included so as to experimentally study the relative effectiveness of placing a B_4C shield upstream (cf. Config. IIIE) vs downstream (cf. Configs. IIID and IIIF) of the homogeneous IVFS mockup.

The full experimental program plan, the original "reference" description of the various configurations and/or components used, and the original experimental measurements, are all documented in ORNL/TM-11989, "Measurements for the JASPER Program In-Vessel Fuel Storage Experiment" (January, 1992). The present report describing the associated analyses should be regarded as a companion document. Moreover, the purpose of the present report is: (1) to document the exact analytical models used to analyze several variations of the configurations briefly described above; (2) to document the calculated Bonner ball and fission chamber responses and multigroup fluxes for each case at various locations of interest; (3) to show the comparisons of the calculated and experimentally measured results (C/E ratios) at each location for which experimental measurements were obtained; and (4) to offer some general observations and explanations, where applicable, that might be of use to shielding designers and analysts.

2.0 OVERVIEW OF ANALYTIC METHODOLOGY

2.1 SOURCE TERMS

The neutron source for these shielding experiments was provided by the 1 MW, spherically-shaped, Tower Shielding Reactor (TSR-II), which is shown schematically in Fig. 2.1 along with its wide-beam concrete collimator through which the neutrons must pass before impinging on the spectral modifiers and/or shield configurations described in Fig. 1.1. Moreover, the spectral modifiers and/or shield configurations described in Fig. 1.1 are located approximately 90 cm from the center of the TSR core. Because of the spherical shape of the TSR core, it may be modeled quite accurately using a stepped, fine-mesh, 2-D RZ model with the +Z axis extending to the left in Fig. 2.1. [Section 4 of ORNL/NPR-92/1, for example, describes a very detailed 2-D RZ model of the TSR core internals, the reflector, the concrete housing, the wide-beam collimator, and a 48-inch spectral modifier made of graphite (for another proposed experiment). That report also describes the methodology for calculating the boundary flux between the wide-beam concrete collimator and the spectral modifier, and actually lists the multigroup directional fluxes for each radial mesh interval at that axial location (just upstream of that particular 48-inch spectral modifier). Unfortunately, that particular analysis was performed using a 27-group energy structure with only 14 fast or epithermal energy groups above 3.05 eV, and 13 energy groups below 3.05 eV.] In the case of the JASPER IVFS analysis, the radially dependent multigroup angular flux used as the boundary source impinging on the spectral modifier just downstream of the wide-beam collimator was the same as that used by C. O. Slater in his 61-group analysis of the JASPER Fission Gas Plenum Experiment. [The origin of this boundary source is described in Sect. 3.1 of ORNL/TM-10681. As noted there (and in Sect. 3.1.4 of ORNL/TM-10701), Maerker's original 51-group S_{16} 1-D spherical boundary source representing the TSR-II core (cf. ORNL/TM-5183) was first converted by Slater to a 2-D RZ internal boundary source which he then incorporated in a 2-D RZ model of a similar shielding configuration which included the TSR reactor, its housing, the wide-beam concrete collimator, and the iron, aluminum, and boral slabs downstream of the collimator. Subsequent to that 2-D RZ 96-direction S_{12} discrete ordinates analysis, the 51-group internal boundary flux across a plane just downstream of the wide-beam collimator was then converted to the VELM 61-group energy structure shown in Table 2.1 prior to his final analysis of the JASPER Fission Gas Plenum Experiment.] Starting with Slater's boundary source just upstream of the spectral modifier, the BSPRP2-code was then used to interpolate the 61-group, 96-direction, S_{12} boundary source over each of the 166 radial mesh intervals shown here in Table 2.2. Moreover, these radial mesh intervals and this particular reference boundary source were used in all of the 2-D RZ JASPER IVFS analyses in this report — i.e., each of the

Fig. 2.1. The spherically-shaped Tower Shielding Reactor (TSR-II) with its wide-beam collimator.

Table 2.1. Energy group structure for the 61 neutron groups in the VELM cross-section library.

Grp	Emax in eV		Emin in eV	Grp	Emax in eV		Emin in eV
1	1.49183e+7	---	1.22140e+7	31	1.22773e+5	---	8.65169e+4
2	1.22140e+7	---	1.00000e+7	32	8.65169e+4	---	5.65622e+4
3	1.00000e+7	---	8.18730e+6	33	5.65622e+4	---	5.24752e+4
4	8.18730e+6	---	6.70320e+6	34	5.24752e+4	---	3.43067e+4
5	6.70320e+6	---	5.48811e+6	35	3.43067e+4	---	2.85011e+4
6	5.48811e+6	---	4.49329e+6	36	2.85011e+4	---	2.70001e+4
7	4.49329e+6	---	3.67879e+6	37	2.70001e+4	---	2.60584e+4
8	3.67879e+6	---	3.01194e+6	38	2.60584e+4	---	2.47875e+4
9	3.01194e+6	---	2.46597e+6	39	2.47875e+4	---	2.35786e+4
10	2.46597e+6	---	2.34570e+6	40	2.35786e+4	---	1.50344e+4
11	2.34570e+6	---	2.23130e+6	41	1.50344e+4	---	9.11882e+3
12	2.23130e+6	---	2.01897e+6	42	9.11882e+3	---	5.53084e+3
13	2.01897e+6	---	1.65299e+6	43	5.53084e+3	---	3.70744e+3
14	1.65299e+6	---	1.35335e+6	44	3.70744e+3	---	3.03539e+3
15	1.35335e+6	---	1.10803e+6	45	3.03539e+3	---	2.61259e+3
16	1.10803e+6	---	9.07180e+5	46	2.61259e+3	---	2.24867e+3
17	9.07180e+5	---	7.42735e+5	47	2.24867e+3	---	2.03468e+3
18	7.42735e+5	---	6.08101e+5	48	2.03468e+3	---	1.23410e+3
19	6.08101e+5	---	5.23397e+5	49	1.23410e+3	---	7.48518e+2
20	5.23397e+5	---	4.97870e+5	50	7.48518e+2	---	4.53999e+2
21	4.97870e+5	---	3.87742e+5	51	4.53999e+2	---	2.75364e+2
22	3.87742e+5	---	3.01974e+5	52	2.75364e+2	---	1.67017e+2
23	3.01974e+5	---	2.98491e+5	53	1.67017e+2	---	1.01301e+2
24	2.98491e+5	---	2.97211e+5	54	1.01301e+2	---	4.78512e+1
25	2.97211e+5	---	2.94518e+5	55	4.78512e+1	---	2.26033e+1
26	2.94518e+5	---	2.73237e+5	56	2.26033e+1	---	1.06770e+1
27	2.73237e+5	---	2.23708e+5	57	1.06770e+1	---	5.04348e+0
28	2.23708e+5	---	1.83156e+5	58	5.04348e+0	---	2.38237e+0
29	1.83156e+5	---	1.49956e+5	59	2.38237e+0	---	1.12535e+0
30	1.49956e+5	---	1.22773e+5	60	1.12535e+0	---	4.13994e-1
				61	4.13994e-1	---	1.00000e-5

Table 2.2. Radial mesh intervals used in all of the 2-D RZ DORT analyses for the JASPER IVFS experiments.

Mesh Num.	Rmin (cm)	Rmax (cm)	Mesh Num.	Rmin (cm)	Rmax (cm)	Mesh Num.	Rmin (cm)	Rmax (cm)	Mesh Num.	Rmin (cm)	Rmax (cm)
1	.000	.750	43	33.000	33.750	85	60.250	61.000	127	87.000	87.650
2	.750	1.500	44	33.750	34.500	86	61.000	61.500	128	87.650	88.350
3	1.500	2.250	45	34.500	35.250	87	61.500	62.000	129	88.350	89.190
4	2.250	3.000	46	35.250	36.000	88	62.000	62.500	130	89.190	89.750
5	3.000	3.750	47	36.000	36.750	89	62.500	63.000	131	89.750	90.250
6	3.750	4.650	48	36.750	37.500	90	63.000	63.500	132	90.250	91.000
7	4.650	5.350	49	37.500	38.250	91	63.500	64.000	133	91.000	92.000
8	5.350	6.000	50	38.250	39.000	92	64.000	64.500	134	92.000	93.000
9	6.000	6.750	51	39.000	39.650	93	64.500	65.000	135	93.000	94.000
10	6.750	7.500	52	39.650	40.350	94	65.000	65.500	136	94.000	95.000
11	7.500	8.250	53	40.350	41.250	95	65.500	66.000	137	95.000	96.140
12	8.250	9.000	54	41.250	42.000	96	66.000	66.500	138	96.140	97.400
13	9.000	9.650	55	42.000	42.750	97	66.500	67.000	139	97.400	99.100
14	9.650	10.350	56	42.750	43.500	98	67.000	67.500	140	99.100	100.900
15	10.350	11.250	57	43.500	44.250	99	67.500	68.452	141	100.900	103.000
16	11.250	12.000	58	44.250	45.000	100	68.452	69.007	142	103.000	104.400
17	12.000	12.750	59	45.000	45.750	101	69.007	69.791	143	104.400	105.800
18	12.750	13.500	60	45.750	46.500	102	69.791	70.209	144	105.800	107.200
19	13.500	14.500	61	46.500	47.250	103	70.209	71.000	145	107.200	108.600
20	14.500	15.500	62	47.250	48.000	104	71.000	71.750	146	108.600	110.000
21	15.500	16.500	63	48.000	48.750	105	71.750	72.500	147	110.000	112.000
22	16.500	17.250	64	48.750	49.650	106	72.500	73.250	148	112.000	114.000
23	17.250	18.000	65	49.650	50.350	107	73.250	74.149	149	114.000	116.000
24	18.000	18.750	66	50.350	51.000	108	74.149	74.750	150	116.000	118.000
25	18.750	19.650	67	51.000	51.865	109	74.750	75.500	151	118.000	120.000
26	19.650	20.350	68	51.865	52.000	110	75.500	76.250	152	120.000	122.000
27	20.350	21.000	69	52.000	52.467	111	76.250	77.000	153	122.000	124.000
28	21.000	21.750	70	52.467	53.000	112	77.000	77.600	154	124.000	126.000
29	21.750	22.500	71	53.000	53.500	113	77.600	78.400	155	126.000	128.000
30	22.500	23.250	72	53.500	54.000	114	78.400	79.250	156	128.000	130.000
31	23.250	24.000	73	54.000	54.500	115	79.250	79.750	157	130.000	132.700
32	24.000	24.750	74	54.500	55.059	116	79.750	80.250	158	132.700	135.400
33	24.750	25.500	75	55.059	55.500	117	80.250	80.750	159	135.400	138.100
34	25.500	26.250	76	55.500	55.902	118	80.750	81.500	160	138.100	140.800
35	26.250	27.000	77	55.902	56.500	119	81.500	82.007	161	140.800	143.500
36	27.000	27.750	78	56.500	57.000	120	82.007	83.000	162	143.500	146.200
37	27.750	28.500	79	57.000	57.500	121	83.000	83.750	163	146.200	148.900
38	28.500	29.500	80	57.500	58.000	122	83.750	84.547	164	148.900	151.600
39	29.500	30.500	81	58.000	58.707	123	84.547	85.307	165	151.600	154.300
40	30.500	31.500	82	58.707	59.000	124	85.307	85.980	166	154.300	157.100
41	31.500	32.250	83	59.000	59.750	125	85.980	86.500			
42	32.250	33.000	84	59.750	60.250	126	86.500	87.000			

calculational models used this boundary source, and each model included all of the materials (spectral modifier + shield configuration + external voids) between that source and the last detector 150 to 176 cm downstream of the experimental shield configuration. This was done to avoid using secondary boundary sources further downstream which would certainly have been more economical but which may have introduced additional approximations. [To compensate for the lack of economy associated with reanalysis of the entire configuration each time, the calculational models for Configurations IIIB, IIIC, IIID, IIIE, and IIIF all used the same number of axial mesh intervals (450) so that we could use the converged flux solution for one configuration as the initial flux guess for the next configuration. This was especially useful when one realizes that 4 separate variations were analyzed for each of the 5 basic configurations mentioned above.] The only exception to this was in the 3-D XYZ TORT analysis of the heterogeneous IVFS fuel slab (Config. IIIA). There, a 3-D XYZ (30 x 57 x 32 mesh) representation of that configuration with a reflective boundary condition at $X=0$ required 13.1 days (315 hours) of CPU time on an IBM Model 530 workstation, and forced us to exclude everything upstream of the last sodium tank and everything more than 31.4 cm downstream of the heterogeneous IVFS fuel slab. In this case, the boundary source just upstream of the sixth sodium tank was based on the tightly converged 2-D RZ DORT internal boundary flux between the fifth and sixth sodium tank in Config. IIIB, which was identical to Config. IIIA except for the arrangement of fuel pins in the IVFS fuel slab. The BS223 code (Boundary Source 2-D to 3-D) was then used to convert the multigroup, angular-dependent, 2-D RZ DORT internal boundary flux to a multigroup, angular-dependent 3-D XYZ TORT boundary flux distributed over the XY plane at $Z=Z_{min}$. Moreover, the BS223 code was written especially for this purpose after the VISTA and DOTTOR codes were found to have a problem with this particular configuration where the extreme corners of the XYZ TORT model were not completely within the bounds of the 2-D RZ model.

In addition to the external boundary sources described above, most of the configurations shown schematically in Fig. 1.1 also had an inherent volumetric source of fission neutrons stemming from the presence of the homogeneous IVFS fuel slab, the heterogeneous IVFS fuel slab, or one or more radial blanket assemblies. Because of these, multiple outer iterations were required to account for the fission source terms in the 2-D DORT or 3-D TORT analyses, thus causing the required CPU time to be many times larger than what it would have been without these multiplying media. Complicating this problem further was the fact that these fuel slabs were physically located downstream of the external boundary source, the iron, aluminum, and boral slabs, and the 205 cm of sodium in the six sodium tanks which, together, constitute a deep penetration shielding problem (with the attendant uncertainties), before one even gets to the multiplying fuel media. Moreover, any uncertainties associated with the deep penetration portion of the problem tend to be "amplified" or made

more visible by the presence of the fuel further downstream. For that reason, particular care was used to ensure that all of the outer (source) iterations as well as all of the inner (spatial) iterations for each energy group were fully converged for each configuration — sometimes/often at the expense of letting these benchmark calculations run considerably longer than might be customary in day-to-day design analyses.

2.2 CROSS-SECTION DATA

The benchmarking of shielding codes against real experimental measurements necessarily requires the use of real cross-section data. One purpose of this benchmark analysis was therefore to validate the use of the VELM 61-group cross-section data library (cf. ORNL/TM-10302, April 1987) which had been developed specifically for sodium-cooled reactor shielding analyses, with particular attention to the spectral weighting of the data for the nuclides in stainless steel, carbon steel, and sodium, where the treatment of anti-resonances (or "windows") important for modeling neutron transmission at certain energies was deemed as important as the treatment of resonances and capture cross sections in other nuclear analyses. The VELM 61n/23g and 22n/10g libraries in both ANISN working and AMPX master formats were derived from the VITAMIN-E 174n/38g fine-group library using problem dependent spectra weighting based on a prototype LMR shield configuration consisting of an LMR source spectrum followed by 1 ft of stainless steel, 15.1 ft of sodium, 3 ft of carbon steel, and 1.5 ft of lithium hydride. The final broad-group working libraries were obtained by using the (174n/38g) fine group fluxes to collapse the data over 1 zone in the stainless steel, 3 separate zones in the sodium, 2 separate zones in the carbon steel, and 1 zone in the lithium hydride, thus resulting in multiple sets of zone-dependent data for many of the nuclides as shown in Tables 4 and 5 of the VELM report (ORNL/TM-10302). In the JASPER IVFS analyses, the VELM sodium data closest to the source was used for the first 3 sodium tanks, the VELM data from the second (asymptotic) region was used for the next 2 sodium tanks, and the VELM data from the third region (closest to the more absorptive carbon steel) was used for the last sodium tank closest to the actual IVFS fuel slab or radial blanket assembly. Moreover, the nuclide ID numbers shown in Table M.2 at the end of Sect. 2 in this report correspond to the ANISN nuclide numbers shown in Tables 4 and 5 of the VELM document.

Exceptions to the use of the original ANISN-formatted VELM 61-group cross sections were made for the U-235 and U-238 in the homogeneous and heterogeneous IVFS fuel slabs and in the radial blanket assemblies for the reasons notes below:

"Initial calculations for Config. IIIF were completed in May 1992. The results were disturbing insofar as the Bonner ball responses were all 1.86 to

1.92 times too low relative to the measured responses. Based on previous experience with the non-fissile spectral modifiers, we had expected to be within 5 to 10% of the measured values. The problem turned out to be in the treatment of the U-235 and U-238 cross-section data. Originally, the stated purpose of these calculations was to determine the adequacy of the ANISN-formatted VELM 61-group cross sections for the IVFS analyses. Unfortunately, the U-235 and U-238 data in the ANISN-formatted portion of that data library is all "infinitely dilute". Separate calculations with 1-D models and other data libraries showed that one could expect to underpredict the fluence downstream of these configurations by a factor of 2 to 2.5 if one used infinitely dilute data in place of the proper resonance self-shielded cross-section data. In group 57 of the VELM library, for example, the total U-238 parasitic capture cross section based on an infinitely dilute model was 174 barns, whereas the more correct value after one accounts for resonance self-shielding was 8.5 barns. Use of the infinitely dilute data reduced the transmission of neutrons through the IVFS slab and, more importantly, prevented the proper number of neutrons from reaching thermal energies where they would contribute significantly to the fission source within the IVFS slab. Once the resonance-self shielded data was used in the DORT analysis of Config. III.F, the Bonner ball measurements 30 cm downstream of the shielding configuration were all found to be within 5 to 7% of the measured responses."

Before continuing with the analysis of the IVFS experiments, therefore, new resonance self-shielding cross-section data for U-235 and U-238 were created for use in those shielding experiments involving fissile material. These new datasets (which supplement the data in Tables 4 and 5 of the VELM report) are listed below in Table 2.3. This data was created as follows: The BONAMI code was used to extract data for all of the fissile and nonfissile nuclides in each homogenized fissile mixture of interest (see number densities for mixtures 32, 48, 52, and 59 in Tables M.1 and M.2 at the end of Sect. 2 in this report) from the AMPX version of the VELM 61-group library, after which it used the Bondarenko (f-factor) method to produce material-dependent resonance self-shielded cross-section data for each nuclide in each mixture, as if each mixture was an infinite homogeneous medium of uniform composition. The U-235 and U-238 data still in an AMPX master format was then extracted and converted to an AMPX working library format using the NITAWL code. The ALPO code was then used to convert that data to an ANISN working library in punched card format. That data was then appended to the end of the VELM BCD ANISN library and converted back to a binary format using the BCBN code originally supplied with the VELM libraries. That augmented VELM library in ANISN binary format was then processed by the GIP code to produce

Table 2.3. New resonance self-shielded cross-section data used for U-235 and U-238 in the JASPER analysis of the IVFS experiments.

Nuclide Name	New VELM ID numbers	Description
U-235a	699-704	Infinitely dilute ($1.0\text{e-}20$ in water; for reference only)
U-235b	705-710	Res Shielded for TSR core fuel (not used in JASPER analyses)
U-235c	711-716	Res Shielded for radial blanket assembly
U-235d	717-722	Res Shielded for 230 pin section of homogeneous IVFS slab
U-235e	723-728	Res Shielded for 306 pin section of homogeneous IVFS slab
U-235f	729-734	Res Shielded for TORT model of heterogeneous IVFS slab
U-238a	735-740	Infinitely dilute ($1.0\text{e-}20$ in water; for reference only)
U-238b	741-746	Res Shielded for TSR core fuel (not used in JASPER analyses)
U-238c	747-752	Res Shielded for radial blanket assembly
U-238d	753-758	Res Shielded for 230 pin section of homogeneous IVFS slab
U-238e	759-764	Res Shielded for 306 pin section of homogeneous IVFS slab
U-238f	765-770	Res Shielded for TORT model of heterogeneous IVFS slab

Note: ID numbers correspond to the P0, P1, P2, P3, P4, and P5 scattering moments, even though only the P0 through P3 moments were used in the JASPER IVFS analyses.

the final pre-mixed cross-section libraries actually used by DORT and TORT in the 2-D and 3-D analyses of the IVFS experiments.

2.3 MATERIAL NUMBER DENSITIES

The composition of each material used in the IVFS experiments is thoroughly documented in Appendix B of ORNL/TM-11989, while the actual construction of the various components (such as the SPERT fuel pins, the homogeneous and heterogeneous IVFS fuel slabs, and the radial blanket assemblies) is clearly illustrated in Appendix C of that report and will not be repeated here. The number densities in each individual mixture such as the UO_2 pellets or the lithiated paraffin blocks are uniquely defined by the material compositions given there. In shielding analyses, however, it is often necessary to homogenize large regions of materials such as that internal portion of the IVFS fuel slab containing the active portion of the fuel pins, or the internal portion of the IVFS fuel slab containing the fission gas plenum portion of the fuel pins, for example. The homogenized number densities for these regions may not be absolutely unique and will vary slightly, depending on how precisely the individual analyst has chosen to model the internals of a particular component. The detailed RZ and XYZ geometric models used to describe each component in each of the IVFS configurations analyzed are clearly defined by the many figures and tabulated geometric descriptions given in Sect. 3. Moreover, those tables show the location and extent of each material mixture in each geometric model. Consistent with those models, Tables M.1 and M.2 at the end of Sect. 2 give a brief verbal description of each material mixture and the number densities for each nuclide in each mixture. As noted above, the nuclide ID's given in Table M.2 correspond to those in Tables 4 and 5 of the VELM document and/or Table 2.3 above. While these ID's correspond to the P_0 scattering moments, the P_0 through P_3 scattering moments were all used in the DORT and TORT shielding analyses.

2.4 RESPONSE FUNCTIONS

2.4.1 Bonner Ball Response Functions

The multigroup response functions used here for the 3-, 4-, 5-, 8-, 10-, and 12-inch Bonner balls are listed in Table 2.4. These values for all 61 neutron energy groups were taken directly from the response function file packaged with the ANISN version of the VELM 61n/23g cross-section library distributed by the Radiation Shielding Information Center (cf. Sect. III.2 and Table 6 of ORNL/TM-10302).

Table 2.4. Detector response functions [(counts/sec)/(n/cm²/sec)] for the 3-, 4-, 5-, 8-, 10-, and 12-inch Bonner balls and the bare and cadmium-covered fission detectors based on the VELM 61-group energy structure.

Grp	3-in BB	4-in BB	5-in BB	8-in BB	10-in BB	12-in BB	Bare Fiss	Cd-cov Fiss
1	3.43080e-3	3.92840e-2	1.19870e-1	4.29990e-1	5.76450e-1	6.47930e-1	1.83044e-4	1.82962e-4
2	4.33480e-3	5.05700e-2	1.54190e-1	5.36020e-1	6.96480e-1	7.56230e-1	1.47466e-4	1.47403e-4
3	5.47290e-3	6.48690e-2	1.97370e-1	6.64810e-1	8.38000e-1	8.80070e-1	1.39406e-4	1.39283e-4
4	6.81740e-3	8.21780e-2	2.46960e-1	7.83530e-1	9.42800e-1	9.44240e-1	1.22462e-4	1.22352e-4
5	9.24500e-3	1.07000e-1	3.10000e-1	9.08710e-1	1.04530e+0	1.00480e+0	8.53570e-5	8.52918e-5
6	1.10220e-2	1.22730e-1	3.49300e-1	9.88020e-1	1.10750e+0	1.03360e+0	7.50234e-5	7.49700e-5
7	1.34140e-2	1.47880e-1	4.10600e-1	1.07080e+0	1.12830e+0	9.86300e-1	7.56750e-5	7.56238e-5
8	1.68580e-2	1.78550e-1	4.78240e-1	1.14430e+0	1.14050e+0	9.43500e-1	7.63591e-5	7.63092e-5
9	2.10080e-2	2.14370e-1	5.57120e-1	1.24290e+0	1.18280e+0	9.33060e-1	7.73033e-5	7.72594e-5
10	2.41110e-2	2.40630e-1	6.14930e-1	1.32070e+0	1.22530e+0	9.41060e-1	7.81650e-5	7.80765e-5
11	2.54250e-2	2.50770e-1	6.34850e-1	1.33300e+0	1.21750e+0	9.19740e-1	7.76546e-5	7.76042e-5
12	2.74860e-2	2.66010e-1	6.63430e-1	1.34410e+0	1.19750e+0	8.81240e-1	7.71570e-5	7.71163e-5
13	3.18430e-2	2.98370e-1	7.26350e-1	1.39140e+0	1.19280e+0	8.42420e-1	7.56029e-5	7.55504e-5
14	3.86540e-2	3.44430e-1	8.06550e-1	1.41120e+0	1.13520e+0	7.49240e-1	7.21490e-5	7.21022e-5
15	4.65630e-2	3.92530e-1	8.82930e-1	1.40870e+0	1.06180e+0	6.53960e-1	6.90093e-5	6.89754e-5
16	5.56070e-2	4.41840e-1	9.53840e-1	1.38660e+0	9.78880e-1	5.62380e-1	6.75073e-5	6.74423e-5
17	6.57780e-2	4.91290e-1	1.01750e+0	1.34830e+0	8.91790e-1	4.78500e-1	6.31955e-5	6.31814e-5
18	7.69570e-2	5.39530e-1	1.07250e+0	1.29740e+0	8.05190e-1	4.04590e-1	6.28680e-5	6.28013e-5
19	8.77140e-2	5.81040e-1	1.11450e+0	1.24610e+0	7.32450e-1	3.48460e-1	6.32367e-5	6.31653e-5
20	9.42930e-2	6.04400e-1	1.13600e+0	1.21490e+0	6.92790e-1	3.19920e-1	6.42575e-5	6.41388e-5
21	1.03720e-1	6.35250e-1	1.16140e+0	1.16940e+0	6.40360e-1	2.84460e-1	6.48623e-5	6.47928e-5
22	1.20890e-1	6.84390e-1	1.19430e+0	1.08720e+0	5.57720e-1	2.33390e-1	6.76480e-5	6.75320e-5
23	1.30770e-1	7.10400e-1	1.21050e+0	1.04740e+0	5.20530e-1	2.11960e-1	6.82148e-5	6.81711e-5
24	1.31340e-1	7.11820e-1	1.21130e+0	1.04510e+0	5.18480e-1	2.10810e-1	6.81926e-5	6.81619e-5
25	1.31820e-1	7.13010e-1	1.21190e+0	1.04320e+0	5.16770e-1	2.09860e-1	6.81314e-5	6.81111e-5
26	1.34780e-1	7.20160e-1	1.21560e+0	1.03100e+0	5.06160e-1	2.04010e-1	6.87428e-5	6.87030e-5
27	1.44330e-1	7.41470e-1	1.22420e+0	9.90760e-1	4.72990e-1	1.86370e-1	7.18133e-5	7.16460e-5
28	1.58840e-1	7.71230e-1	1.23390e+0	9.35360e-1	4.30170e-1	1.64750e-1	7.44612e-5	7.43959e-5
29	1.73320e-1	7.97760e-1	1.23970e+0	8.85280e-1	3.94320e-1	1.47640e-1	7.68242e-5	7.68510e-5
30	1.87720e-1	8.21440e-1	1.24240e+0	8.40720e-1	3.64190e-1	1.33950e-1	7.99436e-5	7.99130e-5
31	2.06380e-1	8.48860e-1	1.24270e+0	7.88770e-1	3.31940e-1	1.19970e-1	8.38366e-5	8.38668e-5
32	2.32240e-1	8.82970e-1	1.24100e+0	7.29590e-1	2.97290e-1	1.05610e-1	9.22626e-5	9.21711e-5
33	2.50080e-1	9.04390e-1	1.23890e+0	6.95220e-1	2.78280e-1	9.80090e-2	1.02783e-4	1.02461e-4
34	2.65080e-1	9.22400e-1	1.23900e+0	6.71640e-1	2.65520e-1	9.30000e-2	9.83796e-5	9.84464e-5
35	2.86260e-1	9.47130e-1	1.24010e+0	6.43500e-1	2.50700e-1	8.72660e-2	1.07095e-4	1.07098e-4
36	2.94300e-1	9.56320e-1	1.24070e+0	6.34070e-1	2.45830e-1	8.54010e-2	1.11987e-4	1.11570e-4
37	2.97310e-1	9.59820e-1	1.24120e+0	6.30860e-1	2.44170e-1	8.47670e-2	1.12577e-4	1.12136e-4
38	3.00160e-1	9.63150e-1	1.24160e+0	6.27910e-1	2.42640e-1	8.41850e-2	1.15118e-4	1.14671e-4
39	3.03500e-1	9.67040e-1	1.24220e+0	6.24530e-1	2.40900e-1	8.35230e-2	1.18427e-4	1.17892e-4
40	3.18520e-1	9.84130e-1	1.24470e+0	6.10090e-1	2.33550e-1	8.07410e-2	1.24674e-4	1.24220e-4
41	3.50610e-1	1.01990e+0	1.25100e+0	5.84320e-1	2.20670e-1	7.59140e-2	1.48722e-4	1.48181e-4
42	3.87180e-1	1.06090e+0	1.26260e+0	5.63080e-1	2.10110e-1	7.19870e-2	1.78812e-4	1.78137e-4
43	4.21950e-1	1.09620e+0	1.26960e+0	5.43970e-1	2.01010e-1	6.86550e-2	2.30478e-4	2.29575e-4
44	4.48010e-1	1.12280e+0	1.27670e+0	5.32720e-1	1.95660e-1	6.67010e-2	2.60168e-4	2.59009e-4
45	4.63430e-1	1.13840e+0	1.28120e+0	5.26840e-1	1.92880e-1	6.56880e-2	2.74323e-4	2.73137e-4
46	4.76970e-1	1.15200e+0	1.28520e+0	5.22040e-1	1.90610e-1	6.48660e-2	3.00563e-4	2.99307e-4
47	4.88750e-1	1.16350e+0	1.28830e+0	5.17940e-1	1.88700e-1	6.41750e-2	3.31278e-4	3.30204e-4
48	5.15180e-1	1.18830e+0	1.29490e+0	5.09270e-1	1.84720e-1	6.27370e-2	3.71907e-4	3.70226e-4
49	5.66220e-1	1.23210e+0	1.30280e+0	4.92250e-1	1.77160e-1	6.00440e-2	4.53434e-4	4.50986e-4
50	6.17610e-1	1.26600e+0	1.29790e+0	4.71380e-1	1.68450e-1	5.69820e-2	6.92291e-4	6.89291e-4
51	6.82050e-1	1.31580e+0	1.30780e+0	4.57370e-1	1.62470e-1	5.48800e-2	7.53588e-4	7.49033e-4
52	7.43580e-1	1.34890e+0	1.29910e+0	4.37870e-1	1.54680e-1	5.21800e-2	1.12181e-3	1.11140e-3
53	7.87220e-1	1.34110e+0	1.24890e+0	4.05560e-1	1.42120e-1	4.76910e-2	1.15320e-3	1.14753e-3
54	7.86080e-1	1.24070e+0	1.22410e+0	4.03010e-1	1.55120e-1	5.93660e-2	1.90375e-3	1.87860e-3
55	8.23470e-1	1.32500e+0	1.25940e+0	3.94910e-1	1.50690e-1	5.72930e-2	2.48257e-3	2.46574e-3
56	9.34500e-1	1.34690e+0	1.21860e+0	3.66330e-1	1.39330e-1	5.29340e-2	2.72620e-3	2.71931e-3
57	1.03770e+0	1.33520e+0	1.15000e+0	3.33150e-1	1.26430e-1	4.80030e-2	2.66656e-3	2.65839e-3
58	1.13350e+0	1.29210e+0	1.06080e+0	2.98010e-1	1.12960e-1	4.28630e-2	9.36798e-4	9.32204e-4
59	1.19060e+0	1.18680e+0	9.30950e-1	2.55390e-1	9.67630e-2	3.66940e-2	1.36041e-3	1.34464e-3
60	1.00810e+0	8.59870e-1	6.42920e-1	1.72970e-1	6.55040e-2	2.47980e-2	4.21628e-3	3.84717e-3
61	0.00000e+0	0.00000e+0	0.00000e+0	0.00000e+0	0.00000e+0	0.00000e+0	2.52344e-2	1.79402e-3

2.4.2 Bare and Cd-Covered Fission Chamber Response Functions

The bare and Cd-covered fission chamber response functions finally used in this study are also listed in Table 2.4. Insofar as these response functions did not previously exist, they had to be generated for this particular study. The following paragraphs describe how that was done.

The fission chambers are cylindrical devices with a thin, flat, circular-shaped nickel/brass fission plate located near the end of the cylinder, directly facing the experimental configuration at the point of interest. Based on a detailed schematic showing the actual construction of the fission chambers, a highly simplified 1-D model was developed which could be used to determine the spectral dependence of the bare and Cd-covered fission chambers. The simplified 1-D model used for the Cd-covered fission chamber is illustrated in Fig. 2.2. It consisted of:

- (a) a fixed isotropic boundary flux (of 1.0 n/s/cm^2 in any "one" energy group) impinging on the left boundary
- (b) a 0.035-inch-thick cadmium foil (at 8.65 g/cc), represented by a region having 8 mesh intervals,
- (c) a 0.275-inch-thick aluminum region (at 2.70 g/cc) having 7 mesh intervals,
- (d) a 0.04125-inch thick homogenized nickel/brass fission plate represented by a region having 5 mesh intervals, and
- (e) a 0.25-inch-thick aluminum backplate represented by a region having 6 mesh intervals, and lastly
- (f) a vacuum boundary condition on the right boundary.

In this case, the homogenized fission plate was comprised of a 0.01-inch-thick nickel plate and a 1/32-inch-thick brass plate having a very thin deposit (1.0 mg[U]/cm^2) of highly enriched uranium (93 wt% U-235) spread uniformly over the surface. [Because of the scant amount of uranium present, the standard (infinitely dilute) VELM cross sections were used for both the U-235 and the U-238.] While the response function for the fission chambers could have been obtained more elegantly by using a simple 1-D adjoint analysis, we chose to use a series of 1-D forward calculations. In the first, the leading edge of the Cd-covered detector was exposed to an isotropic flux of 1.0 n/s/cm^2 in energy group 1, with no impinging flux in any of the other groups. In the second case, the uniform isotropic flux comprising the source was zero for all groups except group 2; etc. For each of the 61 calculations, each taking

* HOMOGENIZED NICKEL/BRASS FISSION PLATE =
 0.01" NICKEL + 1/32" BRASS + 1.0 MG(U)/CM²
 WITH 93 WT% U-235 IN U

Fig. 2.2. Simplified 1-D slab model used to determine the spectral dependence of the Cd-covered fission chamber response function. After replacing the cadmium foil with a void, this same 1-D model was then used for the bare fission chamber.

just a few seconds, all of the multigroup fluxes corresponding to the monoenergetic external source and any internal fissions were properly calculated, and the total resulting internal fission source was duly noted. Table 2.5a shows the total resulting internal fission source (integrated over all energy groups) corresponding to an external isotropic boundary flux of 1.0 n/s/cm^2 in each of the 61 energy groups. This same procedure was repeated with a void being used in place of the 0.035-inch-thick Cd foil in order to determine the spectral response of a bare fission chamber. These results are listed in Table 2.5b.

At this point, some sort of experimental calibration was necessary to normalize the overall spectral response to the magnitude of the actual measured response (i.e., to determine the actual sensitivity). To that end, the calibration data near the end of Sect. 2 in ORNL/TM-11989 was only partially satisfying. Moreover, the flux spectrum and/or experimental configuration under which the calibration was performed is not documented and the degree to which thermal neutron background radiation could have contributed to (or interfered with) the measured data is not known. [It was noted sometime later that this is often a significant source of uncertainty that is difficult to isolate.] All that can really be said of that calibration data is that: if there was no background radiation, if the cadmium on the Cd-covered fission chamber was "perfectly black" to thermal neutrons below 0.414 eV (not a bad approximation), and if the cadmium on the Cd-covered fission chamber was "perfectly transparent" to neutrons above 0.414 eV (a dubious approximation for neutrons in groups 59 and 60), then the bare fission chamber would have a thermal neutron sensitivity of

$$(1.0 \text{ counts/min}) / (0.637 \text{ neutrons/sec/cm}^2), \text{ or}$$

$$(0.0262 \text{ counts/sec}) / (1.0 \text{ neutrons/sec/cm}^2)$$

for group 61 neutrons below 0.414 eV. [Interestingly, that value is only 3.9% higher than the bare detector group 61 value (0.0252) that we ultimately arrived at and used based upon a somewhat different procedure described below.] Besides the assumptions described above, the other problem with the limited calibration data in Sect. 2 of ORNL/TM-11989 is that it gives no hint as to how to normalize the responses from the Cd-covered fission chamber. To that end, it was decided that there was little alternative but to use the bare and Cd-covered fission chamber measurements from at least one of the IVFS experiments to normalize the magnitude of the spectral response data given in Tables 2.5a and 2.5b. The question then was: Which of these experiments would be best suited for this purpose? (Note that previously, fission chamber measurements were never used in any of the Tower Shielding Reactor experiments.) Configurations IA and IA/PB were rejected immediately because the boral slab at the end of the configuration right next to the

Table 2.5a. Cadmium-covered fission chamber response (fissions/sec/cm²) per unit isotropic scalar flux (neut/sec/cm²) impingent on the end of the detector in any one given group (ig=1,...,61), as calculated by the 1-D model of the Cd-covered fission chamber.

Source Group	Total(*) f/s/cm ²	Source Group	Total(*) f/s/cm ²
1	9.64037E-06	31	4.44103E-06
2	7.76793E-06	32	4.84036E-06
3	7.31951E-06	33	5.31007E-06
4	6.42904E-06	34	5.22334E-06
5	4.48543E-06	35	5.65966E-06
6	3.94385E-06	36	5.76129E-06
7	3.97912E-06	37	5.78368E-06
8	4.01575E-06	38	5.91570E-06
9	4.06791E-06	39	6.05807E-06
10	4.09666E-06	40	6.41775E-06
11	4.08399E-06	41	7.65577E-06
12	4.06137E-06	42	9.19598E-06
13	3.97481E-06	43	1.18408E-05
14	3.79447E-06	44	1.33145E-05
15	3.63343E-06	45	1.40521E-05
16	3.54239E-06	46	1.54122E-05
17	3.33370E-06	47	1.71019E-05
18	3.29662E-06	48	1.90241E-05
19	3.31433E-06	49	2.30483E-05
20	3.35056E-06	50	3.54602E-05
21	3.40091E-06	51	3.81280E-05
22	3.53069E-06	52	5.54524E-05
23	3.58776E-06	53	5.88223E-05
24	3.59148E-06	54	9.14649E-05
25	3.59217E-06	55	1.24945E-04
26	3.61713E-06	56	1.41461E-04
27	3.73164E-06	57	1.37835E-04
28	3.90970E-06	58	4.77879E-05
29	4.06927E-06	59	6.61324E-05
30	4.21237E-06	60	1.15722E-04
		61	8.25425E-12

* These values are based on a 0.035-inch Cd foil.

Table 2.5b. Bare fission chamber response (fissions/sec/cm²) per unit isotropic scalar flux (neut/sec/cm²) impingent on the end of the detector in any one given group (ig=1,...,61), as calculated by the 1-D model of the bare fission chamber.

Source Group	Total f/s/cm ²	Source Group	Total f/s/cm ²
1	9.67144E-06	31	4.42964E-06
2	7.79158E-06	32	4.87484E-06
3	7.36573E-06	33	5.43072E-06
4	6.47049E-06	34	5.19804E-06
5	4.50997E-06	35	5.65853E-06
6	3.96398E-06	36	5.91699E-06
7	3.99840E-06	37	5.94815E-06
8	4.03455E-06	38	6.08243E-06
9	4.08444E-06	39	6.25728E-06
10	4.12997E-06	40	6.58733E-06
11	4.10300E-06	41	7.85798E-06
12	4.07671E-06	42	9.44779E-06
13	3.99460E-06	43	1.21777E-05
14	3.81210E-06	44	1.37464E-05
15	3.64621E-06	45	1.44943E-05
16	3.56685E-06	46	1.58807E-05
17	3.33903E-06	47	1.75036E-05
18	3.32173E-06	48	1.96503E-05
19	3.34121E-06	49	2.39579E-05
20	3.39514E-06	50	3.65783E-05
21	3.42710E-06	51	3.98170E-05
22	3.57429E-06	52	5.92726E-05
23	3.60424E-06	53	6.09313E-05
24	3.60306E-06	54	1.00588E-04
25	3.59983E-06	55	1.31170E-04
26	3.63213E-06	56	1.44043E-04
27	3.79437E-06	57	1.40892E-04
28	3.93427E-06	58	4.94972E-05
29	4.05913E-06	59	7.18793E-05
30	4.22395E-06	60	2.22774E-04
		61	1.33330E-03

fission chambers would render them overly sensitive to background radiation [i.e., with little or no thermal flux getting transmitted through the boral slab, the only thing that would really be measured would be fast or epithermal neutrons that did get through and then slowed down in surrounding structures before getting scattered back toward the detectors — a very poorly defined quantity at best]. The same was true of Config. IIID. The same was also true of Configs. IB and IIIC, with the natural UO_2 fuel pins in the radial blanket assemblies close to the detectors. Moreover, the thermal neutron population downstream of the radial blanket assembly could also be affected by the resonance self-shielding treatment used in the UO_2 . Since this was one of the primary things we had hoped to use the experiment to measure, it would certainly be self-defeating to use that same data to normalize the calculated and measured response functions. If this argument applies to Configs. IB and IIIC with the radial blanket assemblies, then it applies even more strongly to Configs. IIIA, IIIB, IIIE, and IIIF, with the homogeneous or heterogeneous IVFS fuel slabs upstream of the detectors. The only remaining choice then was to use the bare and Cd-covered fission chamber measurements 0.7 downstream of the 205-cm-thick sodium tanks in Config. IC to determine the final normalization factor for the spectral response data in Tables 2.5a and 2.5b. [While some may argue that this sort of incestuous self-calibration is self-defeating, it was certainly the cleanest, least compromising, choice available.]

Figure G.8 (and G.7b, as well as Tables G.7b and G.8) in Sect. 3 shows the analytic model used for the calibration case finally selected (Config. IC.6). In particular, it shows the location of the bare and Cd-covered fission chambers of interest — 0.7 cm downstream of the six sodium tanks comprising the spectral modifier. Consistent with that, Table R.8 in Sect. 3 shows the calculated multigroup flux (ϕ^g) at that particular point, while Table X.11 in Sect. 4 (and/or Table 25 in ORNL/TM-11989) shows the experimentally measured bare and Cd-covered fission chamber responses at this location in Config. IC to be 0.206 counts/sec and 0.123 counts/sec, respectively. After folding the unnormalized bare fission chamber data in Table 2.5b with the calculated multigroup fluxes 0.7 cm downstream of the last sodium tank and comparing the result with the measured bare fission chamber response at that point (0.206 counts/sec), all of the unnormalized bare fission chamber responses in Table 2.5b were multiplied by

$$18.9263 \text{ (counts/sec)/(fission/sec/cm}^2\text{)}$$

to obtain the final multigroup response function for the bare fission chambers previously shown in Table 2.4. Here the use of a constant scaling factor is justified because one is simply accounting for the sensitivity of the electronics in the ionization chamber to the number of fission products produced, regardless of the energy of the neutrons causing fission. In the case of the Cd-covered fission chamber, however,

the use of a single multiplicative scaling factor would not have been appropriate since the downscattered neutrons available to cause fission due to neutrons in each source group will be affected differently by the cadmium foil, depending on their energy. Thus, the normalized multigroup response function for the Cd-covered fission chamber (N_{cd}^g) should be given by

$$N_{cd}^g = N_{bare}^g e^{-t^* \Sigma_{cd}^g}$$

where

N_{bare}^g is the normalized multigroup response function for the bare fission chamber as given in Table 2.4,

Σ_{cd}^g is the effective attenuation cross section for the cadmium foil, and

t^* is the effective thickness of the cadmium foil on the actual detector.

Likewise, if there was no multidimensional streaming and the actual thickness of the cadmium foil (t_o) was 0.035 inches, as assumed in the 1-D analysis of the detector response functions, then the unnormalized multigroup response functions for the bare and Cd-covered fission chambers (U_{bare}^g and U_{cd}^g) given in Tables 2.5a and 2.5b would be related by

$$U_{cd}^g = U_{bare}^g e^{-t_o \Sigma_{cd}^g} \quad \text{where } t_o = 0.035 \text{ inches.}$$

From this, the effective attenuation cross section for the cadmium foil may be calculated as

$$\Sigma_{cd}^g = \left(\frac{1}{t_o} \right) \ln(U_{bare}^g / U_{cd}^g)$$

which yields:

$$N_{cd}^g = N_{bare}^g [U_{cd}^g / U_{bare}^g]^{(t^* / t_o)}$$

where N_{bare}^g is given in Table 2.4, U_{bare}^g and U_{cd}^g are given in Tables 2.5a and 2.5b, $t_o=0.035$ inches, and t^* is the "effective" thickness of the cadmium foil on the fission chamber. The final value of t^* (0.00489578 inches) and the normalized multigroup response function for the Cd-covered detector (N_{cd}^g) were then found by adjusting t^* until the folding of the multigroup flux at 0.7 cm downstream of the last sodium tank with this multigroup response function (N_{cd}^g) was able to reproduce the experimentally measured value for the Cd-covered fission chamber response (0.123 counts/sec) at this location. The resulting values for the Cd-covered fission chamber response function are shown in Table 2.4. Except for groups 60 and 61, these values are within 1 or 2% of those for the bare fission chamber, as expected. It is interesting, however, that the Cd-covered response function for group 60 (just above 0.414 eV) is only 8.8% lower than that for the bare detector (not a factor of 1.9 lower, as suggested by Tables 2.5a and 2.5b). Even more interesting is the fact that the effective Cd-covered response function for group 61 ($E<0.414$ eV) is only 14 times lower than that for the bare detector, not 8 orders of magnitude lower as suggested by Tables 2.5a and 2.5b based on a 0.035-inch-thick Cd foil. Since the actual thickness of the Cd foil or Cd canister around the fission chamber was believed to be 30 to 40 mils (0.030 to 0.040 inches), the relatively small value obtained here for the effective thickness ($t^*=0.0049$ inches), and the correspondingly high response function value for group 61, would suggest that there may have been a significant amount of thermal flux "in leakage" entering the actual detector, perhaps where the power and signal cables penetrate the canister, or at some other location. In any event, the use of this "effective thickness" (t^*) would seem to be vindicated by a multitude of experimental measurements. Table X.11 in Sect. 4, for example, shows the C/E ratios (calculated to experimentally measured values) for 44 different measurements involving the Cd-covered fission chamber. While the C/E ratios for these 44 cases span a range between 0.55 and 1.43, with an average value of 0.938, 36 of these are between 0.70 and 1.10, while 24 of these are between 0.90 and 1.10.

2.5 CALCULATION OF THE ACTUAL BONNER BALL RESPONSES

As noted in Sect. 2.4, the energy-dependent Bonner ball response functions in the VELM 61-group energy structure were taken directly from the VELM 61n/23g cross-section library. Moreover, Table 2.4 lists the actual values used here in the analysis of the JASPER IVFS experiments. Historically, ORNL/TM-3451, 3465, and 3739 from June 1971 through April 1972 are the earliest documents describing how these response functions were originally obtained (albeit in a somewhat different energy group structure). How that previously tabulated data should be applied is less clear. As multidimensional shielding methods become more precise and experimental techniques become more refined, we find ourselves at a point where the process of converting the calculated fluxes into calculated Bonner ball responses

represents one of the larger uncertainties in some situations. A description of the techniques historically used and currently used is therefore in order.

2.5.1 Simple Folding at the Physical Center of the Detector

In the most simple-minded approach, one would simply fold the multigroup fluxes at a point with the corresponding response functions to obtain the "calculated" Bonner ball responses at the point of interest (presumably at the center of the detector). These could then be compared with the experimentally measured values. If one is content to find that his calculated values agree with the measured values to within a factor of two (or so), this approach is probably adequate. Unfortunately, for large Bonner balls close to the surface of a shield where the spatial flux distribution is changing more rapidly, the calculated Bonner ball response obtained in this fashion will often underpredict the measured response since, in reality, the forward hemisphere of the Bonner ball is exposed to a higher flux than that which would exist over the rear hemisphere or at the midpoint.

2.5.2 Using the Center-of-Detection Instead of the Physical Center of the Detector

A better approach, although the necessary data may not always be available, would be to perform a reference multigroup adjoint analysis to determine the directionally-dependent adjoint current on the surface of each Bonner ball, and then (for each new shielding experiment or calculation) fold that reference data with the corresponding directionally-dependent incoming angular current over the surface of the Bonner ball to calculate the actual detector response. While this approach would be theoretically more rigorous and was actually used in ORNL/TM-3739, one must go back to the basic question: How was the overall magnitude of the response function actually normalized against a calibrated experiment? Moreover, the data must be used in a fashion consistent with how it was defined. ORNL/TM-3465 (June, 1971) describes the "Calibration of the the Bonner Ball Neutron Detectors Used at the Tower Shielding Facility." Basically, each Bonner ball had been placed 43.72 inches (111.05 cm) center-to-center from a Cf-252 source while the detector counting rates were determined. This was then calibrated against the average flux on the forward hemisphere of each detector as calculated analytically by

$$\phi_{avg} = \frac{\int \phi(\theta) dA}{\int dA} = \frac{\int \left(\frac{S}{4\pi R^2} \right) dA}{\int dA}$$

$$= \left(\frac{S}{4\pi} \right) \left(\frac{1}{2rh} \right) \ln \left[\frac{r^2 + h^2}{(h-r)^2} \right] = \frac{S}{4\pi r_o^2}$$

where, as illustrated in Fig. 2.3,

S is the strength of the point source (1.125×10^8 n/sec) at that time,

r is the radius of the Bonner ball,

h is the center-to-center distance between the source and the Bonner ball,

$R^2 = r^2 + h^2 - 2hr \sin(\theta)$ where R is the distance between the point source and a point on the surface of the Bonner ball,

$dA = 2\pi r^2 \cos(\theta) d\theta$ is the area of a narrow ring on the surface of the Bonner ball,

and the integration is carried out from $\theta=0$ to $\theta=\pi/2$ for a spherical Bonner ball located far from the point source. Said another way: The Bonner balls were calibrated against the analytic flux given by

$$\phi_{cod} = \frac{S}{4\pi r_o^2}$$

where r_o is the distance from the point source to the effective "center-of-detection" for the Bonner ball. This "center-of-detection" is located a short distance (ϵr) upstream of the physical center of the detector, as shown in Fig. 2.4, and is defined by ϵ , where $\epsilon \equiv (h - r_o)/r$ and

$$r_o^2 = (2rh) / \ln \left[\frac{r^2 + h^2}{(h-r)^2} \right]$$

$$R^2 = (h - y)^2 + x^2$$

$$= h^2 + r^2 - 2hr \sin(\theta)$$

$$\cos(\alpha_{max}) = r/h$$

$$\Rightarrow \theta_{min} = (\pi/2) - \arccos(r/h)$$

Fig. 2.3. Geometric relationships between the point source (S) used for calibration purposes, and the spherical surface of the Bonner ball being calibrated. These relationships are used to develop an analytic expression for the average flux over the visible surface of the Bonner ball.

Fig. 2.4. Location of the effective "center-of-detection" for a spherical Bonner ball relative to the physical center of the Bonner ball and an external point source.

just as indicated in ORNL/TM-3465. For 3, 4, 5, 8, 10, and 12-inch Bonner balls with centers 43.72 inches from the source, ϵ spans a fairly narrow range, from 0.493 for the 3-inch Bonner ball, down to 0.473 for the 12-inch Bonner ball. (More exact values for the 3-inch and 12-inch Bonner balls at this distance would have been 0.510 and 0.540, respectively.) Moreover, for large Bonner balls close to the point source, the average flux over the visible surface should be defined by integrating from $\theta_{min}=(\pi/2)-\arccos(r/h)$ to $\theta_{max}=\pi/2$ (rather than from $\theta_{min}=0$ to $\theta_{max}=\pi/2$), and the resulting (slightly modified but more exact) expression for ϕ_{avg} would be

$$\phi_{avg} = \left(\frac{S}{4\pi}\right) \left(\frac{1}{2rh}\right) \left(\frac{1}{1-\sin(\theta_{min})}\right) \ln \left[\frac{r^2 + h^2 - 2hr \sin(\theta_{min})}{(h-r)^2} \right]$$

The resulting expression for r_o , derived from

$$\phi_{cod} = \frac{S}{4\pi r_o^2} = \phi_{avg} \quad ,$$

would then be

$$r_o^2 = 2rh[1 - \sin(\theta_{min})] / \ln \left[\frac{r^2 + h^2 - 2hr \sin(\theta_{min})}{(h-r)^2} \right]$$

For 4, 8, and 12-inch Bonner balls with centers 30 cm from the source, $\epsilon = (h-r_o)/r$ would again span a fairly narrow range - this time from 0.549 for the 4-inch Bonner ball, to 0.599 for the 8-inch ball, to 0.653 for the 12-inch ball. Accordingly, the flux at the center-of-detection defined by $\epsilon=0.6$ was used to obtain the calculated 3, 4, 5, 6, 8, 10, and 12-inch Bonner ball responses in the analysis of the earlier thick sodium shielding experiments for the Fast Test Reactor (cf. Table II on page 5 of ORNL-4880, Jan 1974). The flux at the center-of-detection defined by $\epsilon=0.6$ was also used to obtain the calculated 3, 5, 6, and 10-inch Bonner ball responses in the "Analysis of Phase I of the HTGR Bottom Reflector and Core Support Block Neutron Streaming Experiments" performed for the High Temperature Gas-Cooled Reactor Program (cf. Table 5 on page 27 of ORNL/TM-9252, July 1984).

2.5.3 Numerical Integration Over the Forward Hemisphere

As noted above, the measured counting rates for the Bonner ball detectors were calibrated against the average scalar flux over the visible surface of a Bonner ball due to a point source some distance away. In subsequent analyses, the flux at the center-of-detection [a short distance (ϵr) upstream of the physical center of the detector] was commonly assumed to be the same as (or at least representative of) the average scalar flux over the visible surface. As long as one had a small localized source or the Bonner balls were a considerable distance away from the exterior surface of a shielding experiment, this was not a bad approximation. Once one begins to have 3, 4, 5, 8, 10, or 12-inch Bonner balls whose centers are located just a short distance (30 cm) away from a large (3-ft x 3-ft), highly diffusive shield assembly (such as the IVFS fuel slab) across the face of which the flux is more-or-less uniform, the logic leading to the "center-of-detection" concept begins to break down. For the flux coming from each point on the surface of the shield, for example, one could envision a different "center-of-detection." At that point, one might as well give up the concept completely, and directly determine the average scalar flux over the forward hemisphere of the Bonner ball by numerically averaging the actual DORT or TORT fluxes over a large number of points on the forward hemisphere. Generally this involves dividing the forward hemisphere of the Bonner ball into a number of equally sized elements, spatially interpolating the DORT or TORT fluxes to estimate the flux at the center of each surface element, and then taking a simple numerical average over all the surface elements on the forward hemisphere. This averaged multigroup flux is then folded with the response function to obtain the calculated Bonner ball detector response. Moreover, this was the approach later adopted by C. O. Slater during his "Analysis of Phase II of the HTGR Bottom Reflector and Core Support Block Neutron Streaming Experiments" (cf. Sect. 4.3.1 on page 29 of ORNL/TM-9485, June 1985) and in his pre-experimental analysis of the JASPER experiments in the late 1980's.

2.5.4 Redefinition of the Forward Hemisphere

The approach described above (numerically integrating and averaging the flux over the forward hemisphere of the Bonner balls) was found to work well for both large and small Bonner balls close to the shield along the centerline of the system. When the Bonner balls are located some distance away from the centerline and are more-or-less "off to the side" of the actual shield configuration, the use of the -Z hemisphere is questionable and can cause the calculated Bonner ball responses to be 30 to 50% too low. Consider the horizontal (radial) traces made with the 10-inch Bonner ball 30 cm downstream of Config. IIIA, for example, as illustrated in Fig. 2.5a. Along the centerline, the calculated Bonner ball responses were in

$$\frac{C}{E} = \frac{0.8425}{1.33} = 0.633$$

Fig. 2.5a. Forward hemisphere (of a Bonner ball detector) over which the flux was traditionally averaged before computing the Bonner ball response. For detectors located "off to the side" of a distributed source, this method tends to break down.

$$\frac{C}{E} = \frac{1.2159}{1.33} = 0.914$$

Fig. 2.5b. Redefinition of the forward hemisphere (of a Bonner ball detector) over which the flux is now averaged before computing the Bonner ball response. For detectors located "off to the side" of a distributed source, this method tends to give good results.

excellent agreement with the measurements, as expected. With the Bonner ball located 80 cm off the centerline, however, the bulk of the 10-inch Bonner ball was located in front of the thick lithiated paraffin region next to the environmental concrete shield — i.e., far off to the side of the IVFS fuel slab through which most of the neutrons were coming. Thus, it was no surprise that the calculated Bonner ball responses (using the scheme in Fig. 2.5a) underpredicted the measured response with a C/E ratio of $C/E = 0.8425/1.33 = 0.633$. In such situations, it became obvious that the surface flux on the Bonner ball should be averaged over that portion of the Bonner ball facing the source of most of the neutrons. A decision was then made to redefine "the forward hemisphere" as that hemisphere normal to a vector drawn to the center of the Bonner ball from the midpoint of the external surface of the experimental shield configuration as illustrated in Fig. 2.5b, and then apply the same numerical averaging procedure previously described in Sect. 2.5.3. When that was done, the C/E ratio for the 10-inch Bonner ball located 80 cm off the centerline became $C/E = 1.2159/1.33 = 0.914$, which was deemed significantly better. The nice feature of this procedure, which became the standard procedure used in all of the IVFS analyses, is that it better accommodates edge effects while reducing identically to the old procedure when the Bonner ball is located along the centerline.

2.5.5 Uncertainties and Questions

Even with the same standard multigroup response functions such as those shown in Table 2.4, the calculated detector responses may vary by 30 to 50%, depending on how the response itself was computed from the spatially-dependent multigroup flux. In the early days when people were pleased to be within a factor of 2 or 3 of the measured values, this type of uncertainty in the methodology was immaterial. With the better experimental techniques, shielding codes, and cross-section data available today, a significant portion of the remaining uncertainty may well be due to this seemingly trivial question of how one computes the actual Bonner ball responses. Certainly more effort than we can presently afford should be spent to develop a more refined procedure for doing this before millions of dollars are spent on additional experiments aimed at reducing the uncertainty further. Some remaining questions would include:

1. Should the flux be averaged over something less than the forward hemisphere?
2. What about neutrons entering through the backside of the Bonner balls?
3. Should the Bonner balls be recalibrated (and subsequent folding techniques developed) in terms of the average inward-directed multigroup current over the whole sphere in lieu of the scalar flux on part of the surface?

2.5.6 The DORRE and TORRE Codes

The questions in Sect. 2.5.5 notwithstanding, the approach used in the DORRE and TORRE codes to compute the Bonner ball responses for the JASPER IVFS analyses is basically that outlined in Sects. 2.5.3 and 2.5.4. (The DORRE code is used to compute Bonner ball responses using a 2-D RZ DORT flux file as input, while TORRE is used to compute the Bonner ball responses using a 3-D XYZ TORT flux file as input.) Here, a line is drawn from the center of the external surface of the shield configuration to the center of the Bonner ball to define the forward hemisphere as shown in Fig. 2.5b. Each quadrant of the forward hemisphere is divided into 45 surface elements of equal area distributed in 9 rings about the above line (for a total of 180 equally sized surface elements on the forward hemisphere). The multigroup flux corresponding to the center of each surface element is then obtained by interpolation. In the case of a 2-D RZ flux file, the flux at a given point is obtained by interpolating between the fluxes at the 4 nearest surrounding points in the DORT flux file, and therefore requires the inversion of a 4x4 matrix each time. In the case of a 3-D XYZ flux file, the flux at a given point is obtained by interpolation between the fluxes at the 8 nearest surrounding points in the TORT flux file, and therefore requires the inversion of an 8x8 matrix each time. After the multigroup flux at the center of each of the 180 equally sized surface elements has been computed, the DORRE and TORRE codes then compute the "average" multigroup flux over the forward hemisphere and fold that with the multigroup response functions in Table 2.4 to obtain the final calculated Bonner ball responses found in this report. [Thus, if one folds the multigroup fluxes at a single point of interest with the multigroup response functions in Table 2.4, one can only approximate the Bonner ball responses found in this report. By way of contrast, the final calculated responses for the somewhat smaller bare and Cd-covered fission chambers were indeed obtained by folding the multigroup fluxes at the point of interest with the appropriate multigroup response functions. This was possible because the fission chambers are much smaller devices and the sensitive media (a 2.5-inch-diam x 0.01-inch-thick fission plate) was located right at the end of the detector.]

In addition to calculating the various Bonner ball responses as described above, the DORRE and TORRE codes also fold the bare and Cd-covered fission chamber responses listed in Table 2.4 with the multigroup fluxes at the specified point of interest to obtain the calculated bare and Cd-covered fission chamber responses at that particular point. Note that the flux at that particular point (x,y,z) is obtained using the same 4-point or 8-point linear interpolation scheme in DORRE and TORRE for the 2-D RZ DORT or 3-D XYZ TORT results. While one can have the DORT code print the multigroup flux at key flux locations corresponding to any set of mesh intervals (I_r, J_z), the input to the TORT code implies that one can print the multigroup flux at any arbitrary point (x,y,z). While this is certainly

a convenience, it must be understood that the value printed directly by the TORT code is not an interpolated value (as in the TORRE output), but rather a generic value which is assumed to apply to all points in the mesh interval containing the particular point requested by the user. That is: the TORT code simply determines which mesh interval the requested point is in, and prints out the value corresponding to that particular mesh interval (I,J,K), much the same as in the DORT code. Because the DORRE and TORRE codes do yield interpolated values based on a continuous linear interpolation in all three directions, the values obtained by these post-processor codes are considered more accurate than the values printed directly by DORT and TORT when the point of interest is located inside a large mesh interval. On the other hand, the values obtained are virtually identical to the values given by DORT and TORT when one has small mesh intervals near the point of interest. [In the case of Config. IIIA.1d, for example, this seemingly small distinction can make a 20% difference in the calculated bare and Cd-covered fission chamber responses at 0.7 cm from the face of the IVFS slab (cf. Table X.11) because that particular point is near the edge of a 3.01 cm mesh interval where the thermal flux gradient is relatively steep, while at 30 cm downstream from the IVFS where the point(s) of interest are much closer to the center of somewhat smaller mesh intervals, the results are generally identical to within 5 significant digits. See additional comments in Sect. 4.5.2.]

2.6 THE MEASUREMENT AND MODELING OF THERMAL NEUTRON BACKGROUND RADIATION

In the past, shielding experiments were primarily performed to measure the attenuation of fast and intermediate energy neutrons using Bonner balls and other devices. Because the Tower Shielding Reactor is located outdoors, it has always been considered relatively free of background radiation. In the JASPER IVFS experiments, however, bare and Cd-covered fission detectors were used for the first time to measure thermal and epithermal neutron radiation downstream of the shield configurations. These measurements were greatly complicated and frustrated by the presence of thermal neutron background radiation that had previously not been of any concern in earlier experimental programs.

2.6.1 Clarification of What Was Measured

The initial experimental plan was to measure the thermal flux by taking the difference between the bare and Cd-covered fission chambers a short distance (0.7 cm or 30 cm) downstream of the experimental shield configurations. In practice, it was initially difficult to know exactly what the bare fission chamber was measuring or how to attach uncertainties to those measurements because of thermal neutron

background radiation. Bare fission chamber measurements behind the shield configurations were therefore repeated with a cadmium sheet (or "plate") placed over the face of the shield (between the shield and the bare fission chamber) in an effort to measure the background radiation. The difference between the bare detector measurements with and without the Cd plate was supposed to measure the thermal flux transmitted through the shield specimens (although, as noted later, this logic was somewhat flawed). A second, independent measurement of this component of the thermal flux was then made by placing the bare fission chamber inside a large (5-ft x 5-ft x 1.5-ft deep) 5-sided cadmium box (or "hut"), with the bare fission chamber and the open end of the Cd hut facing the experimental shield specimen and the rest of the hut blocking out thermal neutron background radiation from the environment. Unfortunately, if one looks at the thermal flux as measured by the "hut method" and "difference method" described above, they are not in good agreement, and the ratios (H/D) for Config. IC, and Configs. IIIA through IIIF, seem to vary between 2.0 and 2.8, thus shaking one's confidence in the measured values. Fortunately, the frequently suggested but overly simplistic logic described above contains one or two commonly overlooked fallacies that make the above conclusion null and void. The first fallacy is this: While this logic correctly assumes that the bare fission chamber measures the thermal flux, it neglects the fact that the bare fission chamber also measures the epithermal flux. Behind the cadmium plate, the epithermal flux is essentially the same as in the basic configuration without Cd plate. With the difference method, that portion of the bare detector response due to the epithermal flux is cancelled out (as well as any background thermal radiation). With the bare detector inside the Cd hut, that portion of the detector response due to any background thermal radiation is eliminated as intended, but the epithermal component of the flux still remains (as well as that component of the thermal flux coming through the test specimen). Thus, while both methods eliminate the thermal neutron background radiation and measure the transmitted component of the thermal flux, the hut method will always yield a larger response because its response also includes contributions due to the epithermal neutrons. The second fallacy is that one can use the "difference method" described above to obtain a clean measurement of the thermal flux that comes directly through the shield configuration. The following discussion explains why this is not totally correct, and how it can be seriously misleading in some cases.

To more clearly understand what is actually measured by the bare and Cd-covered fission chambers and what can be inferred from those measurements, consider Figs. 2.6a, 2.6b, and 2.6c which illustrate what is really measured by the bare fission chamber detector when it is placed (a) downstream of the basic shield configuration, (b) downstream of the Cd plate, and (c) inside the Cd hut. In these figures, T and E generally represent the thermal and epithermal neutrons coming from the shield configuration or from any source of background radiation such

Fig. 2.6a. Thermal and epithermal components of the flux measured by a bare fission chamber downstream of the basic shield configuration. Nomenclature is defined in the text.

Fig. 2.6b. Thermal and epithermal components of the flux measured by a bare fission chamber downstream of a cadmium plate placed over the face of the shield configuration.

Fig. 2.6c. Thermal and epithermal components of the flux measured by a bare fission chamber located inside a cadmium hut placed over the face of the shield configuration.

as the lithiated paraffin blocks surrounding the shield configuration, the concrete blocks surrounding the lithiated paraffin blocks, or the concrete slab on the ground downstream of the shield configuration. More precisely, let

T_S and E_S represent those thermal and epithermal neutrons entering the detector which come directly from the shield configuration, and

T_B and E_B represent those thermal and epithermal neutrons entering the detector which come directly from the various sources of background radiation.

In addition, it must be recognized that many of the thermal and epithermal neutrons due to background radiation will re-enter the front surface of the shield configuration, where some will backscatter toward the fission chamber before or after slowing down further. [We will later show that this is a non-negligible source of radiation.] Thus, let

E_{EBRE} represents those (epithermal) neutrons entering the detector which originated as epithermal background neutrons but which first re-entered the shield configuration and were subsequently reflected back toward the detector as epithermal neutrons.

T_{EBRT} represents those (thermal) neutrons entering the detector which originated as epithermal background neutrons but which first re-entered the shield configuration and subsequently slowed down to thermal energies before being reflected back toward the detector as thermal neutrons.

T_{TBRT} represents those (thermal) neutrons entering the detector which originated as thermal background neutrons but which first re-entered the shield configuration before being reflected back toward the detector as thermal neutrons.

Thus, the total response of the bare fission chamber downstream of the basic configuration is equal to the sum of its responses due to all seven components of the thermal and epithermal flux described above and illustrated in Fig. 2.6a (i.e., $A = T_S + E_S + T_B + E_B + E_{EBRE} + T_{EBRT} + T_{TBRT}$). With the Cd plate illustrated in Fig. 2.6b, thermal neutron background radiation cannot re-enter the shield configuration, three of these thermal flux components (T_S , T_{EBRT} , and T_{TBRT}) are eliminated, and the total response of the bare fission chamber downstream of the Cd plate is given by $B = E_S + T_B + E_B + E_{EBRE}$. With the Cd hut illustrated in Fig. 2.6c, only two of the original seven components (T_B and T_{TBRT}) are eliminated, and the total response of the bare fission chamber is given by $C = T_S + E_S + E_B + E_{EBRE} + T_{EBRT}$. Lastly, one must consider the response of the Cd-covered fission chamber. Regardless of whether it is placed downstream of the basic configuration, downstream of the Cd plate, or

inside the Cd hut, all of the thermal flux components would be essentially eliminated and the total response of the Cd-covered fission chamber would be given by $D = E_S + E_B + E_{EBRE}$ in all three cases. Looking at Figs. 2.6a, 2.6b, and 2.6c, these four equations (describing the only measurements which are physically possible) may be quickly and easily written directly in near-matrix form as:

$$[1] (T_S + T_{EBRT}) + [1] (T_B) + [1] (T_{TBRT}) + [1] (E_S + E_B + E_{EBRE}) = A \equiv \left[\begin{array}{l} \text{Bare det. resp.} \\ \text{for basic config} \end{array} \right]$$

$$[0] (T_S + T_{EBRT}) + [1] (T_B) + [0] (T_{TBRT}) + [1] (E_S + E_B + E_{EBRE}) = B \equiv \left[\begin{array}{l} \text{Bare det. resp.} \\ \text{with Cd plate} \end{array} \right]$$

$$[1] (T_S + T_{EBRT}) + [0] (T_B) + [0] (T_{TBRT}) + [1] (E_S + E_B + E_{EBRE}) = C \equiv \left[\begin{array}{l} \text{Bare det. resp.} \\ \text{inside Cd hut} \end{array} \right]$$

$$[0] (T_S + T_{EBRT}) + [0] (T_B) + [0] (T_{TBRT}) + [1] (E_S + E_B + E_{EBRE}) = D \equiv \left[\begin{array}{l} \text{Cd cov det resp} \\ \text{for any config} \end{array} \right]$$

where the 4x4 coefficient matrix of [1]'s and [0]'s may be easily inverted to yield:

$$(T_S + T_{EBRT}) = [0] A + [0] B + [1] C + [-1] D = C - D$$

$$(T_B) = [0] A + [1] B + [0] C + [-1] D = B - D$$

$$(T_{TBRT}) = [1] A + [-1] B + [-1] C + [1] D = A - B - C + D$$

$$(E_S + E_B + E_{EBRE}) = [0] A + [0] B + [0] C + [1] D = D$$

Note that the grouping of the parameters in the original matrix expression was no accident. With only four independent measurements, it is only possible to infer information about four groups of parameters. (1) Since the bare and Cd-covered fission chambers both measure epithermal neutrons from all sources in all three configurations, it is impossible (with the present set of measurements) to determine where the epithermal neutrons are coming from. Thus, E_S , E_B , and E_{EBRE} must all be grouped together as a single parameter. (2) A second (more subtle but important) observation is that "one cannot do a clean measurement of only the thermal flux that comes directly through the shield configuration (T_S) because of the background epithermal flux that re-enters the configuration, slows down, and comes back out as thermal (T_{EBRT}).". If one were to unwittingly (and incorrectly) assume that T_{TBRT} was zero, and separate T_S and T_{EBRT} as two separate columns in a 4x4 matrix, one would find that the resulting matrix could not be inverted (i.e., that the inverse would be indeterminate) because these two columns of leading

coefficients [1's and 0's] would be identical. Thus, these two quantities (T_S and T_{EBRT}) must be grouped together as a single parameter and cannot be determined individually. (3) Lastly, it would be awkward and incorrect to assume that T_{TBRT} is zero. [To do so would leave 3 groups of unknowns and 4 equations. While one could choose any 3 equations from which to obtain the 3 unknowns, the results for $(T_S + T_{EBRT})$ or T_B in Config. IC (for example) would vary by as much as 20 to 26%, depending on which set of 3 equations one chose.] In reality, T_{TBRT} can and should be calculated by keeping that term and using all 4 equations. Its magnitude is often not negligible. Consider, for example, the results of measurements made 30 cm downstream of the six large sodium tanks forming the bulk of the spectral modifier in Config. IC. In this case:

$A = 0.142$ counts/min for the bare fission chamber behind the basic config.

$B = 0.0905$ counts/min for the bare fission chamber behind the Cd plate

$C = 0.117$ counts/min for the bare fission chamber inside the Cd hut

$D = 0.0743$ counts/min for the Cd-cov fission chamber behind the basic config.

Applying the above logic to these measurements, one can now infer the relative contribution due to several of the components:

$$T_S + T_{EBRT} = 0.0427 \text{ counts/min}$$

$$T_B = 0.0162 \text{ counts/min}$$

$$T_{TBRT} = 0.0088 \text{ counts/min}$$

This says that (1) the portion of the detector response due to thermal background radiation which first re-entered the shield configuration before being reflected back toward the detector is at least half as large as the detector response due to all other thermal neutron background radiation, and that (2) the portion of the detector response due to thermal neutron background radiation ($T_B + T_{TBRT} = 0.025$) accounts for about 37% of the total response due to all thermal neutrons entering the detector ($T_S + T_{EBRT} + T_B + T_{TBRT} = 0.0677$) in this particular case. For other shielding configurations, the percentage of the total thermal neutrons at the detector due to thermal neutron background radiation is often much higher. As an extreme example of such a case, consider Config. IIID where the B_4C slab is the last component in the shielding configuration. There,

$A = 7.80E-4$ counts/min for the bare fission chamber behind the basic config.

$B = 7.35E-4$ counts/min for the bare fission chamber behind the Cd plate

$C = 6.08E-4$ counts/min for the bare fission chamber inside the Cd hut

$D = 5.98E-4$ counts/min for the Cd-cov fission chamber behind the basic config.

Because of the B_4C slab, the bulk of the fission chamber response in each case is obviously due to epithermal neutrons reaching the detector. Nevertheless, the above logic may again be applied to infer the relative contribution due to several of the other components:

$$T_S + T_{EBRT} = 0.10E-4 \text{ counts/min}$$

$$T_B = 1.37E-4 \text{ counts/min}$$

$$T_{TBRT} = 0.35E-4 \text{ counts/min}$$

While T_{TBRT} is a less significant fraction of the thermal neutron background radiation than in the previous example, the latter quantity ($T_B + T_{TBRT} = 1.72E-4$) now accounts for about 95% of all the thermal neutrons entering the detector ($T_S + T_{EBRT} + T_B + T_{TBRT} = 1.82E-4$). Moreover, had one simply applied the original "difference method" described at the beginning of Sect. 2.6.1 to estimate the thermal flux coming from the shield configuration, that erroneous and misleading estimate ($A-B$) would have been more than 4.5 times higher than $T_S + T_{EBRT}$.

In light of the above discussion, it is fair to say that calculational models that do not account for thermal and epithermal background radiation in some fashion will have little chance of reproducing experimentally measured values where the effect of background radiation is demonstrably important. Moreover, the importance of having a calculational model that does account for thermal and epithermal background radiation in at least some fashion is also underscored by the realization that T_S cannot be measured separately.

2.6.2 Calculational Models to Account for Thermal Neutron Background Radiation

Experimentally, it became well known that thermal neutron background radiation was a non-negligible problem. Unfortunately, it was not known if this radiation was a "skyshine effect" caused by neutrons leaking out of high flux areas (such as the reactor shed or the sliding door adjacent to the collimator) and subsequently slowing down in the surrounding air and backscattering off nearby buildings or other experimental apparatus, or if it was primarily due to faster neutrons coming through the shielding configuration and scattering off the concrete pad on the ground in front of the shed. Experimentally it did not matter since it could be largely eliminated with proper precautions. Calculationally it did matter since the former effect could not be modeled while the latter effect might be approximated in some gross sense. As noted below, it is now believed that the latter effect (the slowing down in and backscattering of neutrons from the concrete pad in front of

the reactor and the shield configuration) is primarily responsible for this thermal neutron background radiation.

Customarily, 2-D RZ models of the shielding experiment typically model everything up to and including the test specimens, but stop at that point. Since the (Z) axis of the horizontal beam is parallel to the ground, there is no good way to model scattering off the ground, and the modeling of structures, vehicles, or spare components many meters away would be difficult and the number of mesh intervals required would be prohibitive. Based on a hypothetical assumption that the bulk of the thermal neutron background radiation was probably due to fast and epithermal neutrons escaping through the downstream surface of the shield and subsequently slowing down in the concrete pad on the ground in front of the shielding experiment before backscattering toward the experiment as thermal neutrons, an attempt was made to simulate this effect by artificially including a large-diameter concrete ring in the calculational model on the downstream side of the shield. This artificial concrete ring used in the calculational models is clearly shown and labeled on many of the figures in Sect. 3. Based on a large number of trial-and error calculations, it was found that a large concrete ring having an inside diameter of 270.8 cm (8.88ft), an outside diameter of 314.2 cm (total thickness = 21.7 cm = 8.54 inches), and extending 83.11 cm past the downstream surface of the experimental test specimen, could indeed simulate the thermal neutron background radiation fairly well in most cases without having any significant effect on the fast or intermediate neutron fluxes measured by the larger Bonner balls. In cases where there was already a significant source of thermal neutrons in the last few inches of the test specimen (as in Config. IC which terminates with the last of six sodium tanks), and in cases where the existing environmental concrete shield used in the experiment already extended 20 or 30 cm past the test specimen (as in Configs. IIIB and IIIC), this artificial concrete ring used in the calculational models increased the bare fission chamber response 30 cm from the surface by only a very modest amount (8 to 20%). [In the case of Config. IC, for example, the C/E ratio for the bare fission chamber response increases from 0.880 to 0.952.] On the other hand, in cases where one of the last sections of the shield was a strong thermal neutron absorber (such as the B₄C slab in Configs. IA, IIID, or IIIF) and most of the thermal flux measured by the bare fission chamber would almost certainly be due to background radiation, the artificial concrete ring used in the calculational models seemed to account for this quite nicely. In the case of Config. IA, for example, the C/E ratio for the bare fission chamber at 30 cm was 0.452 originally (without the artificial concrete ring to account for thermal neutron background radiation), but was 0.994 after this artificial concrete ring was included in the calculational model. Likewise, in the case of Config. IIIF, the C/E ratio for the bare fission chamber at 30 cm was 0.356 without this concrete ring, but was 1.012 once this artificial concrete ring was included in the calculational model.

In summary, it can be said that the effect of thermal neutron background radiation on the bare fission chamber response has been found to be important, both experimentally and calculationally. The dimensions of the large concrete ring used here to simulate that background radiation, and the generally good agreement that resulted, are not particularly important — after all, those dimensions were adjusted by trial-and-error (initially) so as to obtain reasonably good agreement in most cases. Nevertheless, it is significant that “how one models the imponderables downstream of the shielding configuration” (i.e., “how one models thermal neutron background radiation”) can affect the bare fission chamber response to a much higher degree than the uncertainties associated with neutron transport through the shield or the uncertainties associated with the actual measurements when properly understood. This would suggest that, if thermal neutron measurements are important, one should endeavor to refine future experimental techniques even further so that one can not only quantify the amount of background radiation received (as done here), but eliminate it so that such arbitrary ad hoc fixes to the calculational models will no longer be necessary. Secondly, it is also significant that the artificial concrete ring used here, with its short length and large (8.88-ft) inside diameter, could have such a large effect on the thermal neutron flux 30 cm downstream of the shield configuration. Had skyshine due to neutrons leaking from the sides of the Tower Shielding Reactor been primarily responsible for most of the background radiation as previously suggested by some, the effect of including this 8.88-ft-diam concrete ring downstream of the shield to simulate backscatter off the concrete pad would not have been so large. The fact that this large-diam ring did make a significant difference in several cases suggests that a large amount of the background radiation is in fact due to fast and epithermal neutrons that escape from the downstream face of the shielding configuration and subsequently scatter off the concrete pad on the ground in front of the TSR. Lastly, if not significant, it is at least interesting that a single standard modification to the calculational model such as the inclusion of this artificial concrete ring could bring the calculated results of so many cases into generally good agreement with the experimental measurements.

As noted and illustrated in Sect. 3, each of the basic configurations were analyzed with and without the artificial concrete ring described above, while the C/E ratios for both sets of models are listed in Sect. 4. This was done primarily for the sake of completeness. From the tables in Sect. 4, one can also see that the smaller 3-inch Bonner ball responses were somewhat sensitive to the presence of the artificial concrete ring (in those same situations where the bare fission chambers were most greatly affected), and that the larger diameter Bonner balls were relatively insensitive to the presence or absence of this artificial concrete ring used to simulate thermal neutron background radiation.

Table M.1. Brief verbal description of the material mixtures used in the 2-D RZ DORT (and 3-D XYZ TORT) analyses of the JASPER IVFS configurations. See Table M.2 for the VELM nuclide ID's and number densities in each mixture (25 through 67). See Tables G.1 through G.24 in Sect 3 for location of these materials in the models.

Mix 1 to 24 are not listed here because they were not used in any of the JASPER IVFS analyses

- Mix 25 First iron slab for spectral modifier; see pp 43, ORNL/TM-11989
- Mix 26 Second iron slab for spectral modifier; same as Mix 25
- Mix 27 Aluminum 6061; see pp 43, ORNL/TM-11989; used for the slabs in the spectral modifier, and also for the walls of the sodium tanks
- Mix 28 Aluminum 6061; same as Mix 27
- Mix 29 Homogenized boron with aluminum clad; to get final compositions on pp 44, ORNL/TM-11989
- Mix 30 Pb slabs; see Table 13 on page 52 of ORNL/TM-11989; used in Configs 1A/PB and 1C/PB
- Mix 31 Pb slabs; same as Mix 30
- Mix 32 Bulk of material inside radial blanket assembly (65.07 vol% natural UO₂ pellets, 11.43 vol% Aluminum 8001, 21.93 vol% sodium)
- Mix 33 Lithiated paraffin blocks (see pp 46, ORNL/TM-11989); 60 wt% paraffin, 40 wt% Li₂CO₃ (with x-sects for nat lithium weighted for use in paraffin)
- Mix 34 Small concrete blocks adjacent to the spectral modifier and the lithiated paraffin (see pp 47, ORNL/TM-11989)
- Mix 35 Small concrete blocks adjacent to the spectral modifier and the lithiated paraffin; same as Mix 34
- Mix 36 Large conc blocks for environmental shielding; see pp 51, ORNL/TM-11989
- Mix 37 Large conc blocks for environmental shielding; same as Mix 36
- Mix 38 B4C in B4C slab number 4W; see pp 9 & 48 of ORNL/TM-11989
- Mix 39 SS304; shell of B4C slab
- Mix 40 SS304; stand-alone 2.68-cm SS slab; used in Config IIIF; same as Mix 39

Mix 41-46 represent the sodium in the six sodium tanks. Note that different VELM nuclide ID's were used for the sodium in the first three tanks close to the source, the next two tanks (deep in the sodium), and the last tank (close to the IVFS or absorber slabs further downstream). Specially weighted sodium cross-section data for these different regions is described in ORNL/TM-10302: "VELM61 and VELM22 Multigroup Cross-Section Libraries for Sodium-Cooled Reactor Shield Analyses (April, 1987). Other notes are as follows:

40	Mix 41 Sodium in first tank Mix 42 Sodium in second tank Mix 43 Sodium in third tank Mix 44 Sodium in fourth tank Mix 45 Sodium in fifth tank Mix 46 Sodium in sixth tank	1) see page 48 of ORNL/TM-11989 for list of impurities 2) actually, Ca+Zn (together) = 0.3 wt% (split is unknown) 3) x-sect for Ca varies from 1 to 10 barns from 0.2 keV to 100 keV 4) x-sect for Na is much less than that for Ca 5) x-sect for Zn has a number of small (30 to 500 barn) resonances from 0.2 keV to 100 keV, but Zn is not in VELM library 6) shells of the sodium tanks are made of aluminum 6061
-
- Mix 47 SS304; never used, but available; physically the same as mixture 39, but the x-sects for Fe, Cr, Ni, and Mn were weighted for stainless steel near a stainless steel/sodium interface

 - Mix 48 Part of 230 pin sect of homog IVFS slab in the 2-D RZ DORT models; 13.7734 vol% SS304 clad, 67.8438 vol% low enriched UO₂ pellets (Mix 9212), rest void
 - Mix 49 Part of 230 pin sect of homog IVFS slab in the 2-D RZ DORT models; 13.7668 vol% SS304 clad, 67.8115 vol% aluminum oxide, rest void
 - Mix 50 Part of 230 pin sect of homog IVFS slab in the 2-D RZ DORT models; 23.7133 vol% SS304 clad (and spring in fission gas plenum of pins), rest void
 - Mix 51 Part of 230 pin sect of homog IVFS slab in the 2-D RZ DORT models; 49.2607 vol% SS304 clad (and steel plug near ends of pins), rest void

 - Mix 52 Part of 306 pin sect of homog IVFS slab in the 2-D RZ DORT models; 13.9131 vol% SS304 clad, 68.5321 vol% low enriched UO₂ pellets (Mix 9215), rest void
 - Mix 53 Part of 306 pin sect of homog IVFS slab in the 2-D RZ DORT models; 13.9065 vol% SS304 clad, 68.4994 vol% aluminum oxide
 - Mix 54 Part of 306 pin sect of homog IVFS slab in the 2-D RZ DORT models; 23.9539 vol% SS304 clad (and spring in fission gas plenum of pins), rest void
 - Mix 55 Part of 306 pin sect of homog IVFS slab in the 2-D RZ DORT models; 49.7605 vol% SS304 clad (and steel plug near ends of pins), rest void

 - Mix 56 Part of 188 pin sect of heterog IVFS slab in the 3-D XYZ TORT model; 49.5687 vol% SS304 clad (and steel plug near top of pins), rest void
 - Mix 57 Part of 188 pin sect of heterog IVFS slab in the 3-D XYZ TORT model; 24.7593 vol% SS304 clad (and spring in fission gas plenum of pins), rest void
 - Mix 58 Part of 188 pin sect of heterog IVFS slab in the 3-D XYZ TORT model; 14.3839 vol% SS304 clad, 70.8510 vol% aluminum oxide, rest void
 - Mix 59 Part of 188 pin sect of heterog IVFS slab in the 3-D XYZ TORT model; 14.3839 vol% SS304 clad, 70.8510 vol% low enriched UO₂ pellets (Mix 9218), rest void
 - Mix 60 Part of 188 pin sect of heterog IVFS slab in the 3-D XYZ TORT model; 14.3839 vol% SS304 clad, 70.8510 vol% aluminum oxide, rest void
 - Mix 61 Part of 188 pin sect of heterog IVFS slab in the 3-D XYZ TORT model; 54.5256 vol% SS304 clad (and steel plug near bottom of pins), rest void

 - Mix 62 Void; represented here by helium with a density of 1.0E-20 atoms/(barn*cm)
 - Mix 63 Small amount of sodium near inner edge of radial blanket assembly; as per pp 45 of ORNL/TM-11989
 - Mix 64 Iron casing for radial blanket assembly; see pp 43, ORNL/TM-11989; same as Mix 25

Table M.1 (cont)

- Mix 65 Iron shot in ends of the radial blanket assembly; based on a 60 vol% Fe, which is the maximum packing factor for small spherical Fe particles
 Mix 66 Dummy nuclide ID used to contain the multigroup response functions in the VELM library
 Mix 67 Used to model the Cd-plate (and/or the Cd-hut) used in some configurations; note that a fictitious Cd density of 0.53663 g/cc (rather than 8.65 c/cc) was used here so that the 35 mil = 0.035 inch = 0.08890 cm thick Cd-plate or Cd-hut could be represented as a 1.433-cm-thick zone in the 2-D RZ DORT models.

Note: the following elements, compounds, and mixtures (denoted by 4-digit ID's) are intermediate materials that were ultimately used to describe those mixtures (25 through 67) actually used in the 2-D DORT and 3-D TORT analyses of the JASPER IVFS experiments.

- elem 3000 Natural lithium (7.5 at% Li-6, 92.5 at% Li-7); used to represent trace amounts of lithium in different materials
 elem 3001 Natural lithium (7.5 at% Li-6, 92.5 at% Li-7); cross sections weighted for bulk use in paraffin
 elem 5000 Natural boron (19.9 at% B-10, 80.1 at% B-11)
 elem 9200 Natural uranium (99.2745 at% U-238, 0.72 at% U-235, 0.0055 at% U-234)
 elem 9210 Low (4.81 wt%) enriched uranium for spert fuel; with U-235 and U-238 resonance self-shielded for 230 pin sect of IVFS
 elem 9213 Low (4.81 wt%) enriched uranium for spert fuel; with U-235 and U-238 resonance self-shielded for 306 pin sect of IVFS
 elem 9216 Low (4.81 wt%) enriched uranium for spert fuel; with U-235 and U-238 resonance self-shielded for TORT 3-D sect of IVFS
 comp 5101 B4C made with natural boron
 comp 5102 Boron nitride [BN], made with natural boron
 comp 9201 UO2, made with natural uranium
 comp 9202 H2O
 comp 3002 Paraffin [C25H52], with hydrogen data weighted for use in paraffin
 comp 3003 Li2CO3 (with cross sections for natural lithium weighted for use in paraffin)
 comp 6401 [CO3]
 comp 6403 [SiO2]
 comp 6404 [H2O]
 comp 6407 [AL2O3]
 comp 6408 [Fe2O3]
 comp 6409 [SO3]
 comp 6410 [P2O5]
 comp 9211 UO2; low (4.81 wt%) enriched uranium for spert fuel; with U-235 and U-238 resonance self-shielded for 230 pin sect of IVFS
 comp 9214 UO2; low (4.81 wt%) enriched uranium for spert fuel; with U-235 and U-238 resonance self-shielded for 306 pin sect of IVFS
 comp 9217 UO2; low (4.81 wt%) enriched uranium for spert fuel; with U-235 and U-238 resonance self-shielded for TORT 3-D sect of IVFS
 comp 2718 Aluminum oxide [AL2O3]
 Mix 2719 Aluminum oxide; 3.965 g/cc; taken from CRC handbook; used for spacers in spert fuel pins
 Mix 3901 SS304; used in cladding for spert fuel pins; see pp 50 of ORNL/TM-11989; used standard weighting for Fe, Cr, Ni, and Mn in the stainless steel clad
 Mix 5103 Boral (meat, not including the cladding); used to get elemental compositions on pp 44, ORNL/TM-11989
 Mix 8001 Aluminum used inside radial blanket assembly
 Mix 9203 Natural UO2 pellets in radial blanket assembly fuel pins; see page 45 ORNL/TM-11989
 Mix 9212 Low enriched UO2 pellets in spert fuel; see pp 7, 8, and 109 ORNL/TM-11989; with U-235 and U-238 resonance self-shielded for 230 pin sect of IVFS
 Mix 9215 Low enriched UO2 pellets in spert fuel; see pp 7, 8, and 109 ORNL/TM-11989; with U-235 and U-238 resonance self-shielded for 306 pin sect of IVFS
 Mix 9218 Low enriched UO2 pellets in spert fuel; see pp 7, 8, and 109 ORNL/TM-11989; with U-235 and U-238 resonance self-shielded for TORT 3-D sect of IVFS

Other mixtures that were defined but never used include the following (note that these would have been needed if a 3-D XYZ TORT analyses had been performed on Config I11B, for example):

- Mix 9801 Part of 230 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 46.6169 vol% SS304 clad (and steel plug near top of pins), rest void
 Mix 9802 Part of 230 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 23.7082 vol% SS304 clad (and spring in fission gas plenum of pins), rest void
 Mix 9803 Part of 230 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 13.7733 vol% SS304 clad, 67.8433 vol% aluminum oxide, rest void
 Mix 9804 Part of 230 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 13.7733 vol% SS304 clad, 67.8433 vol% low enriched UO2 pellets (Mix 9212), rest void
 Mix 9805 Part of 230 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 13.7733 vol% SS304 clad, 67.8433 vol% aluminum oxide, rest void
 Mix 9806 Part of 230 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 52.2109 vol% SS304 clad (and steel plug near bottom of pins), rest void
 Mix 9807 Part of 306 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 47.0898 vol% SS304 clad (and steel plug near top of pins), rest void
 Mix 9808 Part of 306 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 23.9488 vol% SS304 clad (and spring in fission gas plenum of pins), rest void
 Mix 9809 Part of 306 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 13.9130 vol% SS304 clad, 68.5315 vol% aluminum oxide, rest void
 Mix 9810 Part of 306 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 13.9130 vol% SS304 clad, 68.5315 vol% low enriched UO2 pellets (Mix 9215), rest void
 Mix 9811 Part of 306 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 13.9130 vol% SS304 clad, 68.5315 vol% aluminum oxide, rest void
 Mix 9812 Part of 306 pin sect of homog IVFS slab in a 3-D XYZ TORT model; 52.7406 vol% SS304 clad (and steel plug near bottom of pins), rest void

Table M.2. Atomic number densities [atoms/(barn*cm)] for each of the material mixtures (25 through 67) used in the analysis of the JASPER IVFS experiments.

Mixing Table Entry	Mixture Number	Density of Mix (g/cc)	VELM Nuc ID Number	Atom Density atoms/barn*cm	Brief Description of nuclide and x-sect weighting	Weight Fraction of the nuclide in the mixture
1	25	7.86000	115	4.20710E-04	si (standard)	2.49626E-03
2	25	7.86000	169	1.36347E-04	cr (standard)	1.49775E-03
3	25	7.86000	193	4.02672E-05	ni (standard)	4.99251E-04
4	25	7.86000	199	2.21212E-05	cu (standard)	2.99551E-04
5	25	7.86000	235	9.85262E-06	mo (standard)	1.99700E-04
6	25	7.86000	567	8.32790E-02	fe (carbstl-thin)	9.82526E-01
7	25	7.86000	573	8.60299E-04	mn (carbstl)	9.98502E-03
8	25	7.86000	579	9.84648E-04	c (carbstl)	2.49626E-03
9	26	7.86000	115	4.20710E-04	si (standard)	2.49626E-03
10	26	7.86000	169	1.36347E-04	cr (standard)	1.49775E-03
11	26	7.86000	193	4.02672E-05	ni (standard)	4.99251E-04
12	26	7.86000	199	2.21212E-05	cu (standard)	2.99551E-04
13	26	7.86000	235	9.85262E-06	mo (standard)	1.99700E-04
14	26	7.86000	567	8.32790E-02	fe (carbstl-thin)	9.82526E-01
15	26	7.86000	573	8.60299E-04	mn (carbstl)	9.98502E-03
16	26	7.86000	579	9.84648E-04	c (carbstl)	2.49626E-03
17	27	2.69811	31	5.26831E-08	li-6 (standard)	1.95031E-07
18	27	2.69811	37	6.49759E-07	li-7 (standard)	2.80564E-06
19	27	2.69811	103	5.75053E-04	mg (standard)	8.60191E-03
20	27	2.69811	115	3.64559E-04	si (standard)	6.30140E-03
21	27	2.69811	157	1.42565E-05	ti (standard)	4.20093E-04
22	27	2.69811	163	4.78548E-06	v (standard)	1.50033E-04
23	27	2.69811	169	6.87642E-05	cr (standard)	2.20049E-03
24	27	2.69811	175	2.95824E-06	mn (standard)	1.00022E-04
25	27	2.69811	193	1.38464E-07	ni (standard)	5.00111E-06
26	27	2.69811	199	5.83176E-05	cu (standard)	2.30051E-03
27	27	2.69811	525	1.36780E-04	fe (alum-bulk)	4.70104E-03
28	27	2.69811	531	5.87274E-02	al (alum-bulk)	9.75217E-01
29	28	2.69811	31	5.26831E-08	li-6 (standard)	1.95031E-07
30	28	2.69811	37	6.49759E-07	li-7 (standard)	2.80564E-06
31	28	2.69811	103	5.75053E-04	mg (standard)	8.60191E-03
32	28	2.69811	115	3.64559E-04	si (standard)	6.30140E-03
33	28	2.69811	157	1.42565E-05	ti (standard)	4.20093E-04
34	28	2.69811	163	4.78548E-06	v (standard)	1.50033E-04
35	28	2.69811	169	6.87642E-05	cr (standard)	2.20049E-03
36	28	2.69811	175	2.95824E-06	mn (standard)	1.00022E-04
37	28	2.69811	193	1.38464E-07	ni (standard)	5.00111E-06
38	28	2.69811	199	5.83176E-05	cu (standard)	2.30051E-03
39	28	2.69811	525	1.36780E-04	fe (alum-bulk)	4.70104E-03
40	28	2.69811	531	5.87274E-02	al (alum-bulk)	9.75217E-01
41	29	2.58736	55	5.61973E-03	b-10 (std)	3.61133E-02
42	29	2.58736	67	2.26201E-02	b-11 (std; 1984)	1.59830E-01
43	29	2.58736	73	7.05996E-03	c (standard)	5.43720E-02
44	29	2.58736	109	4.32928E-02	al (standard)	7.49685E-01
45	30	11.34966	31	1.47723E-06	li-6 (standard)	1.30005E-06
46	30	11.34966	37	1.82192E-05	li-7 (standard)	1.87019E-05
47	30	11.34966	97	2.97335E-07	na (standard)	1.00010E-06
48	30	11.34966	121	1.10344E-06	p (standard)	5.00049E-06
49	30	11.34966	151	1.70547E-07	ca (standard)	1.00010E-06
50	30	11.34966	169	1.31464E-06	cr (standard)	1.00010E-05
51	30	11.34966	175	6.22118E-07	mn (standard)	5.00049E-06
52	30	11.34966	181	1.22403E-07	fe (standard)	1.00010E-06
53	30	11.34966	193	3.49427E-06	ni (standard)	3.00029E-05
54	30	11.34966	199	8.53160E-05	cu (standard)	8.00078E-04
55	30	11.34966	247	1.72776E-06	sn (standard)	3.00029E-05
56	30	11.34966	355	3.29557E-02	pb (standard)	9.99097E-01

Table M.2 (cont)

Mixing Table Entry	Mixture Number	Density of Mix (g/cc)	VELM Nuc ID Number	Atom Density atoms/barn*cm	Brief Description of nuclide and x-sect weighting	Weight Fraction of the nuclide in the mixture
57	31	11.34966	31	1.47723E-06	li-6 (standard)	1.30005E-06
58	31	11.34966	37	1.82192E-05	li-7 (standard)	1.87019E-05
59	31	11.34966	97	2.97335E-07	na (standard)	1.00010E-06
60	31	11.34966	121	1.10344E-06	p (standard)	5.00049E-06
61	31	11.34966	151	1.70547E-07	ca (standard)	1.00010E-06
62	31	11.34966	169	1.31464E-06	cr (standard)	1.00010E-05
63	31	11.34966	175	6.22118E-07	mn (standard)	5.00049E-06
64	31	11.34966	181	1.22403E-07	fe (standard)	1.00010E-06
65	31	11.34966	193	3.49427E-06	ni (standard)	3.00029E-05
66	31	11.34966	199	8.53160E-05	cu (standard)	8.00078E-04
67	31	11.34966	247	1.72776E-06	sn (standard)	3.00029E-05
68	31	11.34966	355	3.29557E-02	pb (standard)	9.99097E-01
69	32	7.19956	7	9.39315E-07	h (std; 1985)	2.18338E-07
70	32	7.19956	31	1.20466E-08	li-6 (standard)	1.67128E-08
71	32	7.19956	37	1.48575E-07	li-7 (standard)	2.40424E-07
72	32	7.19956	79	1.55333E-05	n (standard)	5.01692E-05
73	32	7.19956	85	2.98360E-02	o (standard)	1.10073E-01
74	32	7.19956	97	5.28503E-03	na (standard)	2.80234E-02
75	32	7.19956	103	2.32405E-08	mg (standard)	1.30283E-07
76	32	7.19956	109	6.76805E-03	al (standard)	4.21190E-02
77	32	7.19956	115	1.81938E-07	si (standard)	1.17854E-06
78	32	7.19956	157	2.54195E-07	ti (standard)	2.80708E-06
79	32	7.19956	163	1.61220E-07	v (standard)	1.89424E-06
80	32	7.19956	175	3.78804E-08	mn (standard)	4.79988E-07
81	32	7.19956	181	1.96309E-05	fe (standard)	2.52851E-04
82	32	7.19956	193	3.57773E-05	ni (standard)	4.84274E-04
83	32	7.19956	199	2.16196E-07	cu (standard)	3.19615E-06
84	32	7.19956	385	8.20477E-07	u-234 (std)	4.42895E-05
85	32	7.19956	711	1.07408E-04	u-235c radial blanket	5.82277E-03
86	32	7.19956	747	1.48095E-02	u-238c radial blanket	8.13121E-01
87	33	1.15000	73	3.32281E-02	c (standard)	5.75756E-01
88	33	1.15000	85	1.12505E-02	o (standard)	2.59848E-01
89	33	1.15000	585	6.13141E-02	h (paraffin)	8.92249E-02
90	33	1.15000	591	5.62527E-04	li-6 (paraffin)	4.88582E-03
91	33	1.15000	597	6.93783E-03	li-7 (paraffin)	7.02853E-02
92	34	2.39000	7	5.99823E-03	h (std; 1985)	4.20000E-03
93	34	2.39000	73	1.24259E-02	c (standard)	1.03600E-01
94	34	2.39000	85	4.41179E-02	o (standard)	4.90300E-01
95	34	2.39000	97	1.87819E-05	na (standard)	3.00000E-04
96	34	2.39000	103	1.36201E-04	mg (standard)	2.30000E-03
97	34	2.39000	109	8.53488E-05	al (standard)	1.60000E-03
98	34	2.39000	115	3.99727E-04	si (standard)	7.80000E-03
99	34	2.39000	121	1.85870E-05	p (standard)	4.00000E-04
100	34	2.39000	127	7.63106E-05	s (standard)	1.70000E-03
101	34	2.39000	145	1.47235E-05	k (standard)	4.00000E-04
102	34	2.39000	151	1.36638E-02	ca (standard)	3.80500E-01
103	34	2.39000	157	4.80977E-05	ti (standard)	1.60000E-03
104	34	2.39000	169	4.42895E-05	cr (standard)	1.60000E-03
105	34	2.39000	181	9.53604E-05	fe (standard)	3.70000E-03

Table M.2 (cont)

Mixing Table Entry	Mixture Number	Density of Mix (g/cc)	VELM Nuc ID Number	Atom Density atoms/barn*cm	Brief Description of nuclide and x-sect weighting	Weight Fraction of the nuclide in the mixture
106	35	2.39000	7	5.99823E-03	h (std; 1985)	4.20000E-03
107	35	2.39000	73	1.24259E-02	c (standard)	1.03600E-01
108	35	2.39000	85	4.41179E-02	o (standard)	4.90300E-01
109	35	2.39000	97	1.87819E-05	na (standard)	3.00000E-04
110	35	2.39000	103	1.36201E-04	mg (standard)	2.30000E-03
111	35	2.39000	109	8.53488E-05	al (standard)	1.60000E-03
112	35	2.39000	115	3.99727E-04	si (standard)	7.80000E-03
113	35	2.39000	121	1.85870E-05	p (standard)	4.00000E-04
114	35	2.39000	127	7.63106E-05	s (standard)	1.70000E-03
115	35	2.39000	145	1.47235E-05	k (standard)	4.00000E-04
116	35	2.39000	151	1.36638E-02	ca (standard)	3.80500E-01
117	35	2.39000	157	4.80977E-05	ti (standard)	1.60000E-03
118	35	2.39000	169	4.42895E-05	cr (standard)	1.60000E-03
119	35	2.39000	181	9.53604E-05	fe (standard)	3.70000E-03
120	36	2.40000	7	6.42515E-03	h (std; 1985)	4.48018E-03
121	36	2.40000	73	1.01040E-02	c (standard)	8.38906E-02
122	36	2.40000	85	4.47979E-02	o (standard)	4.95783E-01
123	36	2.40000	103	2.17829E-03	mg (standard)	3.66311E-02
124	36	2.40000	109	6.24306E-04	al (standard)	1.16548E-02
125	36	2.40000	115	4.35821E-03	si (standard)	8.46887E-02
126	36	2.40000	121	7.13460E-06	p (standard)	1.52900E-04
127	36	2.40000	127	5.78257E-05	s (standard)	1.28284E-03
128	36	2.40000	145	1.10983E-04	k (standard)	3.00255E-03
129	36	2.40000	151	9.88896E-03	ca (standard)	2.74233E-01
130	36	2.40000	181	1.08711E-04	fe (standard)	4.20043E-03
131	37	2.40000	7	6.42515E-03	h (std; 1985)	4.48018E-03
132	37	2.40000	73	1.01040E-02	c (standard)	8.38906E-02
133	37	2.40000	85	4.47979E-02	o (standard)	4.95783E-01
134	37	2.40000	103	2.17829E-03	mg (standard)	3.66311E-02
135	37	2.40000	109	6.24306E-04	al (standard)	1.16548E-02
136	37	2.40000	115	4.35821E-03	si (standard)	8.46887E-02
137	37	2.40000	121	7.13460E-06	p (standard)	1.52900E-04
138	37	2.40000	127	5.78257E-05	s (standard)	1.28284E-03
139	37	2.40000	145	1.10983E-04	k (standard)	3.00255E-03
140	37	2.40000	151	9.88896E-03	ca (standard)	2.74233E-01
141	37	2.40000	181	1.08711E-04	fe (standard)	4.20043E-03
142	38	1.41000	55	1.22333E-02	b-10 (std)	1.44255E-01
143	38	1.41000	67	4.92404E-02	b-11 (std; 1984)	6.38445E-01
144	38	1.41000	73	1.38127E-02	c (standard)	1.95204E-01
145	38	1.41000	79	1.23190E-03	n (standard)	2.03159E-02
146	38	1.41000	97	3.69359E-08	na (standard)	1.00002E-06
147	38	1.41000	103	8.73416E-07	mg (standard)	2.50005E-05
148	38	1.41000	109	1.57354E-06	al (standard)	5.00010E-05
149	38	1.41000	115	1.51171E-06	si (standard)	5.00010E-05
150	38	1.41000	121	5.48289E-08	p (standard)	2.00004E-06
151	38	1.41000	127	1.32415E-07	s (standard)	5.00010E-06
152	38	1.41000	133	2.39514E-07	cl (standard)	1.00002E-05
153	38	1.41000	151	1.69487E-05	ca (standard)	8.00016E-04
154	38	1.41000	157	3.99040E-06	ti (standard)	2.25005E-04
155	38	1.41000	169	3.26619E-08	cr (standard)	2.00004E-06
156	38	1.41000	175	1.54563E-07	mn (standard)	1.00002E-05
157	38	1.41000	181	9.12321E-06	fe (standard)	6.00012E-04

Table M.2 (cont)

Mixing Table Entry	Mixture Number	Density of Mix (g/cc)	VELM Nuc ID Number	Atom Density atoms/barn*cm	Brief Description of nuclide and x-sect weighting	Weight Fraction of the nuclide in the mixture
158	39	7.92000	73	2.18604E-04	c (standard)	5.50000E-04
159	39	7.92000	85	5.06909E-05	o (standard)	1.70000E-04
160	39	7.92000	115	8.32133E-04	si (standard)	4.90000E-03
161	39	7.92000	121	3.54164E-05	p (standard)	2.30000E-04
162	39	7.92000	127	2.67754E-05	s (standard)	1.80000E-04
163	39	7.92000	187	6.71729E-05	co (standard)	8.30000E-04
164	39	7.92000	199	1.59985E-04	cu (standard)	2.15000E-03
165	39	7.92000	235	1.23787E-04	mo (standard)	2.49000E-03
166	39	7.92000	501	5.94860E-02	fe (ssclad)	6.96500E-01
167	39	7.92000	507	1.70158E-02	cr (ssclad)	1.85500E-01
168	39	7.92000	513	7.55820E-03	ni (ssclad)	9.30000E-02
169	39	7.92000	519	1.17202E-03	mn (ssclad)	1.35000E-02
170	40	7.92000	73	2.18604E-04	c (standard)	5.50000E-04
171	40	7.92000	85	5.06909E-05	o (standard)	1.70000E-04
172	40	7.92000	115	8.32133E-04	si (standard)	4.90000E-03
173	40	7.92000	121	3.54164E-05	p (standard)	2.30000E-04
174	40	7.92000	127	2.67754E-05	s (standard)	1.80000E-04
175	40	7.92000	187	6.71729E-05	co (standard)	8.30000E-04
176	40	7.92000	199	1.59985E-04	cu (standard)	2.15000E-03
177	40	7.92000	235	1.23787E-04	mo (standard)	2.49000E-03
178	40	7.92000	501	5.94860E-02	fe (ssclad)	6.96500E-01
179	40	7.92000	507	1.70158E-02	cr (ssclad)	1.85500E-01
180	40	7.92000	513	7.55820E-03	ni (ssclad)	9.30000E-02
181	40	7.92000	519	1.17202E-03	mn (ssclad)	1.35000E-02
182	41	.94491	555	4.11765E-05	ca (sodium)	2.90029E-03
183	41	.94491	633	2.46802E-02	na (sodium-76cm)	9.97100E-01
184	42	.94491	555	4.11765E-05	ca (sodium)	2.90029E-03
185	42	.94491	633	2.46802E-02	na (sodium-76cm)	9.97100E-01
186	43	.94491	555	4.11765E-05	ca (sodium)	2.90029E-03
187	43	.94491	633	2.46802E-02	na (sodium-76cm)	9.97100E-01
188	44	.94491	555	4.11765E-05	ca (sodium)	2.90029E-03
189	44	.94491	639	2.46802E-02	na (sodium-228cm)	9.97100E-01
190	45	.94491	555	4.11765E-05	ca (sodium)	2.90029E-03
191	45	.94491	639	2.46802E-02	na (sodium-228cm)	9.97100E-01
192	46	.94491	555	4.11765E-05	ca (sodium)	2.90029E-03
193	46	.94491	645	2.46802E-02	na (sodium-381cm)	9.97100E-01
194	47	7.92000	73	2.18604E-04	c (standard)	5.50000E-04
195	47	7.92000	85	5.06909E-05	o (standard)	1.70000E-04
196	47	7.92000	115	8.32133E-04	si (standard)	4.90000E-03
197	47	7.92000	121	3.54164E-05	p (standard)	2.30000E-04
198	47	7.92000	127	2.67754E-05	s (standard)	1.80000E-04
199	47	7.92000	187	6.71729E-05	co (standard)	8.30000E-04
200	47	7.92000	199	1.59985E-04	cu (standard)	2.15000E-03
201	47	7.92000	603	5.94860E-02	fe (ss-4cm-na)	6.96500E-01
202	47	7.92000	609	1.70158E-02	cr (ss-4cm-na)	1.85500E-01
203	47	7.92000	615	7.55820E-03	ni (ss-4cm-na)	9.30000E-02
204	47	7.92000	621	1.17202E-03	mn (ss-4cm-na)	1.35000E-02
205	47	7.92000	627	1.23787E-04	mo (ss-4cm-na)	2.49000E-03

Table M.2 (cont)

Mixing Table Entry	Mixture Number	Density of Mix (g/cc)	VELM Nuc ID Number	Atom Density atoms/barn*cm	Brief Description of nuclide and x-sect weighting	Weight Fraction of the nuclide in the mixture
206	48	7.97971	73	3.01091E-05	c (standard)	7.51868E-05
207	48	7.97971	85	3.07490E-02	o (standard)	1.02350E-01
208	48	7.97971	115	1.14613E-04	si (standard)	6.69846E-04
209	48	7.97971	121	4.87805E-06	p (standard)	3.14418E-05
210	48	7.97971	127	3.68788E-06	s (standard)	2.46066E-05
211	48	7.97971	187	9.25199E-06	co (standard)	1.13464E-04
212	48	7.97971	199	2.20354E-05	cu (standard)	2.93912E-04
213	48	7.97971	235	1.70497E-05	mo (standard)	3.40391E-04
214	48	7.97971	501	8.19325E-03	fe (ssclad)	9.52139E-02
215	48	7.97971	507	2.34365E-03	cr (ssclad)	2.53585E-02
216	48	7.97971	513	1.04102E-03	ni (ssclad)	1.27134E-02
217	48	7.97971	519	1.61428E-04	mn (ssclad)	1.84550E-03
218	48	7.97971	717	7.48343E-04	u-235d 230 pin ivfs	3.66026E-02
219	48	7.97971	753	1.46227E-02	u-238d 230 pin ivfs	7.24367E-01
220	49	3.77906	73	3.00947E-05	c (standard)	1.58686E-04
221	49	3.77906	85	4.76536E-02	o (standard)	3.34932E-01
222	49	3.77906	109	3.17644E-02	al (standard)	3.76598E-01
223	49	3.77906	115	1.14558E-04	si (standard)	1.41374E-03
224	49	3.77906	121	4.87571E-06	p (standard)	6.63594E-05
225	49	3.77906	127	3.68612E-06	s (standard)	5.19335E-05
226	49	3.77906	187	9.24755E-06	co (standard)	2.39471E-04
227	49	3.77906	199	2.20248E-05	cu (standard)	6.20316E-04
228	49	3.77906	235	1.70415E-05	mo (standard)	7.18413E-04
229	49	3.77906	501	8.18932E-03	fe (ssclad)	2.00954E-01
230	49	3.77906	507	2.34253E-03	cr (ssclad)	5.35203E-02
231	49	3.77906	513	1.04052E-03	ni (ssclad)	2.68323E-02
232	49	3.77906	519	1.61350E-04	mn (ssclad)	3.89501E-03
233	50	1.87809	73	5.18381E-05	c (standard)	5.50000E-04
234	50	1.87809	85	1.20205E-05	o (standard)	1.70000E-04
235	50	1.87809	115	1.97326E-04	si (standard)	4.90000E-03
236	50	1.87809	121	8.39841E-06	p (standard)	2.30000E-04
237	50	1.87809	127	6.34933E-06	s (standard)	1.80000E-04
238	50	1.87809	187	1.59289E-05	co (standard)	8.30000E-04
239	50	1.87809	199	3.79377E-05	cu (standard)	2.15000E-03
240	50	1.87809	235	2.93540E-05	mo (standard)	2.49000E-03
241	50	1.87809	501	1.41061E-02	fe (ssclad)	6.96500E-01
242	50	1.87809	507	4.03501E-03	cr (ssclad)	1.85500E-01
243	50	1.87809	513	1.79230E-03	ni (ssclad)	9.30000E-02
244	50	1.87809	519	2.77926E-04	mn (ssclad)	1.35000E-02
245	51	3.90145	73	1.07686E-04	c (standard)	5.50000E-04
246	51	3.90145	85	2.49707E-05	o (standard)	1.70000E-04
247	51	3.90145	115	4.09915E-04	si (standard)	4.90000E-03
248	51	3.90145	121	1.74464E-05	p (standard)	2.30000E-04
249	51	3.90145	127	1.31898E-05	s (standard)	1.80000E-04
250	51	3.90145	187	3.30898E-05	co (standard)	8.30000E-04
251	51	3.90145	199	7.88097E-05	cu (standard)	2.15000E-03
252	51	3.90145	235	6.09783E-05	mo (standard)	2.49000E-03
253	51	3.90145	501	2.93032E-02	fe (ssclad)	6.96500E-01
254	51	3.90145	507	8.38210E-03	cr (ssclad)	1.85500E-01
255	51	3.90145	513	3.72322E-03	ni (ssclad)	9.30000E-02
256	51	3.90145	519	5.77348E-04	mn (ssclad)	1.35000E-02

Table M.2 (cont)

Mixing Table Entry	Mixture Number	Density of Mix (g/cc)	VELM Nuc ID Number	Atom Density atoms/barn*cm	Brief Description of nuclide and x-sect weighting	Weight Fraction of the nuclide in the mixture
257	52	8.06067	73	3.04145E-05	c (standard)	7.51867E-05
258	52	8.06067	85	3.10610E-02	o (standard)	1.02350E-01
259	52	8.06067	115	1.15776E-04	si (standard)	6.69845E-04
260	52	8.06067	121	4.92753E-06	p (standard)	3.14417E-05
261	52	8.06067	127	3.72529E-06	s (standard)	2.46065E-05
262	52	8.06067	187	9.34583E-06	co (standard)	1.13464E-04
263	52	8.06067	199	2.22589E-05	cu (standard)	2.93912E-04
264	52	8.06067	235	1.72226E-05	mo (standard)	3.40391E-04
265	52	8.06067	501	8.27635E-03	fe (ssclad)	9.52137E-02
266	52	8.06067	507	2.36743E-03	cr (ssclad)	2.53584E-02
267	52	8.06067	513	1.05158E-03	ni (ssclad)	1.27134E-02
268	52	8.06067	519	1.63065E-04	mn (ssclad)	1.84549E-03
269	52	8.06067	723	7.55935E-04	u-235e 306 pin ivfs	3.66027E-02
270	52	8.06067	759	1.47710E-02	u-238e 306 pin ivfs	7.24367E-01
271	53	3.81740	73	3.04001E-05	c (standard)	1.58686E-04
272	53	3.81740	85	4.81370E-02	o (standard)	3.34932E-01
273	53	3.81740	109	3.20866E-02	al (standard)	3.76597E-01
274	53	3.81740	115	1.15721E-04	si (standard)	1.41375E-03
275	53	3.81740	121	4.92519E-06	p (standard)	6.63596E-05
276	53	3.81740	127	3.72352E-06	s (standard)	5.19336E-05
277	53	3.81740	187	9.34139E-06	co (standard)	2.39472E-04
278	53	3.81740	199	2.22483E-05	cu (standard)	6.20318E-04
279	53	3.81740	235	1.72144E-05	mo (standard)	7.18415E-04
280	53	3.81740	501	8.27243E-03	fe (ssclad)	2.00954E-01
281	53	3.81740	507	2.36630E-03	cr (ssclad)	5.35204E-02
282	53	3.81740	513	1.05108E-03	ni (ssclad)	2.68324E-02
283	53	3.81740	519	1.62988E-04	mn (ssclad)	3.89502E-03
284	54	1.89715	73	5.23641E-05	c (standard)	5.50000E-04
285	54	1.89715	85	1.21424E-05	o (standard)	1.70000E-04
286	54	1.89715	115	1.99328E-04	si (standard)	4.90000E-03
287	54	1.89715	121	8.48362E-06	p (standard)	2.30000E-04
288	54	1.89715	127	6.41375E-06	s (standard)	1.80000E-04
289	54	1.89715	187	1.60905E-05	co (standard)	8.30000E-04
290	54	1.89715	199	3.83226E-05	cu (standard)	2.15000E-03
291	54	1.89715	235	2.96518E-05	mo (standard)	2.49000E-03
292	54	1.89715	501	1.42492E-02	fe (ssclad)	6.96500E-01
293	54	1.89715	507	4.07595E-03	cr (ssclad)	1.85500E-01
294	54	1.89715	513	1.81048E-03	ni (ssclad)	9.30000E-02
295	54	1.89715	519	2.80746E-04	mn (ssclad)	1.35000E-02
296	55	3.94103	73	1.08778E-04	c (standard)	5.50000E-04
297	55	3.94103	85	2.52240E-05	o (standard)	1.70000E-04
298	55	3.94103	115	4.14074E-04	si (standard)	4.90000E-03
299	55	3.94103	121	1.76234E-05	p (standard)	2.30000E-04
300	55	3.94103	127	1.33236E-05	s (standard)	1.80000E-04
301	55	3.94103	187	3.34256E-05	co (standard)	8.30000E-04
302	55	3.94103	199	7.96093E-05	cu (standard)	2.15000E-03
303	55	3.94103	235	6.15970E-05	mo (standard)	2.49000E-03
304	55	3.94103	501	2.96005E-02	fe (ssclad)	6.96500E-01
305	55	3.94103	507	8.46715E-03	cr (ssclad)	1.85500E-01
306	55	3.94103	513	3.76100E-03	ni (ssclad)	9.30000E-02
307	55	3.94103	519	5.83205E-04	mn (ssclad)	1.35000E-02

Table M.2 (cont)

Mixing Table Entry	Mixture Number	Density of Mix (g/cc)	VELM Nuc ID Number	Atom Density atoms/barn*cm	Brief Description of nuclide and x-sect weighting	Weight Fraction of the nuclide in the mixture
308	56	3.92584	73	1.08359E-04	c (standard)	5.50000E-04
309	56	3.92584	85	2.51268E-05	o (standard)	1.70000E-04
310	56	3.92584	115	4.12478E-04	si (standard)	4.90000E-03
311	56	3.92584	121	1.75555E-05	p (standard)	2.30000E-04
312	56	3.92584	127	1.32722E-05	s (standard)	1.80000E-04
313	56	3.92584	187	3.32967E-05	co (standard)	8.30000E-04
314	56	3.92584	199	7.93025E-05	cu (standard)	2.15000E-03
315	56	3.92584	235	6.13595E-05	mo (standard)	2.49000E-03
316	56	3.92584	501	2.94865E-02	fe (ssclad)	6.96500E-01
317	56	3.92584	507	8.43451E-03	cr (ssclad)	1.85500E-01
318	56	3.92584	513	3.74650E-03	ni (ssclad)	9.30000E-02
319	56	3.92584	519	5.80957E-04	mn (ssclad)	1.35000E-02
320	57	1.96094	73	5.41247E-05	c (standard)	5.50000E-04
321	57	1.96094	85	1.25507E-05	o (standard)	1.70000E-04
322	57	1.96094	115	2.06030E-04	si (standard)	4.90000E-03
323	57	1.96094	121	8.76886E-06	p (standard)	2.30000E-04
324	57	1.96094	127	6.62940E-06	s (standard)	1.80000E-04
325	57	1.96094	187	1.66315E-05	co (standard)	8.30000E-04
326	57	1.96094	199	3.96112E-05	cu (standard)	2.15000E-03
327	57	1.96094	235	3.06488E-05	mo (standard)	2.49000E-03
328	57	1.96094	501	1.47283E-02	fe (ssclad)	6.96500E-01
329	57	1.96094	507	4.21299E-03	cr (ssclad)	1.85500E-01
330	57	1.96094	513	1.87136E-03	ni (ssclad)	9.30000E-02
331	57	1.96094	519	2.90185E-04	mn (ssclad)	1.35000E-02
332	58	3.94845	73	3.14437E-05	c (standard)	1.58686E-04
333	58	3.94845	85	4.97896E-02	o (standard)	3.34932E-01
334	58	3.94845	109	3.31882E-02	al (standard)	3.76597E-01
335	58	3.94845	115	1.19693E-04	si (standard)	1.41375E-03
336	58	3.94845	121	5.09427E-06	p (standard)	6.63595E-05
337	58	3.94845	127	3.85135E-06	s (standard)	5.19335E-05
338	58	3.94845	187	9.66208E-06	co (standard)	2.39471E-04
339	58	3.94845	199	2.30121E-05	cu (standard)	6.20317E-04
340	58	3.94845	235	1.78054E-05	mo (standard)	7.18414E-04
341	58	3.94845	501	8.55641E-03	fe (ssclad)	2.00954E-01
342	58	3.94845	507	2.44754E-03	cr (ssclad)	5.35204E-02
343	58	3.94845	513	1.08716E-03	ni (ssclad)	2.68323E-02
344	58	3.94845	519	1.68583E-04	mn (ssclad)	3.89502E-03
345	59	8.33342	73	3.14437E-05	c (standard)	7.51868E-05
346	59	8.33342	85	3.21120E-02	o (standard)	1.02350E-01
347	59	8.33342	115	1.19693E-04	si (standard)	6.69846E-04
348	59	8.33342	121	5.09427E-06	p (standard)	3.14417E-05
349	59	8.33342	127	3.85135E-06	s (standard)	2.46066E-05
350	59	8.33342	187	9.66208E-06	co (standard)	1.13464E-04
351	59	8.33342	199	2.30121E-05	cu (standard)	2.93912E-04
352	59	8.33342	235	1.78054E-05	mo (standard)	3.40391E-04
353	59	8.33342	501	8.55641E-03	fe (ssclad)	9.52138E-02
354	59	8.33342	507	2.44754E-03	cr (ssclad)	2.53585E-02
355	59	8.33342	513	1.08716E-03	ni (ssclad)	1.27134E-02
356	59	8.33342	519	1.68583E-04	mn (ssclad)	1.84549E-03
357	59	8.33342	729	7.81514E-04	u-235f tort 3-D ivfs	3.66026E-02
358	59	8.33342	765	1.52708E-02	u-238f tort 3-D ivfs	7.24367E-01

Table M.2 (cont)

Mixing Table Entry	Mixture Number	Density of Mix (g/cc)	VELM Nuc ID Number	Atom Density atoms/barn*cm	Brief Description of nuclide and x-sect weighting	Weight Fraction of the nuclide in the mixture
359	60	3.94845	73	3.14437E-05	c (standard)	1.58686E-04
360	60	3.94845	85	4.97896E-02	o (standard)	3.34932E-01
361	60	3.94845	109	3.31882E-02	al (standard)	3.76597E-01
362	60	3.94845	115	1.19693E-04	si (standard)	1.41375E-03
363	60	3.94845	121	5.09427E-06	p (standard)	6.63595E-05
364	60	3.94845	127	3.85135E-06	s (standard)	5.19335E-05
365	60	3.94845	187	9.66208E-06	co (standard)	2.39471E-04
366	60	3.94845	199	2.30121E-05	cu (standard)	6.20317E-04
367	60	3.94845	235	1.78054E-05	mo (standard)	7.18414E-04
368	60	3.94845	501	8.55641E-03	fe (ssclad)	2.00954E-01
369	60	3.94845	507	2.44754E-03	cr (ssclad)	5.35204E-02
370	60	3.94845	513	1.08716E-03	ni (ssclad)	2.68323E-02
371	60	3.94845	519	1.68583E-04	mn (ssclad)	3.89502E-03
372	61	4.31843	73	1.19195E-04	c (standard)	5.50000E-04
373	61	4.31843	85	2.76395E-05	o (standard)	1.70000E-04
374	61	4.31843	115	4.53726E-04	si (standard)	4.90000E-03
375	61	4.31843	121	1.93110E-05	p (standard)	2.30000E-04
376	61	4.31843	127	1.45995E-05	s (standard)	1.80000E-04
377	61	4.31843	187	3.66264E-05	co (standard)	8.30000E-04
378	61	4.31843	199	8.72328E-05	cu (standard)	2.15000E-03
379	61	4.31843	235	6.74955E-05	mo (standard)	2.49000E-03
380	61	4.31843	501	3.24351E-02	fe (ssclad)	6.96500E-01
381	61	4.31843	507	9.27797E-03	cr (ssclad)	1.85500E-01
382	61	4.31843	513	4.12115E-03	ni (ssclad)	9.30000E-02
383	61	4.31843	519	6.39054E-04	mn (ssclad)	1.35000E-02
384	62	.00000	25	1.00000E-20	he (standard)	1.00000E+00
385	63	.92000	97	2.40995E-02	na (standard)	1.00000E+00
386	64	7.86000	115	4.20710E-04	si (standard)	2.49626E-03
387	64	7.86000	169	1.36347E-04	cr (standard)	1.49775E-03
388	64	7.86000	193	4.02672E-05	ni (standard)	4.99251E-04
389	64	7.86000	199	2.21212E-05	cu (standard)	2.99551E-04
390	64	7.86000	235	9.85262E-06	mo (standard)	1.99700E-04
391	64	7.86000	567	8.32790E-02	fe (carbstdl-thin)	9.82526E-01
392	64	7.86000	573	8.60299E-04	mn (carbstdl)	9.98502E-03
393	64	7.86000	579	9.84648E-04	c (carbstdl)	2.49626E-03
394	65	4.71600	115	2.52426E-04	si (standard)	2.49626E-03
395	65	4.71600	169	8.18083E-05	cr (standard)	1.49775E-03
396	65	4.71600	193	2.41603E-05	ni (standard)	4.99251E-04
397	65	4.71600	199	1.32727E-05	cu (standard)	2.99551E-04
398	65	4.71600	235	5.91157E-06	mo (standard)	1.99700E-04
399	65	4.71600	567	4.99674E-02	fe (carbstdl-thin)	9.82526E-01
400	65	4.71600	573	5.16179E-04	mn (carbstdl)	9.98502E-03
401	65	4.71600	579	5.90789E-04	c (carbstdl)	2.49626E-03
402	66	.00000	1000	1.00000E+00	resp functs 1-68	1.00000E+00
403	67	.53663	241	2.87448E-03	cd (standard)	1.00000E+00

3.0 GEOMETRIC MODELS AND CALCULATIONAL RESULTS

The original detailed descriptions of the various components used in the JASPER IVFS experiments, and the placement of those components in the various shielding configurations, are given in ORNL/TM-11989 and will not be repeated here. While a few (very minor) inconsistencies have since been noted, that report is quite good and should be regarded as the basic reference document. Inevitably, however, one must make some approximations when developing calculational models. Large rectangular blocks of shielding materials may have to be approximated as cylindrical slabs in a 2-D RZ DORT calculation, and arrays of fuel pins will frequently have to be homogenized (even in 3-D XYZ models), with one homogenized material representing the active fuel zone, and perhaps another representing the homogenized materials in the fission gap plenum directly above the active fuel zone, etc.

The purpose of this section is to document, as precisely as possible, the analytic models finally used for each variation of each shielding configuration, and to show the key results (including the raw multigroup fluxes) at key points of interest so that these results might be used for comparison purposes in other high-order benchmark analyses that might be performed, or as reference values against which the results of more approximate lower-order sensitivity studies might be judged. Moreover, the purpose of this section is to present the basic models and the basic results as concisely as possible with little or no comment. Extensive comparisons of the calculated results against the experimentally measured results will be reserved for Sect. 4.

To keep this presentation as concise and as organized as possible, each variation of each shielding configuration will generally be described by

- (a) one figure (Fig. G.n) illustrating the actual geometric model used in the analysis,
- (b) one table (Table G.n) showing the axial mesh distribution and the radial bounds for each material mixture at each axial level, and
- (c) one table (Table R.n) showing the calculated Bonner ball and fission chamber responses, as well as the actual multigroup fluxes, at several points of interest (including, as a minimum, those points for which experimentally measured values were previously reported in ORNL/TM-11989).

Because of their sheer number, most of the figures and tables in this section are grouped together at the end of this section. To facilitate the use of this data in the future, all of the figures and tables (Fig. G.1, and Tables G.1 and R.1) corresponding to the first configuration are grouped together, followed by all the figures and tables (Fig. G.2, and Tables G.2 and R.2) for the second configuration, etc. Any additional comments and/or exceptions to this pattern are noted in the text below.

3.1 OVERVIEW

Figure 3.1 shows an overview of the JASPER IVFS experiments related to the US LMR Program. [Note that this limited subset of the IVFS experiments reported in ORNL/TM-11989 does not include those experiments specifically tailored for the Japanese LMR program.] For each of these basic configurations, several calculated and/or experimental variations were generally studied. As noted in Sect. 2.6.2, for example, one set of calculations was performed for each of the basic configurations as originally reported, while a second set was performed with an extended (artificial) concrete ring appended to the end of each model to simulate thermal neutron background radiation. In addition to the basic measurements for Configs. IA and IC, the NE213 and hydrogen-filled spectrometer measurements were also made behind Pb slabs (cf. Configs. IA/PB and IC/PB). Here the Pb slabs were necessary to reduce the overwhelming spurious noise that would be caused by the gamma radiation if the Pb slabs were not present. Likewise, in addition to the basic experimental measurements behind Configs. IC, IIIA, IIIB, IIIC, IIID, IIIE, and IIIF, experimental measurements using the bare and Cd-covered fission chambers were also made behind variations of these experiments which, in the first case, included a cadmium sheet (or "plate") over the face of the configuration [between the end of the shield and the detector(s)], and which, in the second case, included measurements inside a large (5-ft x 5-ft x 1.5-ft deep) 5-sided cadmium box (or "hut") whose one large open side directly faced the end of the original shield configuration. Altogether, 32 large 2-D RZ DORT calculations and 2 large 3-D XYZ TORT calculations were necessary to model these various experimental shielding configurations. For cross-reference purposes, the calculation ID numbers [Config.Run] associated with the different variations of each experiment are shown in Table 3.1, along with the CPU time required for each calculation on an IBM RS/6000 Model 530 workstation running in a dedicated mode (see comments below). The common set of radial mesh intervals used in all 32 of the 2-D RZ DORT analyses are listed in Table G.1b, at the end of this section, while the axial mesh distribution and the radial bounds for each material zone at each axial level are listed separately for each configuration (cf. Tables G.1 to G.34, below). Likewise, the common set of material mixture ID's (25 through 67) used in these various DORT and TORT models are discussed briefly in Sect. 2.3 and described more fully in Tables M.1 and M.2 at the very end of Sect. 2 (above).

OVERVIEW OF THE JASPER IVFS EXPERIMENTS RELATED TO THE U.S. LMR PROGRAM

CONFIG. IA

DETECTORS

1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IA/PB

DETECTORS

2 PB SLABS (7.62 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IB

DETECTORS

2 BLANKET ASSYS (22.10 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IC

DETECTORS

6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IC/PB

DETECTORS

2 PB SLABS (7.62 CM)
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIA

DETECTORS

HETEROG. (3-D) FUEL SLAB
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIB

DETECTORS

HOMOGENEOUS FUEL SLAB
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIC

DETECTORS

1 BLANKET ASSY (11.05 CM)
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIID

DETECTORS

1 B4C SLAB (6.90 CM)
HOMOGENEOUS FUEL SLAB
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIE

DETECTORS

HOMOGENEOUS FUEL SLAB
1 B4C SLAB (6.90 CM)
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

CONFIG. IIIF

DETECTORS

1 ALUMINUM SLAB (2.57 CM)
1 B4C SLAB (6.90 CM)
1 STEEL SLAB (2.68 CM)
1 LARGE VOID (34.58 CM)
HOMOGENEOUS FUEL SLAB
6 SODIUM TANKS (205 CM)
1 BORAL SLAB (2.54 CM)
3 ALUMINUM SLABS (9.12 CM)
2 IRON SLABS (10.27 CM)

SOURCE FROM TSR

Fig. 3.1. Overview of the JASPER In-Vessel Fuel Storage (IVFS) shielding experiments of direct interest to the US LMR program.

Table 3.1. Brief description of the different calculational models/runs for the experimental IVFS shielding configurations.

Config.Run	Basic description of configuration	Different calculational & experimental variations ...	CPU time
IA.2	Fe/AL/Boral	basic configuration	6.1 hrs
IA.14	Fe/AL/Boral	basic, with extended concrete ring	5.0 hrs
IA/PB.1	Fe/AL/Boral/Pb	basic configuration	8.0 hrs
IA/PB.15	Fe/AL/Boral/Pb	basic, with extended concrete ring	5.7 hrs
IB.1	Fe/AL/Boral/Radial-Blanket	basic configuration	23.9 hrs
IB.2	Fe/AL/Boral/Radial-Blanket	basic, with extended concrete ring	23.1 hrs
IC.2	Fe/AL/Boral/2m Na	basic configuration	15.8 hrs
IC.6	Fe/AL/Boral/2m Na	basic, with extended concrete ring	12.0 hrs
IC.7	Fe/AL/Boral/2m Na	basic, with extended concrete ring and Cd hut	8.8 hrs
IC.8	Fe/AL/Boral/2m Na	basic, with extended concrete ring and Cd plate	9.1 hrs
IC/PB.1	Fe/AL/Boral/2m Na/Pb	basic configuration	17.3 hrs
IC/PB.9	Fe/AL/Boral/2m Na/Pb	basic, with extended concrete ring	11.8 hrs
IIIA.1b	Fe/AL/Boral/2m Na/Het IVFS (3-D TORT)	basic configuration (3-D XYZ, theta weighted)	127.3 hrs
IIIA.1d	Fe/AL/Boral/2m Na/Het IVFS (3-D TORT)	basic configuration (3-D XYZ, nodal method)	315.7 hrs
IIIB.1	Fe/AL/Boral/2m Na/Homog IVFS	basic configuration	72.5 hrs
IIIB.2	Fe/AL/Boral/2m Na/Homog IVFS	basic, with extended concrete ring	60.8 hrs
IIIB.3	Fe/AL/Boral/2m Na/Homog IVFS	basic, with extended concrete ring and Cd hut	49.2 hrs
IIIB.4	Fe/AL/Boral/2m Na/Homog IVFS	basic, with extended concrete ring and Cd plate	50.3 hrs
IIIC.1	Fe/AL/Boral/2m Na/Radial-Blanket	basic configuration	58.6 hrs
IIIC.2	Fe/AL/Boral/2m Na/Radial-Blanket	basic, with extended concrete ring	89.4 hrs
IIIC.3	Fe/AL/Boral/2m Na/Radial-Blanket	basic, with extended concrete ring and Cd hut	58.9 hrs
IIIC.4	Fe/AL/Boral/2m Na/Radial-Blanket	basic, with extended concrete ring and Cd plate	43.2 hrs

Table 3.1 (cont)

IIID.1	Fe/AL/Boral/2m Na/Homog IVFS/B4C	basic configuration	63.6 hrs
IIID.2	Fe/AL/Boral/2m Na/Homog IVFS/B4C	basic, with extended concrete ring	58.8 hrs
IIID.3	Fe/AL/Boral/2m Na/Homog IVFS/B4C	basic, with extended concrete ring and Cd hut	48.5 hrs
IIID.4	Fe/AL/Boral/2m Na/Homog IVFS/B4C	basic, with extended concrete ring and Cd plate	43.1 hrs
IIIE.1	Fe/AL/Boral/2m Na/B4C/Homog IVFS	basic configuration	36.6 hrs
IIIE.2	Fe/AL/Boral/2m Na/B4C/Homog IVFS	basic, with extended concrete ring	55.3 hrs
IIIE.4	Fe/AL/Boral/2m Na/B4C/Homog IVFS	basic, with extended concrete ring and Cd hut	40.5 hrs
IIIE.5	Fe/AL/Boral/2m Na/B4C/Homog IVFS	basic, with extended concrete ring and Cd plate	47.4 hrs
IIIF.1	Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL	basic configuration	151.0 hrs
IIIF.2	Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL	basic, with extended concrete ring	20.2 hrs
IIIF.3	Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL	basic, with extended concrete ring and Cd hut	28.5 hrs
IIIF.4	Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL	basic, with extended concrete ring and Cd plate	32.9 hrs

Notes regarding calculational strategies and running times:

- (1) Both of the 3-D XYZ TORT analyses for Config. IIIA were "started from scratch" with a zero flux guess.
- (2) Of the large 2-D RZ DORT analyses for Configs. IIIB, IIIC, IIID, IIIE, and IIIF, only the analysis for Config. IIIF.1 was "started from scratch" with a zero flux guess. The final, highly converged, results for this run were then used as the initial flux guess for other variations of Config. IIIF.
- (3) The final, highly converged, results for Config. IIIF.2 were then used as the input flux guess for Configs. IIIB.2, IIIC.2, IIID.2, and IIIE.2. Those results, in turn, were then used as initial flux guesses for other variations of Configs. IIIB, IIIC, IIID, and IIIE.
- (4) Wall-clock turnaround times on a dedicated workstation with no other jobs running were typically about 25% longer than the actual CPU times shown here for these particular problems. (For smaller DORT problems where more of the data may be stored in memory, typical wall-clock times may only be 7 or 8% longer than the CPU time.)
- (5) These analyses were performed using Vers 1.5.15 of the DORT and TORT codes obtained from the Radiation Shielding Information Center at ORNL in January 1992. They were compiled using the -P (preprocessor) and -O (optimizer) switches on IBM's XLF Vers 2.2 Fortran compiler running under the AIX 3.1.5 operating system on an IBM RS/6000 Model 530 workstation with 32MB of memory. These DORT and TORT analyses were then performed on that same system.

3.2 CALCULATIONAL RESOURCES AND STRATEGIES

All of the DORT and TORT calculations were performed using the 61 group VELM cross-section library for LMR shielding analyses (cf. Sect. 2.2). All were performed using a standard, fully symmetric, S_{12} quadrature set and the first 3 scattering moments ($S_{12}P_3$). For DORT, this meant solving for the flux in 96 discrete directions and saving the first 10 spherical harmonic moments for the flux in each energy group, in each mesh interval. For TORT, this meant solving for the flux in 192 discrete directions and saving the first 16 spherical harmonic moments for each energy group in each mesh interval when using the theta-weighted difference scheme, plus the equivalent of 3 additional moments for each energy group in each mesh interval when using the nodal method. In the case of the larger DORT analyses, 3.9 MB of storage was needed to accommodate the (relatively small) boundary source at $Z=89.89$ or 91.30 cm, 196.9 MB of storage was needed to accommodate the full flux moment output file, and approximately 650 MB of disk space was needed altogether to perform each calculation. This included space for the boundary source, the cross-section file, the input flux moment flux guess (which was the same size as the flux moment output file), the final flux moment output file, and all the necessary internal scratch files. In the case of the TORT analysis, 210.5 MB of storage was needed just to accommodate the boundary source, while 213.6 MB of storage (or 253.7 MB in the case where we used the nodal method) was needed to accommodate the full flux moment output file, and approximately 1100 MB of disk space was needed altogether to perform each calculation. Again, this includes the boundary source, the cross-section file, the input flux moment flux guess (same size as the output file), the full flux moment output file, and all the necessary scratch files. At the end of each TORT analysis, and/or after every 3 DORT calculations, all of the necessary flux files had to be archived to tape in order to make space available for the next set of calculations. For future reference, the full flux moment files and the smaller scalar flux files were both saved for each calculation described in this report.

As noted above, Table 3.1 shows the amount of CPU time required for each calculation on an IBM RS/6000 Model 530 workstation running in a dedicated mode during the summer of 1992. The calculations for Configs. IA, IA/PB, IC, and IC/PB were relatively short because they involved no fissile material and therefore required no outer iterations over all the energy groups. (The discontinuity and apparent randomness in the suffix to the calculational run ID numbers in Table 3.1 is due to the fact that a number of other scoping calculations were also performed before we settled on the final models actually reported here.) The calculations for Configs. IB.1 and IB.2 took somewhat longer because several outer iterations were required to converge the internal volumetric fission source in the radial blanket assemblies. Both calculations were started from scratch — i.e., both included the

boundary source at $Z=89.89$ cm, and neither used an initial flux guess. While the large 2-D RZ DORT calculations described in Table 3.1 (cf. Configs. IIIB, IIIC, IIID, IIIE, and IIIF) all used the same number of mesh intervals (166 radially, 450 axially) and were all allowed to run for 10 or 11 outer iterations in order to ensure that the fluxes in all groups were fully converged, the average CPU time (2.3 days) varied considerably from one calculation to the next, depending on how good the initial flux guess was and how many inner (spatial) iterations were required for each energy group. [See footnotes regarding calculational strategies and running times at the bottom of Table 3.1.] Moreover, the calculational running times required for these analyses, should not be taken too seriously for several other reasons. First, the multigroup fluxes at the key points of interest were generally converged to 3 (and sometimes 4) places after 5, 6, 7, or 8 outer iterations. For most engineering design calculations, one would stop the analysis at this point. For benchmark analyses such as these, however, the goal was to converge the flux at all points to within 0.01%, and/or the flux at each key point of interest to within 4 or 5 places. Due to the flux in the last few energy groups, and especially the thermal flux in group 61, a total of 10 or 11 outer iterations were generally required to meet this stricter-than-average convergence test. Secondly, the running times for these configurations may be somewhat higher than one would expect in ordinary design analyses because each calculation included everything downstream of the boundary source at $Z=89.89$ cm (i.e., next to the downstream surface of the TSR collimator). Thus, each of these calculations included the iron, aluminum, and boral slabs, and the 6 sodium tanks shown in Fig. G.7b and described in Table G.7b, as well as the other components comprising the tail end of each particular experimental shielding configuration (cf. Figs. G.15 to G.34). Most of these calculations also included a number of additional mesh intervals extending out through the void at the end of the shield configuration to a point 150.4 cm past the end of the experimental test specimen in order to calculate the various detector responses at 150.0 cm (as well as to model the artificial concrete ring which is used in many of the models and which extends 83.11 cm past the end of the experimental test specimens). In most ordinary design analyses, these points downstream of the shield would not be included in the DORT model, and most of the spectral modifier (i.e., the iron, aluminum, and boral slabs, and the 6 sodium tanks) would be replaced with a boundary source located much closer to the experimental test specimen. Noting, however, that the mean free path of fast neutrons in sodium is approximately one foot, and that the boundary source should be located several mean free paths upstream of the experimental test specimen, there would have always been some question as to how much error would have been introduced by such an approximation. To avoid any unnecessary uncertainties in this "reference benchmark analysis," a decision was made very early in the program to avoid any such unnecessary approximations (however expedient) in the interest of rigor. Moreover, the results obtained by this more rigorous approach can then be used by designers and other analysts in the future to gauge how far

back through the sodium one must go to obtain an approximate boundary source that is generally applicable regardless of the shield configuration downstream of the sodium. To partially compensate for the loss of efficiency caused by explicitly keeping the entire spectral modifier in each calculational model, we intentionally used the same number of radial and axial mesh intervals in each problem (for Configs. IIIB, IIIC, IIID, IIIE, and IIIF) and used the highly converged flux moment output file from one model as the initial flux guess for the next model. Nevertheless, while the running times in Table 3.1 accurately represent the CPU time required for these extensive, detailed, and highly converged benchmark analyses, they may still be considerably larger than running times ordinarily encountered in day-to-day design analyses.

Lastly, the running times for the 3-D XYZ TORT analyses of Config. IIIA merit special discussion. Unlike the 2-D RZ DORT calculations where one could afford the luxury of modeling the whole spectral modifier, these 3-D calculations include only the last sodium tank, the heterogeneous IVFS fuel slab (and the surrounding lithiated paraffin and concrete), and the first 31.4 cm of void space downstream of the IVFS fuel slab (cf. Fig. G.13 and Figs. G.14a and G.14b). Moreover, out of necessity, a non-zero boundary flux was applied at the $Z=Z_{\min}$ surface (between the fifth and sixth sodium tanks), and a reflective boundary condition was applied at $X=0$ so that we only had to model half of the full geometry shown in Fig. G.13. In addition, to hold down the running time, the mesh intervals in the fuel (1.95 cm x 3.80 cm x 1.56 cm, typically) were 2 to 4 times larger in each direction than those in the 2-D RZ model, while those in the environmental concrete shield off to the side were up to 4 cm thick in the Z direction and measured anywhere from 4 cm x 4 cm, to 22 cm x 22 cm in the X and Y directions. Instead of resembling the very fine mesh models frequently used in benchmark analyses, the 3-D XYZ TORT analyses (out of necessity) used mesh sizes and boundary conditions that were much more representative of those that might actually be used in real 3-D design analyses. Still, with 30 mesh intervals in the X-direction, 57 in the Y-direction, and 32 in the Z-direction ($30 \times 57 \times 32 = 54720$ total), 192 discrete angular directions and 16 or 19 flux moments corresponding to P_3 scattering, 61 energy groups, and 11 outer iterations required to converge the internal volumetric fission source in the fuel, each of these "spatially very modest" models required 1100 MB of disk space and one to two weeks of CPU time to run on an IBM RS/6000 Model 530 workstation — i.e., 127.3 CPU hours (=5.3 CPU days) using the theta-weighted difference method, and 315.7 CPU hours (=13.1 CPU days) using the nodal method. Wall-clock turnaround times on a dedicated workstation with no other jobs running were about 25% longer — i.e., 6.6 and 16.4 days, respectively. While calculations of this magnitude can be (and have now been) done on relatively inexpensive desktop workstations costing less than \$50K, they clearly strain the limits of what is currently practical on such workstations as of August 1992. By way of comparison, it should be noted that

large production-type 3-D $S_{16}P_3$ 20-group TORT analyses involving over 1,200,000 spatial mesh intervals are currently being performed by ORNL and GE personnel on the massively parallel Cray YMP computer at the Knolls Atomic Power Laboratory in Schenectady, New York.

3.3 CONFIGURATIONS IA AND IA/PB

The geometric model for Config. IA.2 is illustrated in Fig. G.1 and is described further in Table G.1a. The distribution of radial mesh intervals used for this calculation, and in all of the other 2-D RZ DORT calculations in this report, is described in Table G.1b, while the calculated results for this particular configuration are described in Table R.1. Note that the materials referenced in the geometric model corresponding to Table G.1 (and all similar geometry tables in this report) are described in Tables M.1 and M.2 at the end of Sect. 2.

The geometric model for Config. IA.14 (with the extended artificial concrete ring to simulate thermal neutron background radiation) is illustrated in Fig. G.2 and is described further in Table G.2, while the corresponding calculated results are listed in Table R.2.

Likewise, Fig. G.3 and Tables G.3 and R.3 correspond to Config. IA/PB.1, while Fig. G.4 and Table G.4 and R.4 correspond to Config. IA/PB.15.

3.4 CONFIGURATION IB

These configurations employ the radial blanket mockup assemblies containing 522 natural UO_2 pins in each slab. The geometric model for Config. IB.1 is illustrated in Fig. G.5 and is described further in Table G.5, while the calculated results are listed in Table R.5. Likewise, Fig. G.6 and Tables G.6 and R.6 correspond to Config. IB.2 with the extended concrete ring to simulate thermal neutron background radiation.

3.5 CONFIGURATIONS IC AND IC/PB

The geometric model for Config. IC.2 is illustrated in Figs. G.7a and G.7b, and is described further in Tables G.7a and G.7b. Note that while Fig. G.7a shows the location of the detectors relative to the last sodium tank, the calculational model actually includes all 6 sodium tanks, as well as the other components and the boundary source shown in Fig. G.7b. [Moreover, this is also true for all of the remaining configurations described in this report except the 3-D XYZ TORT

models of Config. IIIA which are treated as noted in Sects. 2.1 and 3.2 above and Sect. 3.6 below.] The calculated results for Config. IC.2 are listed in Table R.7. Likewise:

Fig. G.8 and Tables G.8 and R.8 correspond to Config. IC.6 with the extended concrete ring; while

Fig. G.9 and Tables G.9 and R.9 correspond to Config. IC.7 with the Cd hut; and

Fig. G.10 and Tables G.10 and R.10 correspond to Config. IC.8 with the Cd plate.

Calculations were also performed for those cases with the Pb slabs downstream of the basic configuration. These slabs were necessary to facilitate spectral measurements made with the NE213 and hydrogen-filled spectrometers.

Fig. G.11 and Tables G.11 and R.11 correspond to Config. IC/PB.1 with the Pb slabs, while

Fig. G.12 and Tables G.12 and R.12 correspond to Config. IC/PB.9 with the Pb slabs and the extended concrete ring to model thermal neutron background radiation.

3.6 CONFIGURATION IIIA

While two separate 3-D XYZ TORT calculations were performed for Config. IIIA, both used the same geometric model. The first calculation, arbitrarily designated here as Config. IIIA.1b (where the 1b really refers to the calculational run ID), employed the commonly used and considerably faster theta-weighted numerical difference scheme, while the second calculation (designated here as Config. IIIA.1d) used the slower but sometimes more accurate nodal differencing scheme. Here the calculation using the nodal method was used to verify that the larger-than-average mesh intervals used in the first (theta-weighted) calculation were small enough to give accurate results. [The nodal method, while considerably slower, can generally be used to obtain good results with fairly coarse mesh intervals, while the faster theta-weighted difference scheme has been known to yield incorrect flux solutions if the mesh intervals are too coarse. In this case, we used the same size mesh intervals in both calculations in order to verify the acceptability of the mesh size in the theta-weighted difference calculation.] While the nodal method CPU time per inner (spatial) iteration on each energy group was about three times longer than that for the theta-weighted difference scheme, the overall CPU time was only about 2.5 times longer because the nodal method required somewhat fewer inner iterations per outer. Moreover, it was most interesting to note that, at the end of the first outer

iteration, the spatially-dependent multigroup flux solutions for the theta-weighted and nodal methods were considerably different and sometimes differed by as much as a factor of 20 at some key flux locations. By the time both calculations had fully converged, however, the flux solutions (as evidenced by the Bonner ball responses) were generally within 0.5 to 1.0% of each other along the centerline of the system, and differed only slightly at locations 60 to 80 cm away from the centerline (see Tables X.6, X.9, and X.10 in Sect. 4).

As noted above, the geometric models used for the two calculations (IIIA.1b and IIIB.1d) were exactly the same and included just the last of the six sodium tanks, the heterogeneous IVFS fuel slab, and the surrounding lithiated paraffin and environmental concrete shielding shown in Fig. G.13, with sectional views AA and BB as shown in Figs. G.14a and G.14b, respectively. A reflective boundary condition was applied at $X=0$, thus allowing us to model only that portion of the system for which $X \geq 0$, while a non-zero boundary source was applied across the XY plane just upstream of the last (and only) sodium tank included in this model. [See Sect. 2.1 for more details regarding the origin of this boundary source.] While Figs. G.13, G.14a, and G.14b are helpful in visualizing the 3-D XYZ model used, Table G.13 lists the actual TORT input arrays describing each geometric zone and the material mixture ID's used in each zone, while Table G.14 describes the fine mesh boundaries used in the 3-D XYZ TORT model(s). Results for calculational run IIIA.1b using the theta-weighted difference scheme are shown in Table R.13, while those for calculational run IIIA.1d using the nodal method are shown in Table R.14. Both tables show the results along a horizontal (X) traverse 30 cm downstream of the heterogeneous IVFS slab, as well as at a couple other points of interest.

3.7 CONFIGURATION IIIB

Figure G.15 illustrates the 2-D RZ geometric model associated with Config. IIIB.1 featuring the homogeneous IVFS fuel slab, while Table G.15 provides a more detailed description of the basic geometric model. [Note that the thinner (upstream) side of the homogeneous IVFS fuel slab contains 230 fuel pins while the thicker (downstream) side contains 306 fuel pins.] Calculated results for Config. IIIB.1 are given in Table R.15. Likewise:

Fig. G.16 and Tables G.16 and R.16 correspond to Config. IIIB.2, with the extended concrete ring used to model thermal neutron background radiation.

Fig. G.17 and Tables G.17 and R.17 correspond to Config. IIIB.3 with the Cd hut.

Fig. G.18 and Tables G.18 and R.18 correspond to Config. IIIB.4 with the Cd plate.

Note that in all of these cases, the actual calculational model included the geometry shown in Figs. G.15, G.16, G.17, or G.18, respectively, as well as all six sodium tanks and the entire spectral modifier and boundary source illustrated in Fig. G.7b and described further in Table G.7b.

3.8 CONFIGURATION IIIC

Figure G.19 illustrates the 2-D RZ geometric model associated with Config. IIIC.1 featuring the radial blanket assembly mockup with the natural UO_2 fuel pins, while Table G.19 provides a more detailed description of the basic geometric model. Calculated results for Config. IIIC.1 are given in Table R.19. Likewise:

Fig. G.20 and Tables G.20 and R.20 correspond to Config. IIIC.2, with the extended concrete ring used to model thermal neutron background radiation.

Fig. G.21 and Tables G.21 and R.21 correspond to Config. IIIC.3 with the Cd hut.

Fig. G.22 and Tables G.22 and R.22 correspond to Config. IIIC.4 with the Cd plate.

Note that in all of these cases, the actual calculational model included the geometry shown in Figs. G.19, G.20, G.21, or G.22, respectively, as well as all six sodium tanks and the entire spectral modifier and boundary source illustrated in Fig. G.7b and described further in Table G.7b.

3.9 CONFIGURATION IIID

Figure G.23 illustrates the 2-D RZ geometric model associated with Config. IIID.1 featuring a B_4C slab downstream of the homogeneous IVFS fuel slab, while Table G.23 provides a more detailed description of the basic geometric model. Calculated results for Config. IIID.1 are given in Table R.23. Likewise:

Fig. G.24 and Tables G.24 and R.24 correspond to Config. IIID.2, with the extended concrete ring used to model thermal neutron background radiation.

Fig. G.25 and Tables G.25 and R.25 correspond to Config. IIID.3 with the Cd hut.

Fig. G.26 and Tables G.26 and R.26 correspond to Config. IIID.4 with the Cd plate.

Note that in all of these cases, the actual calculational model included the geometry shown in Figs. G.23, G.24, G.25, or G.26, respectively, as well as all six sodium tanks

and the entire spectral modifier and boundary source illustrated in Fig. G.7b and described further in Table G.7b.

3.10 CONFIGURATION IIIE

Figure G.27 illustrates the 2-D RZ geometric model associated with Config. IIIE.1 featuring the homogeneous IVFS fuel slab downstream of the B_4C slab, while Table G.27 provides a more detailed description of the basic geometric model. Calculated results for Config. IIIE.1 are given in Table R.27. Likewise:

Fig. G.28 and Tables G.28 and R.28 correspond to Config. IIIE.2, with the extended concrete ring used to model thermal neutron background radiation.

Fig. G.29 and Tables G.29 and R.29 correspond to Config. IIIE.4 with the Cd hut.

Fig. G.30 and Tables G.30 and R.30 correspond to Config. IIIE.5 with the Cd plate.

Note that in all of these cases, the actual calculational model included the geometry shown in Figs. G.27, G.28, G.29, or G.30, respectively, as well as all six sodium tanks and the entire spectral modifier and boundary source illustrated in Fig. G.7b and described further in Table G.7b.

3.11 CONFIGURATION IIIF

Figure G.31 illustrates the 2-D RZ geometric model associated with Config. IIIF.1 featuring a B_4C slab downstream of the homogeneous IVFS fuel slab (with a large void space between the two for fission chamber measurements), while Table G.31 provides a more detailed description of the basic geometric model. Calculated results for Config. IIIF.1 are given in Table R.31. Likewise:

Fig. G.32 and Tables G.32 and R.32 correspond to Config. IIIF.2, with the extended concrete ring used to model thermal neutron background radiation.

Fig. G.33 and Tables G.33 and R.33 correspond to Config. IIIF.3 with the Cd hut.

Fig. G.34 and Tables G.34 and R.34 correspond to Config. IIIF.4 with the Cd plate.

Note that in all of these cases, the actual calculational model included the geometry shown in Figs. G.31, G.32, G.33, or G.34, respectively, as well as all six sodium tanks and the entire spectral modifier and boundary source illustrated in Fig. G.7b and described further in Table G.7b.

Fig. G.1. Calculation model used for Configuration 1A.2 (Fe/Al/Boral slabs; basic configuration by itself).

Table G.1a. Detailed description of the calculational model for Configuration IA.2 (Fe/AL/Boral slabs; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE						
ZMIN	ZMAX	N	R	M	(etc) ...				
255.800	267.800	15	0.0	62	----->	157.100			
182.740	255.800	37	0.0	62	----->	157.100			
168.440	182.740	7	0.0	62	----->	157.100			
150.400	168.440	9	0.0	62	----->	157.100			
122.720	150.400	35	0.0	62	----->	157.100			
121.590	122.720	2	0.0	62	----->	157.100			
117.400	121.590	5	0.0	62	85.980 33 96.140 34	157.100			
114.860	117.400	9	0.0	29	85.980 33 96.140 34	157.100			
112.900	114.860	2	0.0	62	85.980 33 96.140 34	157.100			
110.360	112.900	5	0.0	27	85.980 33 96.140 34	157.100			
110.000	110.360	1	0.0	62	85.980 33 96.140 34	157.100			
106.710	110.000	5	0.0	28	85.980 33 96.140 34	157.100			
106.340	106.710	1	0.0	62	85.980 33 96.140 34	157.100			
103.050	106.340	5	0.0	27	85.980 33 96.140 34	157.100			
102.680	103.050	1	0.0	62	85.980 33 96.140 34	157.100			
97.570	102.680	9	0.0	26	85.980 33 96.140 34	157.100			
97.200	97.570	1	0.0	62	85.980 33 96.140 34	157.100			
92.040	97.200	9	0.0	25	85.980 33 96.140 34	157.100			
91.300	92.040	1	0.0	62	85.980 33 96.140 34	157.100			

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table G.1b. Radial mesh intervals used in all of the 2-D RZ DORT analyses for the JASPER IVFS experiments.

Mesh Num.	Rmin (cm)	Rmax (cm)	Mesh Num.	Rmin (cm)	Rmax (cm)	Mesh Num.	Rmin (cm)	Rmax (cm)	Mesh Num.	Rmin (cm)	Rmax (cm)
1	.000	.750	43	33.000	33.750	85	60.250	61.000	127	87.000	87.650
2	.750	1.500	44	33.750	34.500	86	61.000	61.500	128	87.650	88.350
3	1.500	2.250	45	34.500	35.250	87	61.500	62.000	129	88.350	89.190
4	2.250	3.000	46	35.250	36.000	88	62.000	62.500	130	89.190	89.750
5	3.000	3.750	47	36.000	36.750	89	62.500	63.000	131	89.750	90.250
6	3.750	4.650	48	36.750	37.500	90	63.000	63.500	132	90.250	91.000
7	4.650	5.350	49	37.500	38.250	91	63.500	64.000	133	91.000	92.000
8	5.350	6.000	50	38.250	39.000	92	64.000	64.500	134	92.000	93.000
9	6.000	6.750	51	39.000	39.650	93	64.500	65.000	135	93.000	94.000
10	6.750	7.500	52	39.650	40.350	94	65.000	65.500	136	94.000	95.000
11	7.500	8.250	53	40.350	41.250	95	65.500	66.000	137	95.000	96.140
12	8.250	9.000	54	41.250	42.000	96	66.000	66.500	138	96.140	97.400
13	9.000	9.650	55	42.000	42.750	97	66.500	67.000	139	97.400	99.100
14	9.650	10.350	56	42.750	43.500	98	67.000	67.500	140	99.100	100.900
15	10.350	11.250	57	43.500	44.250	99	67.500	68.452	141	100.900	103.000
16	11.250	12.000	58	44.250	45.000	100	68.452	69.007	142	103.000	104.400
17	12.000	12.750	59	45.000	45.750	101	69.007	69.791	143	104.400	105.800
18	12.750	13.500	60	45.750	46.500	102	69.791	70.209	144	105.800	107.200
19	13.500	14.500	61	46.500	47.250	103	70.209	71.000	145	107.200	108.600
20	14.500	15.500	62	47.250	48.000	104	71.000	71.750	146	108.600	110.000
21	15.500	16.500	63	48.000	48.750	105	71.750	72.500	147	110.000	112.000
22	16.500	17.250	64	48.750	49.650	106	72.500	73.250	148	112.000	114.000
23	17.250	18.000	65	49.650	50.350	107	73.250	74.149	149	114.000	116.000
24	18.000	18.750	66	50.350	51.000	108	74.149	74.750	150	116.000	118.000
25	18.750	19.650	67	51.000	51.865	109	74.750	75.500	151	118.000	120.000
26	19.650	20.350	68	51.865	52.000	110	75.500	76.250	152	120.000	122.000
27	20.350	21.000	69	52.000	52.467	111	76.250	77.000	153	122.000	124.000
28	21.000	21.750	70	52.467	53.000	112	77.000	77.600	154	124.000	126.000
29	21.750	22.500	71	53.000	53.500	113	77.600	78.400	155	126.000	128.000
30	22.500	23.250	72	53.500	54.000	114	78.400	79.250	156	128.000	130.000
31	23.250	24.000	73	54.000	54.500	115	79.250	79.750	157	130.000	132.700
32	24.000	24.750	74	54.500	55.059	116	79.750	80.250	158	132.700	135.400
33	24.750	25.500	75	55.059	55.500	117	80.250	80.750	159	135.400	138.100
34	25.500	26.250	76	55.500	55.902	118	80.750	81.500	160	138.100	140.800
35	26.250	27.000	77	55.902	56.500	119	81.500	82.007	161	140.800	143.500
36	27.000	27.750	78	56.500	57.000	120	82.007	83.000	162	143.500	146.200
37	27.750	28.500	79	57.000	57.500	121	83.000	83.750	163	146.200	148.900
38	28.500	29.500	80	57.500	58.000	122	83.750	84.547	164	148.900	151.600
39	29.500	30.500	81	58.000	58.707	123	84.547	85.307	165	151.600	154.300
40	30.500	31.500	82	58.707	59.000	124	85.307	85.980	166	154.300	157.100
41	31.500	32.250	83	59.000	59.750	125	85.980	86.500			
42	32.250	33.000	84	59.750	60.250	126	86.500	87.000			

Table R.1. Results for Config IA.2

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 1.17400E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.00838E+04	3.83073E+04	6.07633E+04	5.98174E+04	3.74428E+04	2.10980E+04	3.01898E+00	3.00902E+00
.00	30.00	0.00000E+00	2.39519E+03	9.30361E+03	1.44548E+04	1.27978E+04	7.53361E+03	4.00819E+03	1.51317E+00	1.50306E+00
.00	150.00	0.00000E+00	3.92695E+02	1.47645E+03	2.27039E+03	1.98450E+03	1.16415E+03	6.19368E+02	2.93358E-01	2.73704E-01
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the boral is as follows:										
9.69809E-01	4.50283E+00	1.53572E+01	3.68086E+01	7.30967E+01	1.18796E+02	1.50113E+02	2.12439E+02	3.07223E+02	1.27063E+02	
1.17575E+02	2.43155E+02	6.15670E+02	6.81830E+02	7.39033E+02	1.26649E+03	8.96245E+02	1.35336E+03	8.54578E+02	3.46582E+02	
1.24995E+03	1.57203E+03	6.30238E+01	2.23125E+01	4.52303E+01	3.96642E+02	1.27554E+03	9.97231E+02	4.70693E+02	1.11029E+03	
5.26661E+02	1.89506E+03	3.17568E+02	3.12375E+02	5.21392E+02	2.24334E+02	1.89913E+02	5.72019E+02	4.26173E+02	1.68420E+03	
8.58103E+02	4.35469E+02	3.67977E+02	1.67319E+02	1.05498E+02	8.23398E+01	5.23504E+01	2.60470E+02	2.01115E+02	1.57922E+02	
1.00233E+02	8.51627E+01	6.87441E+01	7.10973E+01	3.73110E+01	1.46629E+01	3.90079E+00	5.77928E-01	3.60750E-02	4.61866E-04	
7.44044E-07										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the boral is as follows:										
5.14562E-01	2.44090E+00	8.38722E+00	1.99177E+01	3.87464E+01	6.13554E+01	7.49257E+01	1.05585E+02	1.52515E+02	6.28944E+01	
5.75928E+01	1.17213E+02	2.94285E+02	3.23439E+02	3.57738E+02	5.83992E+02	4.13683E+02	6.62969E+02	4.03528E+02	1.64176E+02	
5.87236E+02	7.61824E+02	2.96933E+01	1.04250E+01	2.09496E+01	1.85340E+02	5.94816E+02	4.63713E+02	2.06371E+02	5.44892E+02	
2.29247E+02	9.27113E+02	1.49538E+02	1.30817E+02	2.50796E+02	1.04101E+02	9.43243E+01	2.97829E+02	2.05697E+02	7.57117E+02	
3.90491E+02	2.09831E+02	1.82187E+02	8.37672E+01	5.16442E+01	3.93806E+01	2.62738E+01	1.34498E+02	1.04073E+02	8.38216E+01	
5.38056E+01	4.81104E+01	3.98244E+01	4.25922E+01	2.30843E+01	9.22197E+00	2.41276E+00	3.37690E-01	2.08418E-02	6.00992E-03	
2.05847E-01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the boral is as follows:										
1.22073E-01	5.92923E-01	2.06133E+00	4.81473E+00	9.02344E+00	1.34830E+01	1.51897E+01	2.05566E+01	2.91741E+01	1.17990E+01	
1.06603E+01	2.10343E+01	5.05012E+01	5.39951E+01	5.94637E+01	9.15543E+01	6.35623E+01	1.06674E+02	6.14258E+01	2.49090E+01	
8.67139E+01	1.18145E+02	4.42978E+00	1.53585E+00	3.04262E+00	2.67080E+01	8.70206E+01	6.68215E+01	2.85309E+01	8.11904E+01	
3.14713E+01	1.36248E+02	2.18931E+01	1.78011E+01	3.63665E+01	1.42326E+01	1.48144E+01	5.10100E+01	3.24110E+01	1.10464E+02	
5.93419E+01	3.55254E+01	3.16014E+01	1.48865E+01	9.09125E+00	6.92957E+00	4.91763E+00	2.56757E+01	2.02762E+01	1.69650E+01	
1.15206E+01	1.07937E+01	9.20667E+00	1.04260E+01	6.31252E+00	3.06124E+00	1.13212E+00	3.24354E-01	1.21527E-01	1.14247E-01	
7.90264E-01

Table G.2. Detailed description of the calculational model for Configuration 1A.14 (Fe/AL/Boral slabs; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE					
ZMIN	ZMAX	N	R	M	(etc)	...		

ZMIN	ZMAX	N	R	M	(etc)	...		
255.800	267.800	15	0.0	62	----->		157.100	
200.510	255.800	28	0.0	62	----->		157.100	
182.740	200.510	9	0.0	62	----->	135.400	34	157.100
168.440	182.740	7	0.0	62	----->	135.400	34	157.100
150.400	168.440	9	0.0	62	----->	135.400	34	157.100
122.720	150.400	35	0.0	62	----->	135.400	34	157.100
121.590	122.720	2	0.0	62	----->	135.400	34	157.100
117.400	121.590	5	0.0	62	85.980	33 96.140 34	----->	157.100
114.860	117.400	9	0.0	29	85.980	33 96.140 34	----->	157.100
112.900	114.860	2	0.0	62	85.980	33 96.140 34	----->	157.100
110.360	112.900	5	0.0	27	85.980	33 96.140 34	----->	157.100
110.000	110.360	1	0.0	62	85.980	33 96.140 34	----->	157.100
106.710	110.000	5	0.0	28	85.980	33 96.140 34	----->	157.100
106.340	106.710	1	0.0	62	85.980	33 96.140 34	----->	157.100
103.050	106.340	5	0.0	27	85.980	33 96.140 34	----->	157.100
102.680	103.050	1	0.0	62	85.980	33 96.140 34	----->	157.100
97.570	102.680	9	0.0	26	85.980	33 96.140 34	----->	157.100
97.200	97.570	1	0.0	62	85.980	33 96.140 34	----->	157.100
92.040	97.200	9	0.0	25	85.980	33 96.140 34	----->	157.100
91.300	92.040	1	0.0	62	85.980	33 96.140 34	----->	157.100

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.2. Results for Config IA.14

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 1.17400E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.01765E+04	3.85730E+04	6.11042E+04	6.00078E+04	3.75255E+04	2.11302E+04	3.64324E+00	3.25504E+00
.00	30.00	0.00000E+00	2.56097E+03	9.69086E+03	1.49276E+04	1.30611E+04	7.65199E+03	4.05723E+03	3.32900E+00	1.83635E+00
.00	150.00	0.00000E+00	5.17768E+02	1.77108E+03	2.63638E+03	2.20297E+03	1.26783E+03	6.63905E+02	1.32574E+00	4.92228E-01
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the boral is as follows:										
9.69805E-01	4.50282E+00	1.53568E+01	3.68043E+01	7.30869E+01	1.18761E+02	1.50185E+02	2.12866E+02	3.08945E+02	1.27630E+02	
1.18117E+02	2.44291E+02	6.18956E+02	6.86769E+02	7.44949E+02	1.27338E+03	9.15847E+02	1.36641E+03	8.64823E+02	3.49859E+02	
1.26234E+03	1.59324E+03	6.41672E+01	2.27338E+01	4.60736E+01	4.03685E+02	1.29543E+03	1.01740E+03	4.87747E+02	1.13028E+03	
5.49738E+02	1.92861E+03	3.23027E+02	3.34306E+02	5.35734E+02	2.28041E+02	1.92401E+02	5.75747E+02	4.29562E+02	1.71585E+03	
8.90848E+02	4.62924E+02	3.88942E+02	1.76940E+02	1.12335E+02	8.89116E+01	5.65862E+01	2.79547E+02	2.17837E+02	1.72544E+02	
1.12994E+02	9.62649E+01	7.84290E+01	8.32226E+01	4.71266E+01	2.23999E+01	9.93585E+00	5.31203E+00	3.84959E+00	4.03228E+00	
1.60247E+01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the boral is as follows:										
5.14559E-01	2.44091E+00	8.38715E+00	1.99159E+01	3.87424E+01	6.13821E+01	7.50428E+01	1.05928E+02	1.53616E+02	6.32427E+01	
5.79288E+01	1.17916E+02	2.96205E+02	3.26293E+02	3.61168E+02	5.87797E+02	4.24317E+02	6.70369E+02	4.09549E+02	1.66100E+02	
5.94463E+02	7.73668E+02	3.03429E+01	1.06641E+01	2.14300E+01	1.89361E+02	6.05970E+02	4.75240E+02	2.16260E+02	5.56043E+02	
2.42788E+02	9.46195E+02	1.52671E+02	1.44504E+02	2.58752E+02	1.06188E+02	9.57618E+01	3.00008E+02	2.07621E+02	7.77075E+02	
4.10322E+02	2.26818E+02	1.95238E+02	8.99097E+01	5.60591E+01	4.36725E+01	2.90636E+01	1.47398E+02	1.15836E+02	9.45421E+01	
6.35868E+01	5.70497E+01	4.80504E+01	5.37092E+01	3.30895E+01	1.82905E+01	1.06901E+01	8.01372E+00	7.37237E+00	9.45665E+00	
6.32581E+01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the boral is as follows:										
1.22155E-01	5.94388E-01	2.06924E+00	4.83906E+00	9.09492E+00	1.36308E+01	1.54182E+01	2.09594E+01	2.99746E+01	1.20543E+01	
1.09343E+01	2.15488E+01	5.19248E+01	5.61308E+01	6.20152E+01	9.39160E+01	6.95190E+01	1.12284E+02	6.64233E+01	2.63967E+01	
9.20972E+01	1.27211E+02	4.89165E+00	1.70375E+00	3.38272E+00	2.96379E+01	9.52055E+01	7.50754E+01	3.58114E+01	8.80382E+01	
4.14618E+01	1.48641E+02	2.41369E+01	2.82052E+01	4.06900E+01	1.54953E+01	1.56936E+01	5.22666E+01	3.38379E+01	1.26251E+02	
7.36946E+01	4.75407E+01	4.05905E+01	1.92485E+01	1.22660E+01	1.00467E+01	6.93994E+00	3.51727E+01	2.90987E+01	2.51052E+01	
1.89759E+01	1.76227E+01	1.54724E+01	1.87843E+01	1.36608E+01	9.53719E+00	6.87917E+00	5.52652E+00	4.98408E+00	6.16428E+00	
3.53820E+01

Fig. G.3. Calculational model used for Configuration 1A/PB.1 (Fe/AL/Boral/Pb slabs; basic configuration by itself).

Table G.3. Detailed description of the calculational model for Configuration IA/PB.1 (Fe/AL/Boral/Pb slabs; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE				
ZMIN	ZMAX	N	R	M	(etc) ...		
270.100	282.100	15	0.0	62	----->	157.100	
182.740	270.100	44	0.0	62	----->	157.100	
164.700	182.740	9	0.0	62	----->	157.100	
137.020	164.700	35	0.0	62	----->	157.100	
131.700	137.020	6	0.0	62	----->	157.100	
127.890	131.700	7	0.0	31	85.980 62 ----->	157.100	
125.400	127.890	2	0.0	62	----->	157.100	
121.590	125.400	7	0.0	30	85.980 62 ----->	157.100	
117.400	121.590	4	0.0	62	85.980 33 96.140 34 ----->	157.100	
114.860	117.400	9	0.0	29	85.980 33 96.140 34 ----->	157.100	
112.900	114.860	2	0.0	62	85.980 33 96.140 34 ----->	157.100	
110.360	112.900	5	0.0	27	85.980 33 96.140 34 ----->	157.100	
110.000	110.360	1	0.0	62	85.980 33 96.140 34 ----->	157.100	
106.710	110.000	5	0.0	28	85.980 33 96.140 34 ----->	157.100	
106.340	106.710	1	0.0	62	85.980 33 96.140 34 ----->	157.100	
103.050	106.340	5	0.0	27	85.980 33 96.140 34 ----->	157.100	
102.680	103.050	1	0.0	62	85.980 33 96.140 34 ----->	157.100	
97.570	102.680	9	0.0	26	85.980 33 96.140 34 ----->	157.100	
97.200	97.570	1	0.0	62	85.980 33 96.140 34 ----->	157.100	
92.040	97.200	9	0.0	25	85.980 33 96.140 34 ----->	157.100	
91.300	92.040	1	0.0	62	85.980 33 96.140 34 ----->	157.100	

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.3. Results for Config IA/PB.1

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 1.31700E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	5.40647E+03	2.24307E+04	3.55347E+04	3.37953E+04	2.00305E+04	1.03070E+04	1.71503E+00	1.70961E+00
.00	25.00	0.00000E+00	1.48827E+03	5.81172E+03	8.99471E+03	7.78701E+03	4.48802E+03	2.33043E+03	8.86284E-01	8.82706E-01
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last Pb slab is as follows:										
3.52352E-01	1.64634E+00	5.36542E+00	1.25436E+01	2.37565E+01	3.57892E+01	4.67517E+01	7.56553E+01	1.29336E+02	5.31733E+01	
5.49191E+01	1.16984E+02	3.11234E+02	3.84486E+02	4.27812E+02	7.15588E+02	5.60196E+02	7.99476E+02	5.04671E+02	2.89088E+02	
8.45493E+02	8.77854E+02	3.80669E+01	1.40926E+01	2.90136E+01	2.24364E+02	6.71257E+02	6.01452E+02	3.30004E+02	5.91173E+02	
4.22654E+02	9.71171E+02	1.76652E+02	3.22960E+02	3.23632E+02	1.13288E+02	8.76897E+01	1.80374E+02	2.09832E+02	9.82756E+02	
5.75627E+02	3.24237E+02	2.37205E+02	1.03928E+02	6.91159E+01	5.64490E+01	3.28291E+01	1.52612E+02	1.14412E+02	8.49209E+01	
5.48696E+01	4.27963E+01	3.34226E+01	3.39638E+01	1.83692E+01	7.56639E+00	2.18134E+00	3.94424E-01	4.33220E-02	4.09174E-03	
1.01297E-03										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 25.00 cm past the last Pb slab is as follows:										
2.15463E-01	9.89309E-01	3.30244E+00	7.73785E+00	1.44650E+01	2.13963E+01	2.66485E+01	4.13018E+01	6.85735E+01	2.82108E+01	
2.85927E+01	6.07126E+01	1.60528E+02	1.95473E+02	2.17647E+02	3.62267E+02	2.81925E+02	4.08484E+02	2.57572E+02	1.41672E+02	
4.29668E+02	4.51053E+02	1.93731E+01	7.15632E+00	1.47122E+01	1.15088E+02	3.45531E+02	3.09225E+02	1.68133E+02	3.07672E+02	
2.14008E+02	5.00895E+02	9.11815E+01	1.62573E+02	1.71039E+02	5.96906E+01	4.65085E+01	9.55408E+01	1.10214E+02	5.11404E+02	
3.00683E+02	1.69690E+02	1.24502E+02	5.43251E+01	3.60538E+01	2.93312E+01	1.71722E+01	7.92664E+01	5.92110E+01	4.38053E+01	
2.82600E+01	2.20092E+01	1.71207E+01	1.73338E+01	9.35178E+00	3.85836E+00	1.12816E+00	2.23920E-01	4.49651E-02	2.72850E-02	
3.34055E-02

Fig. G.4. Calculational model used for Configuration 1A/PB.15 (Fe/AL/Boral/Pb slabs; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

Table G.4. Detailed description of the calculational model for Configuration IA/PB.15 (Fe/AL/Boral/Pb slabs; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE					
ZMIN	ZMAX	N	R	M	(etc) ...			
270.100	282.100	15	0.0	62	----->	157.100		
214.810	270.100	28	0.0	62	----->	157.100		
182.740	214.810	16	0.0	62	----->	135.400	34	157.100
164.700	182.740	9	0.0	62	----->	135.400	34	157.100
137.020	164.700	35	0.0	62	----->	135.400	34	157.100
131.700	137.020	6	0.0	62	----->	135.400	34	157.100
127.890	131.700	7	0.0	31	85.980 62 ----->	135.400	34	157.100
125.400	127.890	2	0.0	62	----->	135.400	34	157.100
121.590	125.400	7	0.0	30	85.980 62 ----->	135.400	34	157.100
117.400	121.590	4	0.0	62	85.980 33 96.140 34 ----->	157.100		
114.860	117.400	9	0.0	29	85.980 33 96.140 34 ----->	157.100		
112.900	114.860	2	0.0	62	85.980 33 96.140 34 ----->	157.100		
110.360	112.900	5	0.0	27	85.980 33 96.140 34 ----->	157.100		
110.000	110.360	1	0.0	62	85.980 33 96.140 34 ----->	157.100		
106.710	110.000	5	0.0	28	85.980 33 96.140 34 ----->	157.100		
106.340	106.710	1	0.0	62	85.980 33 96.140 34 ----->	157.100		
103.050	106.340	5	0.0	27	85.980 33 96.140 34 ----->	157.100		
102.680	103.050	1	0.0	62	85.980 33 96.140 34 ----->	157.100		
97.570	102.680	9	0.0	26	85.980 33 96.140 34 ----->	157.100		
97.200	97.570	1	0.0	62	85.980 33 96.140 34 ----->	157.100		
92.040	97.200	9	0.0	25	85.980 33 96.140 34 ----->	157.100		
91.300	92.040	1	0.0	62	85.980 33 96.140 34 ----->	157.100		

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.4. Results for Config IA/PB.15

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 1.31700E+02										
'R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	5.52600E+03	2.26950E+04	3.58486E+04	3.39565E+04	2.00994E+04	1.03341E+04	3.53576E+00	2.09127E+00
.00	25.00	0.00000E+00	1.64100E+03	6.13893E+03	9.37568E+03	7.98907E+03	4.58261E+03	2.37192E+03	2.77711E+00	1.23259E+00
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last Pb slab is as follows:										
3.52356E-01	1.64623E+00	5.36602E+00	1.25430E+01	2.37527E+01	3.58037E+01	4.68112E+01	7.58458E+01	1.30226E+02	5.34698E+01	
5.52228E+01	1.17630E+02	3.13154E+02	3.87750E+02	4.32053E+02	7.20302E+02	5.75821E+02	8.09153E+02	5.12609E+02	2.91769E+02	
8.54889E+02	8.96798E+02	3.90243E+01	1.44518E+01	2.97450E+01	2.30200E+02	6.86780E+02	6.16245E+02	3.43473E+02	6.04164E+02	
4.41684E+02	9.91900E+02	1.80358E+02	3.42218E+02	3.31333E+02	1.15523E+02	8.92334E+01	1.82608E+02	2.12083E+02	1.00526E+03	
5.99440E+02	3.45298E+02	2.52757E+02	1.11375E+02	7.45607E+01	6.17944E+01	3.62506E+01	1.68749E+02	1.29244E+02	9.85696E+01	
6.73657E+01	5.43042E+01	4.40336E+01	4.82596E+01	3.11415E+01	1.89582E+01	1.23524E+01	9.61556E+00	8.66948E+00	1.07823E+01	
6.11668E+01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 25.00 cm past the last Pb slab is as follows:										
2.15464E-01	9.89335E-01	3.30245E+00	7.73753E+00	1.44632E+01	2.14240E+01	2.67233E+01	4.14818E+01	6.92202E+01	2.84123E+01	
2.87981E+01	6.11383E+01	1.61785E+02	1.97614E+02	2.20427E+02	3.65349E+02	2.91961E+02	4.14947E+02	2.62911E+02	1.43420E+02	
4.35977E+02	4.63780E+02	2.00122E+01	7.39402E+00	1.51943E+01	1.18974E+02	3.55997E+02	3.19242E+02	1.77362E+02	3.16582E+02	
2.27137E+02	5.15536E+02	9.38037E+01	1.76171E+02	1.76468E+02	6.12831E+01	4.76124E+01	9.71413E+01	1.11824E+02	5.27759E+02	
3.17994E+02	1.85106E+02	1.36017E+02	5.98980E+01	4.01388E+01	3.33628E+01	1.97704E+01	9.16051E+01	7.07206E+01	5.45599E+01	
3.82640E+01	3.13591E+01	2.58734E+01	2.93651E+01	2.03392E+01	1.38963E+01	1.03241E+01	8.75566E+00	8.19535E+00	1.04585E+01	
6.55594E+01

Fig. G.5. Calculational model used for Configuration IB.1 (Fe/AL/Boral/Radial-Blanket assemblies; basic configuration by itself).

Table G.5. Detailed description of the calculational model for Configuration IB.1 (Fe/AL/Boral/Radial-Blanket assemblies; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
306.600	318.600	15	0.0	62	----->							157.100
289.500	306.600	12	0.0	62	----->							157.100
277.500	289.500	15	0.0	62	----->							157.100
222.210	277.500	32	0.0	62	----->							157.100
172.100	222.210	28	0.0	62	----->							157.100
156.260	172.100	20	0.0	62	----->							157.100
142.100	156.260	18	0.0	62	----->							157.100
139.100	142.100	4	0.0	62	----->							157.100
138.624	139.100	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980	33 96.140 34 157.100
137.018	138.624	5	0.0	32	68.452 63 69.007 64	----->					85.980	33 96.140 34 157.100
130.132	137.018	21	0.0	32	68.452 63 69.007 64	----->	74.149	65	82.007 64 84.547 62	----->	85.980	33 96.140 34 157.100
128.524	130.132	5	0.0	32	68.452 63 69.007 64	----->					85.980	33 96.140 34 157.100
128.050	128.524	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980	33 96.140 34 157.100
127.050	128.050	1	0.0	62	----->						85.980	33 96.140 34 157.100
126.574	127.050	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980	33 96.140 34 157.100
124.968	126.574	5	0.0	32	68.452 63 69.007 64	----->					85.980	33 96.140 34 157.100
118.082	124.968	21	0.0	32	68.452 63 69.007 64	----->	74.149	65	82.007 64 84.547 62	----->	85.980	33 96.140 34 157.100
116.474	118.082	5	0.0	32	68.452 63 69.007 64	----->					85.980	33 96.140 34 157.100
116.000	116.474	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980	33 96.140 34 157.100
115.000	116.000	1	0.0	62	----->						85.980	33 96.140 34 157.100
112.460	115.000	9	0.0	29	----->						85.980	33 96.140 34 157.100
111.930	112.460	1	0.0	62	----->						85.980	33 96.140 34 157.100
109.390	111.930	5	0.0	27	----->						85.980	33 96.140 34 157.100
108.860	109.390	1	0.0	62	----->						85.980	33 96.140 34 157.100
105.570	108.860	5	0.0	28	----->						85.980	33 96.140 34 157.100
105.040	105.570	1	0.0	62	----->						85.980	33 96.140 34 157.100
101.750	105.040	5	0.0	27	----->						85.980	33 96.140 34 157.100
101.220	101.750	1	0.0	62	----->						85.980	33 96.140 34 157.100
96.110	101.220	9	0.0	26	----->						85.980	33 96.140 34 157.100
95.580	96.110	1	0.0	62	----->						85.980	33 96.140 34 157.100
90.420	95.580	9	0.0	25	----->						85.980	33 96.140 34 157.100
89.890	90.420	1	0.0	62	----->						85.980	33 96.140 34 157.100

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.5. Results for Config IB.1

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 1.39100E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	2.74607E+03	1.02796E+04	1.59803E+04	1.42230E+04	8.06917E+03	4.12006E+03	8.46616E-01	8.37113E-01
.00	30.00	0.00000E+00	6.45567E+02	2.14826E+03	3.01464E+03	2.11394E+03	1.08244E+03	5.12649E+02	4.67458E-01	4.06993E-01
.00	150.00	0.00000E+00	1.02007E+02	3.31645E+02	4.65515E+02	3.32334E+02	1.72426E+02	8.23079E+01	1.03848E-01	7.51540E-02
.00	179.10	0.00000E+00	7.41403E+01	2.46691E+02	3.47797E+02	2.47101E+02	1.28015E+02	6.14720E+01	7.69835E-02	5.01625E-02
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last radial blanket assembly is as follows:										
9.96158E-02	4.52231E-01	1.54734E+00	3.97127E+00	8.29385E+00	1.40011E+01	1.56976E+01	2.23640E+01	3.87705E+01	1.58331E+01	
1.47114E+01	2.14950E+01	4.75351E+01	5.34266E+01	5.95182E+01	4.48250E+01	1.03080E+02	1.60618E+02	1.38258E+02	4.76732E+01	
1.05565E+02	1.80992E+02	8.37331E+00	3.33278E+00	7.35265E+00	6.07717E+01	1.72694E+02	1.83001E+02	1.65655E+02	2.07384E+02	
2.59242E+02	4.56355E+02	5.64576E+01	2.48825E+02	1.13448E+02	2.68126E+01	6.71691E+01	9.66159E+01	5.92913E+01	4.17129E+02	
3.50069E+02	2.61350E+02	1.38685E+02	2.54686E+01	6.21550E+00	1.83669E+01	2.66598E+01	1.53468E+02	1.26987E+02	8.85999E+01	
6.00392E+01	4.13027E+01	1.52931E+01	2.26599E+01	9.53017E+00	3.29483E+00	6.38403E-01	4.39663E-01	2.89865E-01	2.03290E-01	
2.55901E-01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last radial blanket assembly is as follows:										
5.64809E-02	2.53754E-01	8.65445E-01	2.17031E+00	4.43355E+00	7.28281E+00	7.99149E+00	1.12647E+01	1.93893E+01	8.01234E+00	
7.36913E+00	1.07974E+01	2.39146E+01	2.66002E+01	2.94346E+01	2.23570E+01	5.12773E+01	7.93571E+01	6.84228E+01	2.32729E+01	
5.00620E+01	9.00946E+01	4.22179E+00	1.69665E+00	3.77097E+00	3.07856E+01	8.63728E+01	8.80024E+01	8.16650E+01	1.00234E+02	
1.25257E+02	2.16336E+02	2.60866E+01	1.14982E+02	4.42378E+01	4.93184E+00	2.34043E+01	3.76327E+01	2.88027E+01	2.11418E+02	
1.70119E+02	1.10862E+02	6.49854E+01	1.17126E+01	3.21755E+00	8.70461E+00	1.22592E+01	6.99618E+01	5.70421E+01	3.99036E+01	
2.55946E+01	1.90247E+01	7.74211E+00	1.15793E+01	5.52016E+00	2.57041E+00	1.15582E+00	9.84389E-01	8.10969E-01	8.33928E-01	
2.49611E+00										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last radial blanket assembly is as follows:										
1.37588E-02	5.85105E-02	1.94746E-01	4.63636E-01	9.04692E-01	1.38777E+00	1.39245E+00	1.88557E+00	3.30466E+00	1.43075E+00	
1.28151E+00	1.83339E+00	3.97391E+00	4.28233E+00	4.55931E+00	3.44343E+00	7.79702E+00	1.20111E+01	1.01627E+01	3.44047E+00	
7.13590E+00	1.31771E+01	6.06526E-01	2.46286E-01	5.52519E-01	4.50883E+00	1.26149E+01	1.27020E+01	1.17067E+01	1.43993E+01	
1.78327E+01	3.06993E+01	3.67522E+00	1.62091E+01	6.48970E+00	7.44874E-01	2.85577E+00	5.01865E+00	4.07572E+00	3.06656E+01	
2.48816E+01	1.59714E+01	9.77509E+00	1.99755E+00	7.15558E-01	1.41563E+00	1.89937E+00	1.05154E+01	8.51281E+00	6.10864E+00	
3.96531E+00	3.20704E+00	1.70423E+00	2.53273E+00	1.67830E+00	1.23766E+00	9.87013E-01	8.71088E-01	7.48929E-01	7.82362E-01	
1.19843E+00										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 179.10 cm past the last radial blanket assembly is as follows:										
9.19651E-03	3.89438E-02	1.29306E-01	3.14941E-01	6.32410E-01	9.96306E-01	1.03240E+00	1.41818E+00	2.45036E+00	1.03780E+00	
9.42369E-01	1.36610E+00	2.98116E+00	3.24921E+00	3.51140E+00	2.62917E+00	6.02976E+00	9.27326E+00	7.87359E+00	2.67305E+00	
5.51410E+00	1.01522E+01	4.69516E-01	1.91402E-01	4.28769E-01	3.48137E+00	9.79545E+00	9.86357E+00	9.12070E+00	1.12189E+01	
1.39623E+01	2.42427E+01	2.87808E+00	1.27824E+01	5.31229E+00	6.22289E-01	2.29540E+00	3.92900E+00	3.20966E+00	2.39287E+01	
1.93940E+01	1.25201E+01	7.31123E+00	1.25074E+00	3.50978E-01	1.03654E+00	1.44414E+00	8.07611E+00	6.57970E+00	4.61468E+00	
2.99336E+00	2.23963E+00	9.63271E-01	1.44720E+00	7.52946E-01	4.14273E-01	2.51181E-01	2.23692E-01	2.03170E-01	2.42290E-01	
1.13193E+00

Fig. G.6. Computational model used for Configuration IB.2 (Fe/AL/Boral/Radial-Blanket assemblies; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

Table G.6. Detailed description of the calculational model for Configuration 1B.2 (Fe/AL/Boral/Radial-Blanket assemblies; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
306.600	318.600	15	0.0	62	----->							157.100
289.500	306.600	12	0.0	62	----->							157.100
277.500	289.500	15	0.0	62	----->							157.100
222.210	277.500	32	0.0	62	----->							157.100
172.100	222.210	28	0.0	62	----->							157.100
156.260	172.100	20	0.0	62	----->							157.100
142.100	156.260	18	0.0	62	----->							157.100
139.100	142.100	4	0.0	62	----->							157.100
138.624	139.100	1	0.0	64	----->							157.100
137.018	138.624	5	0.0	32	68.452 63 69.007 64	69.791	62	74.149	64	----->	85.980 33 96.140 34	157.100
130.132	137.018	21	0.0	32	68.452 63 69.007 64	----->	74.149	65	82.007 64	84.547 62	85.980 33 96.140 34	157.100
128.524	130.132	5	0.0	32	68.452 63 69.007 64	----->					85.980 33 96.140 34	157.100
128.050	128.524	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980 33 96.140 34	157.100
127.050	128.050	1	0.0	62	----->						85.980 33 96.140 34	157.100
126.574	127.050	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980 33 96.140 34	157.100
124.968	126.574	5	0.0	32	68.452 63 69.007 64	----->					85.980 33 96.140 34	157.100
118.082	124.968	21	0.0	32	68.452 63 69.007 64	----->	74.149	65	82.007 64	84.547 62	85.980 33 96.140 34	157.100
116.474	118.082	5	0.0	32	68.452 63 69.007 64	----->					85.980 33 96.140 34	157.100
116.000	116.474	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980 33 96.140 34	157.100
115.000	116.000	1	0.0	62	----->						85.980 33 96.140 34	157.100
112.460	115.000	9	0.0	29	----->						85.980 33 96.140 34	157.100
111.930	112.460	1	0.0	62	----->						85.980 33 96.140 34	157.100
109.390	111.930	5	0.0	27	----->						85.980 33 96.140 34	157.100
108.860	109.390	1	0.0	62	----->						85.980 33 96.140 34	157.100
105.570	108.860	5	0.0	28	----->						85.980 33 96.140 34	157.100
105.040	105.570	1	0.0	62	----->						85.980 33 96.140 34	157.100
101.750	105.040	5	0.0	27	----->						85.980 33 96.140 34	157.100
101.220	101.750	1	0.0	62	----->						85.980 33 96.140 34	157.100
96.110	101.220	9	0.0	26	----->						85.980 33 96.140 34	157.100
95.580	96.110	1	0.0	62	----->						85.980 33 96.140 34	157.100
90.420	95.580	9	0.0	25	----->						85.980 33 96.140 34	157.100
89.890	90.420	1	0.0	62	----->						85.980 33 96.140 34	157.100

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.6. Results for Config IB.2

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 1.39100E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	2.77397E+03	1.03402E+04	1.60492E+04	1.42564E+04	8.08349E+03	4.12588E+03	1.17999E+00	9.20919E-01
.00	30.00	0.00000E+00	6.85597E+02	2.23043E+03	3.10747E+03	2.15783E+03	1.10113E+03	5.20242E+02	8.78310E-01	4.92798E-01
.00	150.00	0.00000E+00	1.31753E+02	3.95674E+02	5.40305E+02	3.70133E+02	1.88418E+02	8.85694E+01	3.68419E-01	1.31224E-01
.00	179.10	0.00000E+00	9.12730E+01	2.82445E+02	3.88936E+02	2.67538E+02	1.36780E+02	6.49564E+01	2.70895E-01	8.85212E-02
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last radial blanket assembly is as follows:										
9.99664E-02	4.54107E-01	1.55435E+00	3.99087E+00	8.33701E+00	1.40792E+01	1.58197E+01	2.25582E+01	3.91465E+01	1.59518E+01	
1.48265E+01	2.17182E+01	4.80199E+01	5.39959E+01	6.01629E+01	4.54409E+01	1.04296E+02	1.61759E+02	1.39313E+02	4.80119E+01	
1.06779E+02	1.83134E+02	8.50298E+00	3.38140E+00	7.45000E+00	6.15575E+01	1.74908E+02	1.85296E+02	1.67906E+02	2.09928E+02	
2.63050E+02	4.61350E+02	5.72615E+01	2.53209E+02	1.14995E+02	2.72128E+01	6.78511E+01	9.75208E+01	5.97905E+01	4.22783E+02	
3.56143E+02	2.66908E+02	1.42740E+02	2.72596E+01	7.39556E+01	1.97142E+01	2.76711E+01	1.57897E+02	1.31063E+02	9.23270E+01	
6.33920E+01	4.44041E+01	1.79114E+01	2.63993E+01	1.26852E+01	5.93796E+00	2.81004E+00	2.51421E+00	2.26015E+00	2.58063E+00	
1.08511E+01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last radial blanket assembly is as follows:										
5.66494E-02	2.54676E-01	8.68859E-01	2.18001E+00	4.45515E+00	7.32772E+00	8.06472E+00	1.13838E+01	1.96253E+01	8.08635E+00	
7.44231E+00	1.09405E+01	2.42284E+01	2.69739E+01	2.98596E+01	2.27566E+01	5.20691E+01	8.01231E+01	6.91685E+01	2.35141E+01	
5.09432E+01	9.15777E+01	4.31116E+00	1.72991E+00	3.83801E+00	3.13381E+01	8.79484E+01	8.96358E+01	8.32733E+01	1.02019E+02	
1.28029E+02	2.19904E+02	2.66881E+01	1.18235E+02	4.55318E+01	5.28899E+00	2.37803E+01	3.81108E+01	2.91558E+01	2.15451E+02	
1.74608E+02	1.15117E+02	6.80850E+01	1.31322E+01	4.19770E+00	9.77552E+00	1.30049E+01	7.34402E+01	6.03739E+01	4.30255E+01	
2.85238E+01	2.17294E+01	1.01484E+01	1.49796E+01	8.52076E+00	5.20777E+00	3.47381E+00	3.17173E+00	2.89982E+00	3.43723E+00	
1.63088E+01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last radial blanket assembly is as follows:										
1.37947E-02	5.88669E-02	1.96032E-01	4.67525E-01	9.15737E-01	1.41065E+00	1.42606E+00	1.93960E+00	3.41020E+00	1.46561E+00	
1.31920E+00	1.90223E+00	4.13340E+00	4.48414E+00	4.79363E+00	3.63645E+00	8.18449E+00	1.25300E+01	1.07134E+01	3.61675E+00	
7.78208E+00	1.41878E+01	6.61830E-01	2.66424E-01	5.93408E-01	4.86277E+00	1.36586E+01	1.37717E+01	1.27970E+01	1.55549E+01	
1.96872E+01	3.30858E+01	4.10419E+00	1.83996E+01	7.37586E+00	9.92465E-01	3.02942E+00	5.24652E+00	4.30979E+00	3.34961E+01	
2.79255E+01	1.87776E+01	1.18576E+01	2.99152E+00	1.40740E+00	2.09255E+00	2.34513E+00	1.27867E+01	1.07425E+01	8.20455E+00	
5.91358E+00	5.00060E+00	3.33964E+00	4.75863E+00	3.65839E+00	2.99486E+00	2.55009E+00	2.29503E+00	2.07995E+00	2.43845E+00	
1.00585E+01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 179.10 cm past the last radial blanket assembly is as follows:										
9.21445E-03	3.90826E-02	1.29990E-01	3.17214E-01	6.38818E-01	1.01014E+00	1.05350E+00	1.45300E+00	2.51494E+00	1.05935E+00	
9.66121E-01	1.40819E+00	3.08174E+00	3.37666E+00	3.66302E+00	2.75347E+00	6.28330E+00	9.62372E+00	8.24191E+00	2.79099E+00	
5.95178E+00	1.08388E+01	5.06118E-01	2.04764E-01	4.56071E-01	3.71886E+00	1.04933E+01	1.05773E+01	9.84824E+00	1.19931E+01	
1.51928E+01	2.58366E+01	3.16407E+00	1.42182E+01	5.89125E+00	7.82437E-01	2.40629E+00	4.07378E+00	3.37134E+00	2.58966E+01	
2.14267E+01	1.43634E+01	8.68314E+00	1.89729E+00	7.98779E-01	1.48023E+00	1.73861E+00	9.57065E+00	8.03487E+00	5.97747E+00	
4.25257E+00	3.40474E+00	2.02201E+00	2.90029E+00	2.04929E+00	1.56786E+00	1.28088E+00	1.17018E+00	1.09554E+00	1.36346E+00	
7.74465E+00

Fig. G.7a. Calculational model used for Configuration IC.2 (Fe/AL/Boral/2m Na spectral modifier; basic configuration by itself). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.7a. Detailed description of the calculational model for Configuration IC.2
(Fe/AL/Boral/2m Na spectral modifier; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE				
ZMIN	ZMAX	N	R	M	(etc) ...		
461.700	473.700	15	0.0	62	----->	157.100	
426.150	461.700	19	0.0	62	----->	157.100	
369.733	426.150	30	0.0	62	----->	157.100	
368.300	369.733	2	0.0	62	----->	157.100	
363.300	368.300	3	0.0	62	----->	157.100	
356.300	363.300	4	0.0	62	----->	96.140	34 157.100
333.300	356.300	29	0.0	62	----->	96.140	34 157.100
324.733	333.300	11	0.0	62	85.980 33	96.140 34	157.100
323.300	324.733	2	0.0	62	85.980 33	96.140 34	157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)				

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

BASIC SPECTRAL MODIFIER FOR CONFIGS IC, IIIA, IIIB, IIIC, IIID, IIIE, IIIF, AND IIIF.
MADE OF 2 IRON SLABS, 3 AL SLABS, 1 BORAL SLAB, AND SIX SODIUM TANKS

Fig. 6.7b. Computational model used to represent the thick sodium spectral modifier present in Configurations IC, IIIA, IIIB, IIIC, IIID, IIIE, and IIIF.

Table G.7b. Detailed description of the calculational model used to represent the thick sodium spectral modifier present in Configurations IC, IIIA, IIIB, IIIC, IIID, IIIE, and IIIF.

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
322.665	323.300	1	0.0	28	----->	85.980	33	96.140	34	157.100		
321.561	322.665	1	0.0	46	20.350 62 ----->	84.550	28	85.980	33	96.140	34	157.100
320.457	321.561	1	0.0	46	-----> 71.000 62	84.550	28	85.980	33	96.140	34	157.100
291.643	320.457	28	0.0	46	----->	84.550	28	85.980	33	96.140	34	157.100
290.539	291.643	1	0.0	46	-----> 71.000 62	84.550	28	85.980	33	96.140	34	157.100
289.435	290.539	1	0.0	46	20.350 62 ----->	84.550	28	85.980	33	96.140	34	157.100
288.800	289.435	1	0.0	28	----->	85.980	33	96.140	34	157.100		
288.400	288.800	1	0.0	62	----->	85.980	33	96.140	34	157.100		
287.765	288.400	1	0.0	27	----->	85.980	33	96.140	34	157.100		
286.135	287.765	1	0.0	45	20.350 62 ----->	84.550	27	85.980	33	96.140	34	157.100
284.505	286.135	1	0.0	45	-----> 71.000 62	84.550	27	85.980	33	96.140	34	157.100
256.495	284.505	28	0.0	45	----->	84.550	27	85.980	33	96.140	34	157.100
254.865	256.495	1	0.0	45	-----> 71.000 62	84.550	27	85.980	33	96.140	34	157.100
253.235	254.865	1	0.0	45	20.350 62 ----->	84.550	27	85.980	33	96.140	34	157.100
252.600	253.235	1	0.0	27	----->	85.980	33	96.140	34	157.100		
251.800	252.600	1	0.0	62	----->	85.980	33	96.140	34	157.100		
251.165	251.800	1	0.0	28	----->	85.980	33	96.140	34	157.100		
250.061	251.165	1	0.0	44	20.350 62 ----->	84.550	28	85.980	33	96.140	34	157.100
248.957	250.061	1	0.0	44	-----> 71.000 62	84.550	28	85.980	33	96.140	34	157.100
220.143	248.957	28	0.0	44	----->	84.550	28	85.980	33	96.140	34	157.100
219.039	220.143	1	0.0	44	-----> 71.000 62	84.550	28	85.980	33	96.140	34	157.100
217.935	219.039	1	0.0	44	20.350 62 ----->	84.550	28	85.980	33	96.140	34	157.100
217.300	217.935	1	0.0	28	----->	85.980	33	96.140	34	157.100		
216.500	217.300	1	0.0	62	----->	85.980	33	96.140	34	157.100		
215.865	216.500	1	0.0	27	----->	85.980	33	96.140	34	157.100		
186.635	215.865	28	0.0	43	----->	84.550	27	85.980	33	96.140	34	157.100
186.000	186.635	1	0.0	27	----->	85.980	33	96.140	34	157.100		
185.500	186.000	1	0.0	62	----->	85.980	33	96.140	34	157.100		
184.865	185.500	1	0.0	28	----->	85.980	33	96.140	34	157.100		
183.365	184.865	1	0.0	42	20.350 62 ----->	84.550	28	85.980	33	96.140	34	157.100
181.847	183.365	1	0.0	42	-----> 71.000 62	84.550	28	85.980	33	96.140	34	157.100
153.653	181.847	28	0.0	42	----->	84.550	28	85.980	33	96.140	34	157.100
152.144	153.653	1	0.0	42	-----> 71.000 62	84.550	28	85.980	33	96.140	34	157.100
150.635	152.144	1	0.0	42	20.350 62 ----->	84.550	28	85.980	33	96.140	34	157.100
150.000	150.635	1	0.0	28	----->	85.980	33	96.140	34	157.100		
149.600	150.000	1	0.0	62	----->	85.980	33	96.140	34	157.100		
148.965	149.600	1	0.0	27	----->	85.980	33	96.140	34	157.100		
147.982	148.965	1	0.0	41	20.350 62 ----->	84.550	27	85.980	33	96.140	34	157.100
146.999	147.982	1	0.0	41	-----> 71.000 62	84.550	27	85.980	33	96.140	34	157.100
118.001	146.999	28	0.0	41	----->	84.550	27	85.980	33	96.140	34	157.100
117.018	118.001	1	0.0	41	-----> 71.000 62	84.550	27	85.980	33	96.140	34	157.100
116.035	117.018	1	0.0	41	20.350 62 ----->	84.550	27	85.980	33	96.140	34	157.100
115.400	116.035	1	0.0	27	----->	85.980	33	96.140	34	157.100		
115.000	115.400	1	0.0	62	----->	85.980	33	96.140	34	157.100		
112.460	115.000	9	0.0	29	----->	85.980	33	96.140	34	157.100		
111.930	112.460	1	0.0	62	----->	85.980	33	96.140	34	157.100		
109.390	111.930	5	0.0	27	----->	85.980	33	96.140	34	157.100		
108.860	109.390	1	0.0	62	----->	85.980	33	96.140	34	157.100		
105.570	108.860	5	0.0	28	----->	85.980	33	96.140	34	157.100		
105.040	105.570	1	0.0	62	----->	85.980	33	96.140	34	157.100		
101.750	105.040	5	0.0	27	----->	85.980	33	96.140	34	157.100		
101.220	101.750	1	0.0	62	----->	85.980	33	96.140	34	157.100		
96.110	101.220	9	0.0	26	----->	85.980	33	96.140	34	157.100		
95.580	96.110	1	0.0	62	----->	85.980	33	96.140	34	157.100		
90.420	95.580	9	0.0	25	----->	85.980	33	96.140	34	157.100		
89.890	90.420	1	0.0	62	----->	85.980	33	96.140	34	157.100		

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.7. Results for Config IC.2

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.23300E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	7.94432E+01	1.36864E+02	1.43102E+02	6.19244E+01	2.64640E+01	1.07756E+01	1.95366E-01	1.24740E-01
.00	.70	0.00000E+00	7.29185E+01	1.26334E+02	1.32818E+02	5.80180E+01	2.49698E+01	1.02308E+01	1.90851E-01	1.20372E-01
.00	30.00	0.00000E+00	3.54923E+01	5.68801E+01	5.58927E+01	2.08349E+01	8.25183E+00	3.16038E+00	1.24975E-01	7.10257E-02
.00	150.00	0.00000E+00	7.47051E+00	1.17615E+01	1.15146E+01	4.25876E+00	1.68015E+00	6.42644E-01	3.30076E-02	1.53273E-02

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last sodium tank is as follows:

1.54396E-04	5.55365E-04	1.90147E-03	3.90066E-03	6.77312E-03	1.14635E-02	1.34829E-02	1.82665E-02	2.36599E-02	6.70212E-03
7.47488E-03	1.31396E-02	6.07466E-02	8.96001E-02	8.93098E-02	7.63969E-02	6.88473E-02	5.50939E-02	7.31110E-02	6.94171E-02
1.98016E-01	2.56492E-01	6.93685E-03	7.55384E-03	3.86123E-02	1.48949E-01	2.69436E-01	2.11292E-01	3.09486E-01	4.16104E-01
6.56281E-01	1.08163E+00	6.83300E-02	8.23772E-01	5.90427E-01	1.79848E-01	1.19944E-01	1.67488E-01	1.64540E-01	1.47182E+00
1.51254E+00	1.05544E+00	3.02191E-01	3.15617E-02	8.01328E-03	2.09306E-02	4.19254E-02	1.32358E+00	3.11896E+00	4.38134E+00
5.25182E+00	5.86158E+00	6.19427E+00	8.57827E+00	8.19014E+00	7.33216E+00	6.18047E+00	4.96603E+00	3.84248E+00	3.45181E+00
2.92946E+00									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the last sodium tank is as follows:

1.51264E-04	5.45518E-04	1.86676E-03	3.82395E-03	6.62628E-03	1.11784E-02	1.30864E-02	1.77069E-02	2.27941E-02	6.49683E-03
7.16129E-03	1.25746E-02	5.82165E-02	8.56763E-02	8.47157E-02	7.28150E-02	6.45938E-02	5.18959E-02	6.81297E-02	6.55159E-02
1.83788E-01	2.40311E-01	6.49929E-03	6.88017E-03	3.53377E-02	1.38917E-01	2.52993E-01	1.93448E-01	2.73130E-01	3.76919E-01
5.76889E-01	9.93424E-01	6.49151E-02	7.13345E-01	5.34616E-01	1.73769E-01	1.16935E-01	1.63518E-01	1.61000E-01	1.43258E+00
1.46160E+00	1.01619E+00	2.91834E-01	3.14585E-02	8.45617E-03	2.10946E-02	4.08469E-02	1.27647E+00	3.00463E+00	4.21609E+00
5.05053E+00	5.63899E+00	5.95961E+00	8.25620E+00	7.88702E+00	7.06390E+00	5.95652E+00	4.78941E+00	3.71028E+00	3.34223E+00
2.92600E+00									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last sodium tank is as follows:

1.21499E-04	4.40932E-04	1.49068E-03	2.95996E-03	4.92599E-03	7.95482E-03	8.89314E-03	1.18990E-02	1.48878E-02	4.14216E-03
4.63830E-03	8.02452E-03	3.73501E-02	5.41062E-02	5.27145E-02	4.45962E-02	4.02580E-02	3.19353E-02	4.27396E-02	4.18143E-02
1.11549E-01	1.46017E-01	3.77378E-03	4.36243E-03	2.32403E-02	8.50698E-02	1.48559E-01	1.17159E-01	1.72677E-01	2.18409E-01
3.61105E-01	5.73176E-01	3.55795E-02	4.56695E-01	2.89700E-01	9.83630E-02	6.71855E-02	9.50759E-02	9.43843E-02	8.45354E-01
8.62128E-01	6.03049E-01	1.67392E-01	1.60324E-02	3.99317E-03	1.22363E-02	2.55226E-02	7.68536E-01	1.74436E+00	2.41674E+00
2.88214E+00	3.20938E+00	3.38566E+00	4.70154E+00	4.50680E+00	4.06474E+00	3.46829E+00	2.83545E+00	2.24377E+00	2.09373E+00
2.25242E+00									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last sodium tank is as follows:

4.95956E-05	1.83555E-04	6.05903E-04	1.15326E-03	1.74651E-03	2.57080E-03	2.56706E-03	3.40061E-03	3.76016E-03	9.65837E-04
1.10534E-03	1.81020E-03	9.28867E-03	1.29517E-02	1.13501E-02	9.08627E-03	8.08574E-03	6.36511E-03	8.71974E-03	1.07985E-02
2.26613E-02	2.91579E-02	7.30679E-04	9.70001E-04	6.49048E-03	1.88413E-02	2.84187E-02	2.25857E-02	3.40445E-02	4.38437E-02
6.83939E-02	1.10152E-01	6.73822E-03	8.50519E-02	5.59375E-02	1.82522E-02	1.22931E-02	1.74439E-02	1.74296E-02	1.57004E-01
1.60002E-01	1.14101E-01	3.97051E-02	8.31825E-03	4.00194E-03	6.20591E-03	7.01374E-03	1.41096E-01	3.30573E-01	4.62740E-01
5.53119E-01	6.18231E-01	6.56187E-01	9.32920E-01	9.07085E-01	8.36022E-01	7.34355E-01	6.22421E-01	5.15494E-01	5.17599E-01
7.42835E-01

Fig. G.8. Computational model used for Configuration IC.6 (Fe/AL/Boral/2m Na spectral modifier; basic configuration, with extended concrete ring in analytic model to simulate background radiation). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.8. Detailed description of the calculational model for Configuration IC.6 (Fe/AL/Boral/2m Na spectral modifier; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE				
ZMIN	ZMAX	N	R	M	(etc) ...		
461.700	473.700	15	0.0	62	----->	157.100	
406.410	461.700	29	0.0	62	----->	157.100	
369.733	406.410	20	0.0	62	----->	135.400	34 157.100
368.300	369.733	2	0.0	62	----->	135.400	34 157.100
363.300	368.300	3	0.0	62	----->	135.400	34 157.100
356.300	363.300	4	0.0	62	----->	96.140	34 -----> 157.100
333.300	356.300	29	0.0	62	----->	96.140	34 -----> 157.100
324.733	333.300	11	0.0	62	85.980 33	96.140 34 ----->	157.100
323.300	324.733	2	0.0	62	85.980 33	96.140 34 ----->	157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)				

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.8. Results for Config IC.6

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.23300E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	8.01317E+01	1.37798E+02	1.43940E+02	6.21746E+01	2.65521E+01	1.08056E+01	2.10042E-01	1.27265E-01
.00	.70	0.00000E+00	7.36356E+01	1.27307E+02	1.33695E+02	5.82811E+01	2.50622E+01	1.02621E+01	2.06000E-01	1.23001E-01
.00	30.00	0.00000E+00	3.57572E+01	5.72309E+01	5.62108E+01	2.09405E+01	8.29258E+00	3.17580E+00	1.35239E-01	7.23370E-02
.00	150.00	0.00000E+00	8.01108E+00	1.25173E+01	1.22164E+01	4.49118E+00	1.76536E+00	6.72237E-01	4.26642E-02	1.70364E-02
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last sodium tank is as follows:										
1.54394E-04	5.55353E-04	1.90148E-03	3.90055E-03	6.77308E-03	1.14616E-02	1.34890E-02	1.82932E-02	2.37596E-02	6.73717E-03	
7.50798E-03	1.32083E-02	6.09056E-02	8.98699E-02	8.97334E-02	7.68808E-02	6.97892E-02	5.57954E-02	7.37110E-02	6.96492E-02	
1.98860E-01	2.58173E-01	7.02341E-03	7.59363E-03	3.87092E-02	1.49650E-01	2.71410E-01	2.13427E-01	3.11694E-01	4.18915E-01	
6.60673E-01	1.08892E+00	6.93098E-02	8.30235E-01	5.94522E-01	1.80936E-01	1.20684E-01	1.68525E-01	1.65565E-01	1.48188E+00	
1.52483E+00	1.06785E+00	3.11144E-01	3.50444E-02	1.02382E-02	2.39843E-02	4.45135E-02	1.33757E+00	3.13448E+00	4.40239E+00	
5.27934E+00	5.89776E+00	6.23666E+00	8.65152E+00	8.27189E+00	7.42011E+00	6.27027E+00	5.05423E+00	3.92989E+00	3.56401E+00	
3.44578E+00										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the last sodium tank is as follows:										
1.51262E-04	5.45520E-04	1.86677E-03	3.82402E-03	6.62623E-03	1.11765E-02	1.30935E-02	1.77369E-02	2.29047E-02	6.53479E-03	
7.19694E-03	1.26483E-02	5.83874E-02	8.59698E-02	8.51736E-02	7.33335E-02	6.56206E-02	5.26306E-02	6.87456E-02	6.57457E-02	
1.84650E-01	2.42101E-01	6.59522E-03	6.92222E-03	3.54362E-02	1.39654E-01	2.55086E-01	1.95727E-01	2.75430E-01	3.79866E-01	
5.81519E-01	1.00104E+00	6.59688E-02	7.20153E-01	5.38875E-01	1.74896E-01	1.17703E-01	1.64593E-01	1.62067E-01	1.44314E+00	
1.47453E+00	1.02924E+00	3.01284E-01	3.51590E-02	1.08423E-02	2.42464E-02	4.34818E-02	1.29073E+00	3.02085E+00	4.23834E+00	
5.07974E+00	5.67726E+00	6.00448E+00	8.33363E+00	7.97316E+00	7.15619E+00	6.05050E+00	4.88160E+00	3.80140E+00	3.45878E+00	
3.45796E+00										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last sodium tank is as follows:										
1.21499E-04	4.40920E-04	1.49069E-03	2.95995E-03	4.92611E-03	7.95487E-03	8.89626E-03	1.19072E-02	1.49163E-02	4.15405E-03	
4.65104E-03	8.05330E-03	3.74106E-02	5.41970E-02	5.28646E-02	4.47617E-02	4.05535E-02	3.22217E-02	4.30111E-02	4.19289E-02	
1.11911E-01	1.46591E-01	3.80167E-03	4.37663E-03	2.32777E-02	8.53380E-02	1.49262E-01	1.17911E-01	1.73566E-01	2.19445E-01	
3.62776E-01	5.75885E-01	3.59126E-02	4.59202E-01	2.91169E-01	9.87632E-02	6.74540E-02	9.54514E-02	9.47535E-02	8.48831E-01	
8.66335E-01	6.07374E-01	1.70631E-01	1.73878E-02	4.90071E-03	1.35259E-02	2.65703E-02	7.74037E-01	1.74990E+00	2.42362E+00	
2.89081E+00	3.22084E+00	3.39914E+00	4.72575E+00	4.53501E+00	4.09628E+00	3.50192E+00	2.87088E+00	2.28137E+00	2.14692E+00	
2.63342E+00										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last sodium tank is as follows:										
4.96239E-05	1.83797E-04	6.06751E-04	1.15587E-03	1.75367E-03	2.58583E-03	2.59155E-03	3.44199E-03	3.83919E-03	9.90147E-04	
1.13081E-03	1.85638E-03	9.40888E-03	1.31784E-02	1.16722E-02	9.37652E-03	8.62139E-03	6.84054E-03	9.08073E-03	1.09221E-02	
2.32142E-02	3.03723E-02	7.94860E-04	9.94057E-04	6.54214E-03	1.92736E-02	2.98535E-02	2.40285E-02	3.54738E-02	4.55370E-02	
7.14712E-02	1.14731E-01	7.57114E-03	8.95093E-02	5.80286E-02	1.89142E-02	1.27544E-02	1.81060E-02	1.81141E-02	1.64102E-01	
1.68472E-01	1.22293E-01	4.54277E-02	1.08314E-02	5.68588E-03	7.84622E-03	8.09550E-03	1.48433E-01	3.42216E-01	4.79572E-01	
5.75009E-01	6.45072E-01	6.87486E-01	9.85593E-01	9.64631E-01	8.96465E-01	7.95205E-01	6.82304E-01	5.74110E-01	5.93151E-01	
1.08048E+00

Fig. G.9. Computational model used for Configuration IC.7 (Fe/Al/Boral/2m Na spectral modifier; basic configuration, with extended concrete ring and Cd hut). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.9. Detailed description of the calculational model for Configuration IC.7 (Fe/AL/Boral/2m Na spectral modifier; basic configuration, with extended concrete ring and Cd hut).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
461.700	473.700	15	0.0	62	----->	157.100						
406.410	461.700	29	0.0	62	----->	157.100						
369.733	406.410	20	0.0	62	----->	135.400	34	157.100				
368.300	369.733	2	0.0	67	----->	85.980	62	----->	135.400	34	157.100	
363.300	368.300	3	0.0	62	84.547	67	85.980	62	----->	135.400	34	157.100
356.300	363.300	4	0.0	62	84.547	67	85.980	62	96.140	34	----->	157.100
333.300	356.300	29	0.0	62	84.547	67	85.980	62	96.140	34	----->	157.100
324.733	333.300	11	0.0	62	84.547	67	85.980	33	96.140	34	----->	157.100
323.300	324.733	2	0.0	62	84.547	67	85.980	33	96.140	34	----->	157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.9. Results for Config IC.7

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.23300E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	8.03693E+01	1.38233E+02	1.44381E+02	6.23369E+01	2.66127E+01	1.08269E+01	1.74272E-01	1.24852E-01
.00	.70	0.00000E+00	7.38592E+01	1.27735E+02	1.34133E+02	5.84446E+01	2.51235E+01	1.02838E+01	1.67723E-01	1.20363E-01
.00	30.00	0.00000E+00	3.61668E+01	5.78948E+01	5.68542E+01	2.11644E+01	8.37468E+00	3.20500E+00	1.08112E-01	7.10546E-02
.00	150.00	0.00000E+00	7.62890E+00	1.20451E+01	1.17918E+01	4.35602E+00	1.71518E+00	6.54323E-01	2.20359E-02	1.46843E-02

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last sodium tank is as follows:

1.54396E-04	5.55345E-04	1.90298E-03	3.90459E-03	6.77937E-03	1.14711E-02	1.35005E-02	1.83098E-02	2.37813E-02	6.74467E-03
7.51714E-03	1.32293E-02	6.10060E-02	9.00498E-02	8.99569E-02	7.71150E-02	7.00702E-02	5.61720E-02	7.42073E-02	6.99721E-02
2.00642E-01	2.60426E-01	7.11981E-03	7.63783E-03	3.88171E-02	1.50826E-01	2.74051E-01	2.15657E-01	3.14260E-01	4.22526E-01
6.66099E-01	1.09848E+00	7.03205E-02	8.36872E-01	5.99569E-01	1.82413E-01	1.21694E-01	1.69962E-01	1.66990E-01	1.49473E+00
1.53828E+00	1.07786E+00	3.15006E-01	3.57409E-02	1.04889E-02	2.44576E-02	4.51113E-02	1.34661E+00	3.14941E+00	4.42249E+00
5.30275E+00	5.92178E+00	6.26410E+00	8.67642E+00	8.30106E+00	7.45391E+00	6.30499E+00	5.08812E+00	3.95228E+00	3.47611E+00
2.02399E+00									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the last sodium tank is as follows:

1.51264E-04	5.45511E-04	1.86833E-03	3.82852E-03	6.63310E-03	1.11868E-02	1.31057E-02	1.77542E-02	2.29265E-02	6.54228E-03
7.20626E-03	1.26698E-02	5.84911E-02	8.61548E-02	8.54012E-02	7.35694E-02	6.59004E-02	5.30153E-02	6.92568E-02	6.60829E-02
1.86499E-01	2.44403E-01	6.69522E-03	6.96669E-03	3.55426E-02	1.40883E-01	2.57783E-01	1.97988E-01	2.78046E-01	3.83578E-01
5.87063E-01	1.01078E+00	6.69977E-02	7.26840E-01	5.44043E-01	1.76393E-01	1.18724E-01	1.66042E-01	1.63506E-01	1.45611E+00
1.48807E+00	1.03926E+00	3.05113E-01	3.58354E-02	1.10811E-02	2.47017E-02	4.40641E-02	1.29976E+00	3.03587E+00	4.25858E+00
5.10320E+00	5.70109E+00	6.03187E+00	8.35700E+00	8.00140E+00	7.18965E+00	6.08494E+00	4.91512E+00	3.82264E+00	3.36005E+00
1.93899E+00									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last sodium tank is as follows:

1.21493E-04	4.41182E-04	1.49266E-03	2.97208E-03	4.94225E-03	7.97813E-03	8.92335E-03	1.19444E-02	1.49690E-02	4.17134E-03
4.67122E-03	8.09641E-03	3.75980E-02	5.45210E-02	5.32553E-02	4.51581E-02	4.11093E-02	3.28722E-02	4.38673E-02	4.25193E-02
1.14803E-01	1.50170E-01	3.96910E-03	4.44165E-03	2.34034E-02	8.73880E-02	1.53272E-01	1.21199E-01	1.77614E-01	2.24681E-01
3.71401E-01	5.89460E-01	3.74244E-02	4.69516E-01	2.97752E-01	1.00845E-01	6.89225E-02	9.75673E-02	9.68690E-02	8.67882E-01
8.85995E-01	6.21795E-01	1.76088E-01	1.85498E-02	5.42351E-03	1.42207E-02	2.73218E-02	7.86442E-01	1.77228E+00	2.45463E+00
2.92768E+00	3.26059E+00	3.44352E+00	4.77818E+00	4.59120E+00	4.15408E+00	3.56007E+00	2.92856E+00	2.32623E+00	2.10963E+00
1.53119E+00									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last sodium tank is as follows:

4.93413E-05	1.82814E-04	6.03264E-04	1.14766E-03	1.73848E-03	2.56143E-03	2.56576E-03	3.40718E-03	3.80153E-03	9.80523E-04
1.11967E-03	1.83912E-03	9.31341E-03	1.30500E-02	1.15703E-02	9.30185E-03	8.55413E-03	6.78367E-03	8.96195E-03	1.07036E-02
2.28863E-02	3.00284E-02	7.94988E-04	9.73661E-04	6.38778E-03	1.90075E-02	2.95759E-02	2.38559E-02	3.50567E-02	4.50413E-02
7.06707E-02	1.13493E-01	7.56466E-03	8.85224E-02	5.74207E-02	1.86866E-02	1.25982E-02	1.78792E-02	1.78821E-02	1.61994E-01
1.66319E-01	1.20797E-01	4.49953E-02	1.07961E-02	5.71238E-03	7.80515E-03	8.01401E-03	1.46235E-01	3.35793E-01	4.71688E-01
5.62896E-01	6.25072E-01	6.74700E-01	9.32006E-01	9.34972E-01	8.83240E-01	7.82758E-01	6.68102E-01	5.51055E-01	4.33503E-01
3.03426E-01

Fig. G.10. Computational model used for Configuration IC.8 (Fe/AL/Boral/2m Na spectral modifier; basic configuration, with extended concrete ring and Cd plate). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.10. Detailed description of the calculational model for Configuration IC.8 (Fe/AL/Boral/2m Na spectral modifier; basic configuration, with extended concrete ring and Cd plate).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE				
ZMIN	ZMAX	N	R	M	(etc) ...		
461.700	473.700	15	0.0	62	----->	157.100	
406.410	461.700	29	0.0	62	----->	157.100	
369.733	406.410	20	0.0	62	----->	135.400	34 157.100
368.300	369.733	2	0.0	62	----->	135.400	34 157.100
363.300	368.300	3	0.0	62	----->	135.400	34 157.100
356.300	363.300	4	0.0	62	----->	96.140	34 157.100
333.300	356.300	29	0.0	62	----->	96.140	34 157.100
324.733	333.300	11	0.0	62	85.980 33	96.140 34	-----> 157.100
323.300	324.733	2	0.0	67	85.980 33	96.140 34	-----> 157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)				

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.10. Results for Config IC.8

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.23300E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	8.15466E+01	1.40100E+02	1.46154E+02	6.29174E+01	2.68207E+01	1.08984E+01	1.53824E-01	1.23880E-01
.00	2.13	0.00000E+00	6.34887E+01	1.10343E+02	1.16625E+02	5.19752E+01	2.25694E+01	9.30401E+00	1.30560E-01	1.07128E-01
.00	30.00	0.00000E+00	3.41380E+01	5.52184E+01	5.43944E+01	2.03338E+01	8.05650E+00	3.08680E+00	8.15530E-02	6.44400E-02
.00	150.00	0.00000E+00	7.69848E+00	1.21299E+01	1.18664E+01	4.37425E+00	1.72032E+00	6.55358E-01	2.59529E-02	1.50897E-02

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last sodium tank is as follows:

1.54288E-04	5.55040E-04	1.90141E-03	3.90437E-03	6.78406E-03	1.14849E-02	1.35275E-02	1.83516E-02	2.38591E-02	6.77971E-03
7.56082E-03	1.33325E-02	6.15138E-02	9.10027E-02	9.11766E-02	7.84305E-02	7.13670E-02	5.77714E-02	7.62900E-02	7.14422E-02
2.07929E-01	2.69157E-01	7.51535E-03	7.76561E-03	3.90312E-02	1.55665E-01	2.84193E-01	2.23631E-01	3.23462E-01	4.36230E-01
6.85705E-01	1.13594E+00	7.39924E-02	8.59745E-01	6.19291E-01	1.88653E-01	1.25945E-01	1.76046E-01	1.73048E-01	1.54827E+00
1.59271E+00	1.11522E+00	3.26051E-01	3.63195E-02	1.00019E-02	2.44008E-02	4.59071E-02	1.37713E+00	3.20483E+00	4.50272E+00
5.39018E+00	5.99809E+00	6.37362E+00	8.71011E+00	8.40636E+00	7.59368E+00	6.43462E+00	5.19935E+00	4.00413E+00	3.18510E+00
1.19733E+00									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 2.13 cm past the last sodium tank is as follows:

1.48973E-04	5.38371E-04	1.83795E-03	3.74964E-03	6.48731E-03	1.09032E-02	1.27383E-02	1.72559E-02	2.22954E-02	6.35307E-03
7.00688E-03	1.23250E-02	5.68128E-02	8.37421E-02	8.31550E-02	7.17609E-02	6.46258E-02	5.18382E-02	6.73470E-02	6.37836E-02
1.80978E-01	2.37774E-01	6.67743E-03	6.66358E-03	3.39197E-02	1.37117E-01	2.50840E-01	1.93449E-01	2.71496E-01	3.71489E-01
5.71635E-01	9.79711E-01	6.59725E-02	7.08397E-01	5.25076E-01	1.69793E-01	1.14626E-01	1.60756E-01	1.57963E-01	1.40868E+00
1.43755E+00	1.00497E+00	2.97238E-01	3.60328E-02	1.16140E-02	2.46523E-02	4.27416E-02	1.24286E+00	2.88532E+00	4.07211E+00
4.83232E+00	5.28617E+00	5.75619E+00	7.39120E+00	7.48305E+00	6.96666E+00	5.89153E+00	4.71944E+00	3.53543E+00	1.94828E+00
9.42538E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last sodium tank is as follows:

1.20572E-04	4.37538E-04	1.47825E-03	2.93178E-03	4.87662E-03	7.86985E-03	8.79601E-03	1.17732E-02	1.47464E-02	4.10622E-03
4.59852E-03	7.96717E-03	3.70204E-02	5.36696E-02	5.23955E-02	4.44170E-02	4.02273E-02	3.20524E-02	4.25783E-02	4.12606E-02
1.11125E-01	1.45555E-01	3.84433E-03	4.29140E-03	2.27388E-02	8.46725E-02	1.48652E-01	1.17767E-01	1.72203E-01	2.18385E-01
3.59834E-01	5.73376E-01	3.62859E-02	4.55240E-01	2.90364E-01	9.80455E-02	6.69569E-02	9.47640E-02	9.40841E-02	8.42791E-01
8.60172E-01	6.03646E-01	1.70920E-01	1.76932E-02	4.96919E-03	1.35543E-02	2.64418E-02	7.64183E-01	1.71759E+00	2.38669E+00
2.82918E+00	3.11121E+00	3.34211E+00	4.42563E+00	4.39791E+00	4.05989E+00	3.46647E+00	2.82362E+00	2.18412E+00	1.40262E+00
6.92299E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last sodium tank is as follows:

4.92748E-05	1.82571E-04	6.02397E-04	1.14614E-03	1.73687E-03	2.55969E-03	2.56452E-03	3.40541E-03	3.79914E-03	9.80115E-04
1.11899E-03	1.83830E-03	9.30609E-03	1.30407E-02	1.15696E-02	9.30756E-03	8.55645E-03	6.80048E-03	8.97902E-03	1.07067E-02
2.29815E-02	3.00829E-02	7.96666E-04	9.74961E-04	6.38875E-03	1.90242E-02	2.96645E-02	2.39362E-02	3.51268E-02	4.52031E-02
7.08063E-02	1.14010E-01	7.60812E-03	8.87012E-02	5.77536E-02	1.87659E-02	1.26519E-02	1.79589E-02	1.79631E-02	1.62687E-01
1.67082E-01	1.21435E-01	4.52624E-02	1.08085E-02	5.66996E-03	7.79847E-03	8.04773E-03	1.46867E-01	3.36656E-01	4.72764E-01
5.64298E-01	6.27006E-01	6.76561E-01	9.37017E-01	9.38871E-01	8.85794E-01	7.85235E-01	6.70885E-01	5.55005E-01	4.56789E-01
4.52855E-01

Fig. G.11. Computational model used for Configuration IC/PB.1 (Fe/AL/Boral/2m Na/Pb slabs; basic configuration by itself). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.11. Detailed description of the calculational model for Configuration IC/PB.1 (Fe/AL/Boral/2m Na/Pb slabs; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE				
ZMIN	ZMAX	N	R	M	(etc) ...		
473.700	485.700	15	0.0	62	----->	157.100	
368.300	473.700	53	0.0	62	----->	157.100	
363.300	368.300	6	0.0	62	----->	157.100	
335.300	363.300	35	0.0	62	----->	96.140	34 157.100
333.300	335.300	4	0.0	31	85.980	62 96.140	34 157.100
331.490	333.300	3	0.0	31	85.980	33 96.140	34 157.100
327.680	331.490	7	0.0	30	85.980	33 96.140	34 157.100
323.300	327.680	4	0.0	62	85.980	33 96.140	34 157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)				

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.11. Results for Config IC/PB.1

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.35300E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	7.29183E+01	1.33436E+02	1.47505E+02	6.74611E+01	2.80020E+01	1.10248E+01	1.19694E-01	7.33711E-02
.00	25.00	0.00000E+00	2.12803E+01	3.32832E+01	3.23170E+01	1.17806E+01	4.68970E+00	1.82199E+00	7.77395E-02	4.40312E-02
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last Pb slab is as follows:										
6.89454E-05	2.52090E-04	8.21685E-04	1.63127E-03	2.63830E-03	4.00103E-03	4.70232E-03	7.29994E-03	1.10275E-02	3.28209E-03	
3.81277E-03	7.40267E-03	3.25884E-02	5.19553E-02	5.36298E-02	5.18643E-02	4.82428E-02	4.11065E-02	4.47165E-02	4.96136E-02	
1.32380E-01	1.45083E-01	5.86328E-03	2.66438E-03	9.96817E-03	7.51980E-02	1.54463E-01	1.31276E-01	1.48907E-01	1.99421E-01	
3.27015E-01	5.01428E-01	6.73546E-02	4.11251E-01	2.86957E-01	9.12968E-02	6.22996E-02	8.27896E-02	9.14243E-02	8.15542E-01	
8.64592E-01	6.83571E-01	2.87997E-01	6.30204E-02	2.19463E-02	2.43676E-02	2.86062E-02	7.32774E-01	1.53642E+00	2.17126E+00	
2.68769E+00	3.07715E+00	3.33744E+00	4.81065E+00	4.70316E+00	4.34215E+00	3.78135E+00	3.12744E+00	2.47225E+00	2.26524E+00	
1.92385E+00										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 25.00 cm past the last Pb slab is as follows:										
5.62421E-05	2.05484E-04	6.74689E-04	1.31544E-03	2.07996E-03	3.07043E-03	3.45565E-03	5.16911E-03	7.51220E-03	2.20913E-03	
2.54652E-03	4.87785E-03	2.14846E-02	3.37254E-02	3.43930E-02	3.26995E-02	3.03548E-02	2.57254E-02	2.82745E-02	3.08802E-02	
8.21006E-02	9.03809E-02	3.55327E-03	1.71403E-03	6.79017E-03	4.68788E-02	9.50038E-02	8.05694E-02	9.15279E-02	1.21342E-01	
1.96762E-01	2.98289E-01	3.94964E-02	2.42839E-01	1.72432E-01	5.49446E-02	3.74008E-02	4.88716E-02	5.47860E-02	4.83519E-01	
5.09424E-01	4.01050E-01	1.68472E-01	3.66260E-02	1.29513E-02	1.47474E-02	1.73744E-02	4.32958E-01	9.02641E-01	1.27352E+00	
1.57456E+00	1.80207E+00	1.95428E+00	2.82139E+00	2.76478E+00	2.56340E+00	2.24288E+00	1.87115E+00	1.49646E+00	1.40002E+00	
1.40616E+00

Fig. G.12. Calculation model used for Configuration IC/PB.9 (Fe/AL/Boral/2m Na/Pb slabs; basic configuration, with extended concrete ring in analytic model to simulate background radiation). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.12. Detailed description of the calculational model for Configuration IC/PB.9 (Fe/AL/Boral/2m Na/Pb slabs; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE					
ZMIN	ZMAX	N	R	M	(etc) ...			
473.700	485.700	15	0.0	62	----->	157.100		
418.410	473.700	28	0.0	62	----->	157.100		
368.300	418.410	25	0.0	62	----->	135.400	34	157.100
363.300	368.300	6	0.0	62	----->	135.400	34	157.100
335.300	363.300	35	0.0	62	----->	96.140	34	157.100
333.300	335.300	4	0.0	31	85.980 62	96.140	34	157.100
331.490	333.300	3	0.0	31	85.980 33	96.140	34	157.100
327.680	331.490	7	0.0	30	85.980 33	96.140	34	157.100
323.300	327.680	4	0.0	62	85.980 33	96.140	34	157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)					

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.12. Results for Config 1C/PB.9

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.35300E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	7.33359E+01	1.33967E+02	1.47963E+02	6.75921E+01	2.80486E+01	1.10407E+01	1.31739E-01	7.53760E-02
.00	25.00	0.00000E+00	2.15994E+01	3.37003E+01	3.26884E+01	1.19018E+01	4.73882E+00	1.84219E+00	8.78634E-02	4.54661E-02

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last Pb slab is as follows:

6.89457E-05	2.52091E-04	8.21678E-04	1.63125E-03	2.63832E-03	4.00246E-03	4.70982E-03	7.32116E-03	1.11086E-02	3.31072E-03
3.84033E-03	7.45854E-03	3.27284E-02	5.22356E-02	5.40706E-02	5.23711E-02	4.93193E-02	4.18274E-02	4.52888E-02	4.98316E-02
1.33204E-01	1.47006E-01	5.96113E-03	2.70186E-03	1.00474E-02	7.58678E-02	1.56427E-01	1.33332E-01	1.50859E-01	2.01662E-01
3.30907E-01	5.06526E-01	6.82572E-02	4.16571E-01	2.89337E-01	9.20090E-02	6.28005E-02	8.35136E-02	9.21821E-02	8.23094E-01
8.73918E-01	6.93240E-01	2.95322E-01	6.64636E-02	2.43540E-02	2.66916E-02	3.00875E-02	7.41232E-01	1.54797E+00	2.18741E+00
2.70905E+00	3.10378E+00	3.36951E+00	4.86759E+00	4.76319E+00	4.40874E+00	3.84773E+00	3.19576E+00	2.54358E+00	2.35724E+00
2.35049E+00									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 25.00 cm past the last Pb slab is as follows:

5.62423E-05	2.05485E-04	6.74681E-04	1.31541E-03	2.08010E-03	3.07162E-03	3.46021E-03	5.18056E-03	7.55537E-03	2.22529E-03
2.56269E-03	4.91188E-03	2.15670E-02	3.38868E-02	3.46480E-02	3.29979E-02	3.09555E-02	2.61650E-02	2.86396E-02	3.10194E-02
8.26018E-02	9.14836E-02	3.61127E-03	1.73628E-03	6.83712E-03	4.72845E-02	9.61882E-02	8.17862E-02	9.27198E-02	1.22693E-01
1.99089E-01	3.01331E-01	4.00311E-02	2.45992E-01	1.73849E-01	5.53707E-02	3.76963E-02	4.92969E-02	5.52336E-02	4.87908E-01
5.14841E-01	4.06712E-01	1.72809E-01	3.87158E-02	1.44323E-02	1.61994E-02	1.83118E-02	4.38176E-01	9.09549E-01	1.28288E+00
1.58690E+00	1.81728E+00	1.97256E+00	2.85404E+00	2.80078E+00	2.60318E+00	2.28469E+00	1.91411E+00	1.54182E+00	1.46133E+00
1.77574E+00									

TOP VIEW OF
CONFIG. IIIA

Fig. G.13. Top view of the calculational model used for configurations IIIA.1b and IIIA.1d featuring the heterogeneous IVFS fuel slab. Axially, the model includes the IVFS fuel slab and the last of six sodium tanks, with a 3-D XYZ boundary source located at what would have been the interface between the fifth and sixth sodium tanks. Vertical XY planes represented by views AA and BB are shown in Figs. G.14a and G.14b.

Fig. G.14a. Cross section through the heterogeneous IVFS fuel slab corresponding to View AA in Fig. G.13 for Configs IIIA.1b and IIIA.1d.

Fig. G.14b. Cross section through the sodium tank corresponding to View BB in Fig. G.13 for Configurations IIIA.1b and IIIA.1d.

Table G.13. Location of materials used in the 3-D XYZ TORT model(s) for Configuration IIIA involving the Fe, AL, and Boral slabs, the 2m-thick Na spectral modifier and the heterogeneous IVFS mockup (1,2).

Zone No.	Matl No.	XMIN 14**	XMAX 15**	YMIN 16**	YMAX 17**	ZMIN 18**	ZMAX 19**	DESCRIPTION <-- TORT array number
1	62	0.000	147.320	-167.640	147.320	288.800	371.568	void
2	34	0.000	147.320	-167.640	147.320	288.800	363.300	concrete
3	62	0.000	86.360	-96.520	86.360	288.800	363.300	void
4	33	0.000	86.360	-96.520	86.360	288.800	343.200	lithiated paraffin
5	28	0.000	76.200	-76.200	76.200	288.800	323.300	AL around Na tank
6	46	0.000	74.930	-74.930	74.930	289.435	322.665	Na in Na tank
7	62	0.000	46.090	-55.575	55.575	323.300	343.200	void
8	27	0.000	46.090	-55.575	55.575	323.300	340.190	AL around IVFS slab
9	28	7.815	22.995	-53.085	53.115	323.935	339.555	AL spacer in IVFS
10	28	38.625	43.610	-53.085	53.115	323.935	339.555	AL spacer in IVFS

(half of) central fuel column:

11	56	0.000	7.815	-53.085	53.115	323.935	339.555	top of fuel pins
12	57	0.000	7.815	-53.085	51.465	323.935	339.555	fission gas plenum
13	58	0.000	7.815	-53.085	41.989	323.935	339.555	insulator
14	59	0.000	7.815	-53.085	40.922	323.935	339.555	active fuel
15	60	0.000	7.815	-53.085	-50.518	323.935	339.555	insulator
16	61	0.000	7.815	-53.085	-51.585	323.935	339.555	bottom of fuel pins

other (complete) fuel column:

17	56	22.995	38.625	-53.085	53.115	323.935	339.555	top of fuel pins
18	57	22.995	38.625	-53.085	51.465	323.935	339.555	fission gas plenum
19	58	22.995	38.625	-53.085	41.989	323.935	339.555	insulator
20	59	22.995	38.625	-53.085	40.922	323.935	339.555	active fuel
21	60	22.995	38.625	-53.085	-50.518	323.935	339.555	insulator
22	61	22.995	38.625	-53.085	-51.585	323.935	339.555	bottom of fuel pins

- 1) An internal boundary flux based on the 2-D DORT flux between the fifth and sixth sodium tanks in Config IIIB.1 (i.e., at Z=288.8 cm) was used as an external boundary source in this 3-D XYZ TORT model which explicitly models only those components downstream of that location.
- 2) Calculational run IIIA.1b used the faster (albeit sometimes less accurate) theta-weighted difference scheme to solve for the flux throughout this geometric model, whereas calculational run IIIA.1d used the slower (but generally more accurate) nodal method to solve for the fluxes throughout this same geometric model. In the text, these are loosely referred to as Configurations IIIA.1b and IIIA.1d, respectively, although the same geometric model was used in both cases.
- 3) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 4) The fine mesh boundaries for this XYZ model are given in Table G.14. Model includes all X>0; a reflective boundary condition was then applied at the X=0 plane.
- 5) The materials used in each of the 22 box-like zones given above are to be interpreted in a "progressive" fashion, such that the specifications for each zone override the specifications for all previous zones. Thus: zone 2 overlays portions of zone 1, zone 3 overlays portions of zone 2; etc.

Table G.14. Fine mesh boundaries (cm) used in the 3-D XYZ TORT model(s) of Configuration IIIA involving the Fe, AL, and Boral slabs, the 2m-thick Na spectral modifier and the heterogeneous IVFS mockup.

I	XMIN	to	XMAX	J	YMIN	to	YMAX	K	ZMIN	to	ZMAX
1	.000	to	1.954	1	-167.640	to	-141.592	1	288.800	to	289.435
2	1.954	to	3.908	2	-141.592	to	-115.544	2	289.435	to	293.127
3	3.908	to	5.861	3	-115.544	to	-102.520	3	293.127	to	296.819
4	5.861	to	7.815	4	-102.520	to	-98.520	4	296.819	to	300.512
5	7.815	to	10.851	5	-98.520	to	-96.520	5	300.512	to	304.204
6	10.851	to	13.887	6	-96.520	to	-89.747	6	304.204	to	307.896
7	13.887	to	16.923	7	-89.747	to	-82.973	7	307.896	to	311.588
8	16.923	to	19.959	8	-82.973	to	-76.200	8	311.588	to	315.281
9	19.959	to	22.995	9	-76.200	to	-74.930	9	315.281	to	318.973
10	22.995	to	25.600	10	-74.930	to	-67.753	10	318.973	to	322.665
11	25.600	to	28.205	11	-67.753	to	-60.575	11	322.665	to	323.300
12	28.205	to	30.810	12	-60.575	to	-57.575	12	323.300	to	323.935
13	30.810	to	33.415	13	-57.575	to	-55.575	13	323.935	to	325.497
14	33.415	to	36.020	14	-55.575	to	-53.085	14	325.497	to	327.059
15	36.020	to	38.625	15	-53.085	to	-51.585	15	327.059	to	328.621
16	38.625	to	41.118	16	-51.585	to	-50.518	16	328.621	to	330.183
17	41.118	to	43.610	17	-50.518	to	-46.778	17	330.183	to	331.745
18	43.610	to	46.090	18	-46.778	to	-43.038	18	331.745	to	333.307
19	46.090	to	48.090	19	-43.038	to	-39.299	19	333.307	to	334.869
20	48.090	to	51.090	20	-39.299	to	-35.559	20	334.869	to	336.431
21	51.090	to	63.010	21	-35.559	to	-31.819	21	336.431	to	337.993
22	63.010	to	74.930	22	-31.819	to	-28.079	22	337.993	to	339.555
23	74.930	to	76.200	23	-28.079	to	-24.339	23	339.555	to	340.190
24	76.200	to	81.280	24	-24.339	to	-20.599	24	340.190	to	343.200
25	81.280	to	86.360	25	-20.599	to	-16.859	25	343.200	to	347.220
26	86.360	to	88.860	26	-16.859	to	-13.120	26	347.220	to	351.240
27	88.860	to	92.860	27	-13.120	to	-9.380	27	351.240	to	355.260
28	92.860	to	103.750	28	-9.380	to	-5.640	28	355.260	to	359.280
29	103.750	to	125.535	29	-5.640	to	-1.900	29	359.280	to	363.300
30	125.535	to	147.320	30	-1.900	to	1.900	30	363.300	to	366.056
				31	1.900	to	5.802	31	366.056	to	368.812
				32	5.802	to	9.704	32	368.812	to	371.568
				33	9.704	to	13.607				
				34	13.607	to	17.509				
				35	17.509	to	21.411				
				36	21.411	to	25.313				
				37	25.313	to	29.215				
				38	29.215	to	33.118				
				39	33.118	to	37.020				
				40	37.020	to	40.922				
				41	40.922	to	41.989				
				42	41.989	to	46.727				
				43	46.727	to	51.465				
				44	51.465	to	53.115				
				45	53.115	to	55.575				
				46	55.575	to	57.575				
				47	57.575	to	60.575				
				48	60.575	to	67.753				
				49	67.753	to	74.930				
				50	74.930	to	76.200				
				51	76.200	to	81.280				
				52	81.280	to	86.360				
				53	86.360	to	88.860				
				54	88.860	to	92.860				
				55	92.860	to	103.750				
				56	103.750	to	125.535				
				57	125.535	to	147.320				

Mirror-like reflection
was applied at X=0

An external boundary source
was applied at Z=288.800 cm
(upstream of the 6th Na tank)

Downstream surface of the
heterogeneous IVFS slab
was located at Z=340.19 cm.

(top surface)

Table R.13. Results for Config IIIA.1b

TORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.40190E+02

X	Y	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	.00	0.00000E+00	1.16184E+01	4.25653E+01	7.15563E+01	7.75143E+01	4.95663E+01	2.79255E+01	8.06472E-03	7.07442E-03
.00	.00	.70	0.00000E+00	9.76503E+00	3.66276E+01	6.27655E+01	7.05245E+01	4.60144E+01	2.64089E+01	9.60449E-03	8.25585E-03
.00	.00	30.00	0.00000E+00	8.36512E+00	1.76143E+01	2.17708E+01	1.46957E+01	8.32355E+00	4.48585E+00	1.99963E-02	1.32071E-02
5.00	.00	30.00	0.00000E+00	8.87093E+00	1.79287E+01	2.16699E+01	1.45956E+01	8.29682E+00	4.45665E+00	2.38667E-02	1.54267E-02
10.00	.00	30.00	0.00000E+00	8.89266E+00	1.78422E+01	2.14575E+01	1.43395E+01	8.16279E+00	4.39040E+00	2.36299E-02	1.54775E-02
15.00	.00	30.00	0.00000E+00	7.96599E+00	1.67518E+01	2.06666E+01	1.39178E+01	7.88786E+00	4.24695E+00	1.92447E-02	1.25500E-02
20.00	.00	30.00	0.00000E+00	7.82330E+00	1.59282E+01	1.94474E+01	1.32519E+01	7.52496E+00	4.04336E+00	2.12344E-02	1.37916E-02
25.00	.00	30.00	0.00000E+00	7.65836E+00	1.54408E+01	1.85777E+01	1.23973E+01	7.09870E+00	3.83831E+00	2.07860E-02	1.30303E-02
30.00	.00	30.00	0.00000E+00	6.49472E+00	1.36171E+01	1.68442E+01	1.15218E+01	6.56171E+00	3.55831E+00	1.65164E-02	1.06284E-02
35.00	.00	30.00	0.00000E+00	6.36102E+00	1.27953E+01	1.54536E+01	1.04318E+01	5.96473E+00	3.22818E+00	1.88393E-02	1.15167E-02
40.00	.00	30.00	0.00000E+00	5.40225E+00	1.11861E+01	1.37276E+01	9.35855E+00	5.37774E+00	2.92126E+00	1.32304E-02	8.47106E-03
45.00	.00	30.00	0.00000E+00	3.99283E+00	8.73730E+00	1.11410E+01	8.09873E+00	4.72268E+00	2.58801E+00	1.00472E-02	6.46464E-03
50.00	.00	30.00	0.00000E+00	4.09607E+00	8.16035E+00	9.84682E+00	6.78230E+00	3.95156E+00	2.18753E+00	1.22991E-02	7.51274E-03
55.00	.00	30.00	0.00000E+00	3.15470E+00	6.70674E+00	8.37084E+00	5.77601E+00	3.32742E+00	1.82347E+00	7.87665E-03	4.72934E-03
60.00	.00	30.00	0.00000E+00	1.99734E+00	4.49956E+00	5.89807E+00	4.55625E+00	2.72542E+00	1.52382E+00	5.54473E-03	3.25059E-03
65.00	.00	30.00	0.00000E+00	1.64772E+00	3.62306E+00	4.64199E+00	3.49830E+00	2.13080E+00	1.21548E+00	4.66558E-03	2.67847E-03
70.00	.00	30.00	0.00000E+00	1.32956E+00	2.94050E+00	3.78637E+00	2.86446E+00	1.72225E+00	9.78017E-01	3.93576E-03	2.19629E-03
75.00	.00	30.00	0.00000E+00	1.17351E+00	2.52084E+00	3.17994E+00	2.37334E+00	1.43654E+00	8.17438E-01	3.78145E-03	2.06084E-03
78.00	.00	30.00	0.00000E+00	1.07515E+00	2.32057E+00	2.93226E+00	2.14955E+00	1.29604E+00	7.37687E-01	3.38120E-03	1.77224E-03
79.50	.00	30.00	0.00000E+00	9.93570E-01	2.18316E+00	2.78300E+00	2.05624E+00	1.23498E+00	7.01700E-01	3.16560E-03	1.61392E-03
80.00	.00	30.00	0.00000E+00	9.63802E-01	2.13107E+00	2.72836E+00	2.02536E+00	1.21586E+00	6.90171E-01	3.10029E-03	1.56441E-03
85.00	.00	30.00	0.00000E+00	6.90170E-01	1.58036E+00	2.09031E+00	1.68733E+00	1.04030E+00	5.90524E-01	2.48294E-03	1.09209E-03
88.00	.00	30.00	0.00000E+00	5.53699E-01	1.29292E+00	1.73892E+00	1.45414E+00	9.17032E-01	5.28278E-01	2.21079E-03	8.69158E-04
90.00	.00	30.00	0.00000E+00	4.79829E-01	1.12883E+00	1.52516E+00	1.30424E+00	8.29540E-01	4.83575E-01	2.15812E-03	7.92225E-04
95.00	.00	30.00	0.00000E+00	3.56549E-01	8.21700E-01	1.10553E+00	9.69157E-01	6.31292E-01	3.75671E-01	1.93387E-03	6.21649E-04
100.00	.00	30.00	0.00000E+00	2.53794E-01	5.65236E-01	7.54553E-01	6.83458E-01	4.61527E-01	2.84655E-01	1.67905E-03	4.83217E-04

Flux (n/s/cm2/watt) by group (ig=1,61) at X= .00, Y= .00, Z= .00 cm past the IVFS slab is as follows:

9.70949E-04	5.13248E-03	1.91466E-02	5.44946E-02	1.22514E-01	2.22701E-01	3.03898E-01	4.41838E-01	6.72016E-01	2.25958E-01
2.07285E-01	3.47637E-01	7.48509E-01	8.19123E-01	8.91353E-01	7.16348E-01	1.28561E+00	1.57509E+00	1.13488E+00	3.64086E-01
9.14360E-01	1.30733E+00	6.27747E-02	2.31484E-02	4.82600E-02	4.02177E-01	1.09255E+00	9.72361E-01	7.82106E-01	9.79508E-01
1.00641E+00	1.52666E+00	2.12726E-01	7.01965E-01	3.40793E-01	6.30068E-02	9.92436E-02	1.55480E-01	1.23420E-01	7.08695E-01
5.80213E-01	3.40712E-01	2.27045E-01	1.01659E-01	5.85965E-02	4.36938E-02	3.11904E-02	1.68950E-01	2.39385E-01	3.04188E-01
3.09680E-01	3.50437E-01	2.13201E-01	4.90139E-01	3.01234E-01	2.03143E-01	8.17817E-02	2.97543E-01	3.15335E-01	1.79201E-01
3.78658E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at X= .00, Y= .00, Z= .70 cm past the IVFS slab is as follows:

9.25404E-04	4.89267E-03	1.82649E-02	5.19032E-02	1.16658E-01	2.12057E-01	2.90078E-01	4.21168E-01	6.36255E-01	2.16097E-01
1.96447E-01	3.31262E-01	7.15337E-01	7.81310E-01	8.44051E-01	6.97982E-01	1.19375E+00	1.47298E+00	1.04957E+00	3.42580E-01
8.67318E-01	1.22954E+00	5.76931E-02	2.11976E-02	4.40881E-02	3.72243E-01	1.03585E+00	8.97550E-01	6.90549E-01	9.08335E-01
8.83336E-01	1.44988E+00	2.08174E-01	6.09501E-01	3.26562E-01	7.08707E-02	1.06715E-01	1.64946E-01	1.30917E-01	7.31578E-01
5.91821E-01	3.46803E-01	2.34013E-01	1.02958E-01	5.88446E-02	4.38394E-02	3.11050E-02	1.82278E-01	2.68951E-01	3.46669E-01
3.63254E-01	4.12642E-01	2.75794E-01	5.87996E-01	3.89995E-01	2.79077E-01	1.36895E-01	3.52213E-01	3.59240E-01	2.18373E-01
5.22239E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at X= .00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:

3.89509E-04	2.04733E-03	7.66373E-03	2.16313E-02	4.88868E-02	8.99516E-02	1.28133E-01	1.85533E-01	2.71348E-01	9.38306E-02
8.36757E-02	1.49555E-01	3.28043E-01	3.57258E-01	3.74173E-01	3.63647E-01	4.79233E-01	5.92129E-01	4.02922E-01	1.45474E-01
4.25008E-01	5.31249E-01	2.25258E-02	8.14171E-03	1.67976E-02	1.51137E-01	4.58099E-01	3.66051E-01	2.24468E-01	4.11301E-01
2.76039E-01	7.35535E-01	1.12439E-01	1.80480E-01	1.97200E-01	8.87904E-02	8.93831E-02	1.22641E-01	9.92038E-02	5.26590E-01
4.22722E-01	2.65575E-01	1.80863E-01	6.92836E-02	3.82286E-02	3.20650E-02	2.36013E-02	2.12655E-01	3.55093E-01	4.70252E-01
5.44708E-01	6.18646E-01	5.48673E-01	9.25855E-01	7.79512E-01	6.46107E-01	4.64578E-01	5.69265E-01	5.12895E-01	4.20512E-01
2.79955E-01									

Table R.13 (cont)

Flux (n/s/cm ² /watt) by group (ig=1,61) at X= 10.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:												
3.38176E-04	1.76892E-03	6.60491E-03	1.87163E-02	4.24416E-02	7.83820E-02	1.10899E-01	1.62227E-01	2.42116E-01	8.37937E-02			
7.54266E-02	1.32892E-01	2.92719E-01	3.22533E-01	3.42186E-01	3.36482E-01	4.49734E-01	5.58636E-01	3.83738E-01	1.37632E-01			
4.07676E-01	5.05370E-01	2.17252E-02	7.87874E-03	1.62781E-02	1.44715E-01	4.38885E-01	3.53307E-01	2.19762E-01	3.96646E-01			
2.71239E-01	7.10814E-01	1.09329E-01	1.79275E-01	1.95992E-01	1.04040E-01	8.68715E-02	1.20229E-01	1.00639E-01	5.36925E-01			
4.34189E-01	2.74838E-01	1.83225E-01	6.75685E-02	3.71679E-02	3.24057E-02	2.46588E-02	2.37518E-01	4.01683E-01	5.32255E-01			
6.21836E-01	7.06469E-01	6.66081E-01	1.05468E+00	9.34505E-01	7.96995E-01	6.15115E-01	6.45011E-01	5.68525E-01	4.86761E-01			
3.36575E-01												
Flux (n/s/cm ² /watt) by group (ig=1,61) at X= 20.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:												
3.25551E-04	1.70247E-03	6.35802E-03	1.79600E-02	4.06414E-02	7.49458E-02	1.06040E-01	1.54854E-01	2.30812E-01	7.98738E-02			
7.18094E-02	1.26777E-01	2.78653E-01	3.06232E-01	3.23989E-01	3.15659E-01	4.24485E-01	5.25406E-01	3.60586E-01	1.29041E-01			
3.78513E-01	4.71949E-01	2.03120E-02	7.36735E-03	1.52250E-02	1.35227E-01	4.08010E-01	3.28745E-01	2.05655E-01	3.66602E-01			
2.53922E-01	6.54153E-01	1.00609E-01	1.68138E-01	1.79340E-01	9.13230E-02	7.98859E-02	1.10130E-01	9.12438E-02	4.89985E-01			
3.96749E-01	2.52156E-01	1.70087E-01	6.42260E-02	3.58052E-02	3.09427E-02	2.30872E-02	2.13049E-01	3.57168E-01	4.72328E-01			
5.50346E-01	6.25218E-01	5.82628E-01	9.37504E-01	8.23958E-01	7.01372E-01	5.36672E-01	5.81800E-01	5.17011E-01	4.42059E-01			
3.07403E-01												
Flux (n/s/cm ² /watt) by group (ig=1,61) at X= 40.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:												
2.37800E-04	1.23622E-03	4.59875E-03	1.28976E-02	2.89080E-02	5.28582E-02	7.37899E-02	1.07136E-01	1.58217E-01	5.57396E-02			
4.93408E-02	8.61146E-02	1.90213E-01	2.09022E-01	2.20799E-01	2.15821E-01	2.87372E-01	3.60382E-01	2.45563E-01	8.80054E-02			
2.56600E-01	3.23862E-01	1.38039E-02	4.99590E-03	1.03094E-02	9.17916E-02	2.81710E-01	2.23532E-01	1.39545E-01	2.45186E-01			
1.72966E-01	4.34355E-01	6.83819E-02	1.15662E-01	1.15897E-01	5.49253E-02	5.30701E-02	7.51413E-02	6.08358E-02	3.26336E-01			
2.66060E-01	1.70501E-01	1.17118E-01	4.59458E-02	2.62036E-02	2.24824E-02	1.65013E-02	1.37346E-01	2.20473E-01	2.88864E-01			
3.32667E-01	3.79198E-01	3.46435E-01	5.71419E-01	4.96089E-01	4.21855E-01	3.20306E-01	3.60608E-01	3.25231E-01	2.76894E-01			
1.96756E-01												
Flux (n/s/cm ² /watt) by group (ig=1,61) at X= 60.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:												
1.48490E-04	7.59330E-04	2.78762E-03	7.69353E-03	1.69595E-02	3.05678E-02	4.19560E-02	5.98908E-02	8.65439E-02	3.04973E-02			
2.66835E-02	4.62063E-02	1.01270E-01	1.09539E-01	1.13958E-01	1.07025E-01	1.45501E-01	1.80357E-01	1.22270E-01	4.29761E-02			
1.20537E-01	1.58779E-01	6.72362E-03	2.42745E-03	4.98339E-03	4.41633E-02	1.35264E-01	1.06508E-01	6.74915E-02	1.12636E-01			
8.37627E-02	1.96578E-01	3.12804E-02	5.61426E-02	5.02612E-02	2.07338E-02	2.30523E-02	3.27255E-02	2.56602E-02	1.38038E-01			
1.12563E-01	7.18312E-02	5.08577E-02	2.11895E-02	1.23874E-02	1.02363E-02	7.23445E-03	5.42344E-02	8.44209E-02	1.09769E-01			
1.24825E-01	1.41751E-01	1.23689E-01	2.14220E-01	1.80119E-01	1.51160E-01	1.11543E-01	1.40304E-01	1.30648E-01	1.10435E-01			
9.54102E-02												
Flux (n/s/cm ² /watt) by group (ig=1,61) at X= 80.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:												
8.27913E-05	4.15703E-04	1.50487E-03	4.02359E-03	8.65461E-03	1.52164E-02	2.01962E-02	2.84723E-02	4.07265E-02	1.47565E-02			
1.26174E-02	2.17760E-02	4.79834E-02	5.15843E-02	5.28573E-02	5.10495E-02	6.57525E-02	8.25933E-02	5.58137E-02	1.98186E-02			
5.69944E-02	7.35605E-02	3.06761E-03	1.10282E-03	2.25277E-03	2.03087E-02	6.31681E-02	4.94302E-02	3.14343E-02	5.28247E-02			
3.94042E-02	9.33899E-02	1.52192E-02	2.77841E-02	2.52848E-02	9.85071E-03	1.14670E-02	1.66183E-02	1.27914E-02	6.77995E-02			
5.52722E-02	3.59210E-02	2.62649E-02	1.12193E-02	6.73899E-03	5.62560E-03	3.81613E-03	2.65274E-02	3.94733E-02	5.07908E-02			
5.75617E-02	6.52998E-02	5.64486E-02	9.95425E-02	8.34475E-02	7.00199E-02	5.16431E-02	6.62804E-02	6.25780E-02	5.48087E-02			
6.43234E-02												
Flux (n/s/cm ² /watt) by group (ig=1,61) at X=100.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:												
2.43305E-05	1.21285E-04	4.33954E-04	1.18973E-03	2.61165E-03	4.60794E-03	5.81117E-03	8.26126E-03	1.26181E-02	4.49895E-03			
4.04205E-03	6.61636E-03	1.40889E-02	1.48872E-02	1.54191E-02	1.23688E-02	1.98822E-02	2.41061E-02	1.73096E-02	5.64713E-03			
1.48892E-02	1.97219E-02	8.94288E-04	3.26448E-04	6.67731E-04	5.81073E-03	1.62959E-02	1.42462E-02	1.06564E-02	1.40032E-02			
1.40453E-02	2.33408E-02	3.55520E-03	1.11222E-02	6.53253E-03	1.91246E-03	1.90268E-03	2.77426E-03	2.32967E-03	1.47547E-02			
1.34909E-02	1.04156E-02	7.82069E-03	3.64334E-03	2.49841E-03	2.33871E-03	1.55135E-03	8.26888E-03	9.82142E-03	1.14104E-02			
1.25337E-02	1.37974E-02	1.28988E-02	2.17805E-02	2.02224E-02	1.87220E-02	1.64291E-02	1.82133E-02	1.79077E-02	1.94925E-02			
5.06268E-02												

Table R.14. Results for Config IIIA.1d

TORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.40190E+02

X	Y	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	.00	0.00000E+00	1.17711E+01	4.27257E+01	7.15709E+01	7.74920E+01	4.95293E+01	2.78565E+01	8.44965E-03	7.29904E-03
.00	.00	.70	0.00000E+00	9.92988E+00	3.68223E+01	6.28343E+01	7.05103E+01	4.59745E+01	2.63174E+01	1.02425E-02	8.67076E-03
.00	.00	30.00	0.00000E+00	8.47781E+00	1.78211E+01	2.19093E+01	1.45979E+01	8.26389E+00	4.46384E+00	1.98225E-02	1.28510E-02
5.00	.00	30.00	0.00000E+00	8.99262E+00	1.79217E+01	2.15552E+01	1.45342E+01	8.25991E+00	4.43094E+00	2.47046E-02	1.58802E-02
10.00	.00	30.00	0.00000E+00	8.67340E+00	1.76850E+01	2.14762E+01	1.43116E+01	8.12781E+00	4.36524E+00	2.36189E-02	1.49254E-02
15.00	.00	30.00	0.00000E+00	8.25076E+00	1.69795E+01	2.06750E+01	1.38657E+01	7.86519E+00	4.22757E+00	2.11318E-02	1.36257E-02
20.00	.00	30.00	0.00000E+00	7.85010E+00	1.60966E+01	1.96539E+01	1.32411E+01	7.49293E+00	4.02348E+00	2.16986E-02	1.36249E-02
25.00	.00	30.00	0.00000E+00	7.57157E+00	1.52846E+01	1.84589E+01	1.24434E+01	7.09851E+00	3.81551E+00	2.12407E-02	1.31047E-02
30.00	.00	30.00	0.00000E+00	6.57138E+00	1.37507E+01	1.69129E+01	1.14405E+01	6.52057E+00	3.54568E+00	1.63774E-02	1.03821E-02
35.00	.00	30.00	0.00000E+00	6.27203E+00	1.26821E+01	1.54128E+01	1.04625E+01	5.93258E+00	3.19549E+00	1.93432E-02	1.16998E-02
40.00	.00	30.00	0.00000E+00	5.53168E+00	1.13662E+01	1.38399E+01	9.32971E+00	5.37936E+00	2.91654E+00	1.40949E-02	8.47311E-03
45.00	.00	30.00	0.00000E+00	4.02244E+00	8.77699E+00	1.11828E+01	8.09983E+00	4.70396E+00	2.58332E+00	1.05567E-02	6.79612E-03
50.00	.00	30.00	0.00000E+00	4.43025E+00	8.60382E+00	1.01670E+01	6.81845E+00	3.96484E+00	2.18404E+00	1.37901E-02	8.17615E-03
55.00	.00	30.00	0.00000E+00	3.27422E+00	6.92814E+00	8.62632E+00	5.90165E+00	3.37792E+00	1.84652E+00	8.41299E-03	4.89265E-03
60.00	.00	30.00	0.00000E+00	1.97703E+00	4.49983E+00	5.93549E+00	4.61811E+00	2.76366E+00	1.54580E+00	5.70481E-03	3.23011E-03
65.00	.00	30.00	0.00000E+00	1.64503E+00	3.61992E+00	4.64042E+00	3.49856E+00	2.12969E+00	1.21494E+00	4.85129E-03	2.69400E-03
70.00	.00	30.00	0.00000E+00	1.34267E+00	2.95594E+00	3.79759E+00	2.86164E+00	1.71596E+00	9.71905E-01	4.11181E-03	2.22836E-03
75.00	.00	30.00	0.00000E+00	1.15193E+00	2.47038E+00	3.11991E+00	2.34887E+00	1.42762E+00	8.15174E-01	3.81191E-03	2.03432E-03
78.00	.00	30.00	0.00000E+00	1.04761E+00	2.23852E+00	2.81416E+00	2.08286E+00	1.26855E+00	7.30443E-01	3.41854E-03	1.75245E-03
79.50	.00	30.00	0.00000E+00	9.70949E-01	2.10213E+00	2.65545E+00	1.96439E+00	1.19436E+00	6.89150E-01	3.21693E-03	1.60468E-03
80.00	.00	30.00	0.00000E+00	9.42933E-01	2.05289E+00	2.60101E+00	1.92663E+00	1.17052E+00	6.75687E-01	3.15616E-03	1.55943E-03
85.00	.00	30.00	0.00000E+00	6.87184E-01	1.56550E+00	2.05396E+00	1.59889E+00	9.78600E-01	5.61413E-01	2.55206E-03	1.10934E-03
88.00	.00	30.00	0.00000E+00	5.47241E-01	1.28879E+00	1.73675E+00	1.42093E+00	8.80131E-01	5.04212E-01	2.22650E-03	8.58095E-04
90.00	.00	30.00	0.00000E+00	4.65692E-01	1.10786E+00	1.50962E+00	1.28520E+00	8.08537E-01	4.67277E-01	2.14355E-03	7.53851E-04
95.00	.00	30.00	0.00000E+00	3.23643E-01	7.64432E-01	1.04676E+00	9.39338E-01	6.18983E-01	3.69544E-01	1.87816E-03	5.54752E-04
100.00	.00	30.00	0.00000E+00	2.13743E-01	4.90265E-01	6.73068E-01	6.46658E-01	4.44299E-01	2.77233E-01	1.61937E-03	4.10705E-04

Flux (n/s/cm2/watt) by group (ig=1,61) at X= .00, Y= .00, Z= .00 cm past the IVFS slab is as follows:

9.69609E-04	5.12501E-03	1.91267E-02	5.44545E-02	1.22518E-01	2.22850E-01	3.04220E-01	4.42328E-01	6.74125E-01	2.26763E-01
2.08039E-01	3.49492E-01	7.52127E-01	8.23053E-01	8.94473E-01	7.21815E-01	1.28856E+00	1.57940E+00	1.13740E+00	3.66154E-01
9.22904E-01	1.31322E+00	6.29411E-02	2.32021E-02	4.83872E-02	4.04507E-01	1.09804E+00	9.77576E-01	7.81229E-01	9.93564E-01
1.00403E+00	1.54766E+00	2.14536E-01	6.99433E-01	3.54654E-01	6.48187E-02	1.01329E-01	1.57808E-01	1.24881E-01	7.16997E-01
5.87467E-01	3.45333E-01	2.30267E-01	1.02938E-01	5.93341E-02	4.42114E-02	3.15129E-02	1.73212E-01	2.46766E-01	3.13588E-01
3.19536E-01	3.62036E-01	2.22754E-01	5.07127E-01	3.14395E-01	2.13396E-01	8.81929E-02	3.07182E-01	3.23734E-01	1.86117E-01
4.45423E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at X= .00, Y= .00, Z= .70 cm past the IVFS slab is as follows:

9.24682E-04	4.88881E-03	1.82575E-02	5.18996E-02	1.16733E-01	2.12312E-01	2.90545E-01	4.21818E-01	6.38261E-01	2.16743E-01
1.97120E-01	3.32780E-01	7.18481E-01	7.84768E-01	8.46769E-01	7.03114E-01	1.19728E+00	1.47623E+00	1.05192E+00	3.43766E-01
8.73800E-01	1.23614E+00	5.79745E-02	2.12977E-02	4.43072E-02	3.74214E-01	1.04140E+00	9.02311E-01	6.93104E-01	9.16919E-01
8.87258E-01	1.46678E+00	2.10597E-01	6.13104E-01	3.35300E-01	7.46198E-02	1.10006E-01	1.68955E-01	1.33937E-01	7.46135E-01
6.03617E-01	3.54467E-01	2.39812E-01	1.04998E-01	5.99322E-02	4.46836E-02	3.16359E-02	1.89165E-01	2.80949E-01	3.62527E-01
3.81783E-01	4.33737E-01	2.94586E-01	6.19315E-01	4.16119E-01	2.99661E-01	1.50976E-01	3.69725E-01	3.74611E-01	2.31262E-01
6.14375E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at X= .00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:

4.11360E-04	2.16493E-03	8.09215E-03	2.27610E-02	5.11246E-02	9.35602E-02	1.32448E-01	1.90815E-01	2.78025E-01	9.52089E-02
8.53823E-02	1.51718E-01	3.31485E-01	3.59443E-01	3.75688E-01	3.57261E-01	4.83531E-01	5.90184E-01	4.04029E-01	1.43002E-01
4.14560E-01	5.28365E-01	2.26813E-02	8.21271E-03	1.69625E-02	1.50366E-01	4.49705E-01	3.63611E-01	2.29211E-01	4.00749E-01
2.83774E-01	7.12965E-01	1.09473E-01	1.87799E-01	1.87669E-01	8.51843E-02	8.54619E-02	1.16627E-01	9.43349E-02	5.02614E-01
4.03682E-01	2.53627E-01	1.73788E-01	6.76728E-02	3.75333E-02	3.10438E-02	2.27840E-02	2.03906E-01	3.39454E-01	4.49710E-01
5.22269E-01	5.92871E-01	5.30810E-01	8.90915E-01	7.55328E-01	6.29766E-01	4.56922E-01	5.52352E-01	4.96960E-01	4.10541E-01
2.87994E-01									

Table R.14 (cont)

Flux (n/s/cm²/watt) by group (ig=1,61) at X= 10.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:

3.34426E-04	1.74847E-03	6.52311E-03	1.84561E-02	4.17736E-02	7.70670E-02	1.08882E-01	1.59555E-01	2.39384E-01	8.26425E-02
7.47389E-02	1.31343E-01	2.89136E-01	3.18902E-01	3.38652E-01	3.27882E-01	4.48114E-01	5.53611E-01	3.81904E-01	1.35196E-01
3.97396E-01	5.01043E-01	2.17564E-02	7.89750E-03	1.63264E-02	1.43906E-01	4.31826E-01	3.50827E-01	2.21721E-01	3.87312E-01
2.74252E-01	6.92138E-01	1.06736E-01	1.82770E-01	1.86817E-01	9.74955E-02	8.28665E-02	1.15282E-01	9.67411E-02	5.19713E-01
4.20595E-01	2.66565E-01	1.77512E-01	6.59610E-02	3.64712E-02	3.19013E-02	2.43181E-02	2.29516E-01	3.85459E-01	5.09903E-01
5.94483E-01	6.75211E-01	6.36472E-01	1.00954E+00	8.93486E-01	7.63581E-01	5.89641E-01	6.20487E-01	5.47156E-01	4.69724E-01
3.60079E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at X= 20.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:

3.26832E-04	1.70915E-03	6.37952E-03	1.80005E-02	4.06331E-02	7.47700E-02	1.05454E-01	1.53846E-01	2.29704E-01	7.92326E-02
7.14719E-02	1.25950E-01	2.76589E-01	3.03854E-01	3.21352E-01	3.09779E-01	4.21857E-01	5.20158E-01	3.57845E-01	1.26960E-01
3.72108E-01	4.68743E-01	2.02849E-02	7.35925E-03	1.52124E-02	1.34406E-01	4.02916E-01	3.26811E-01	2.05789E-01	3.60497E-01
2.54019E-01	6.41314E-01	9.86340E-02	1.68653E-01	1.72848E-01	8.76026E-02	7.59952E-02	1.06144E-01	8.84096E-02	4.78514E-01
3.88000E-01	2.46504E-01	1.64983E-01	6.23456E-02	3.48518E-02	3.04049E-02	2.29597E-02	2.10563E-01	3.51269E-01	4.63636E-01
5.38865E-01	6.12106E-01	5.74398E-01	9.17584E-01	8.09992E-01	6.92299E-01	5.34235E-01	5.70348E-01	5.05619E-01	4.34021E-01
3.34505E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at X= 40.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:

2.45896E-04	1.27719E-03	4.74796E-03	1.33309E-02	2.98828E-02	5.46201E-02	7.60644E-02	1.10252E-01	1.62818E-01	5.68084E-02
5.06050E-02	8.78626E-02	1.93296E-01	2.11780E-01	2.23584E-01	2.14201E-01	2.92605E-01	3.62468E-01	2.48445E-01	8.73092E-02
2.53220E-01	3.25184E-01	1.40018E-02	5.07456E-03	1.04773E-02	9.20774E-02	2.79393E-01	2.23840E-01	1.42774E-01	2.41161E-01
1.77705E-01	4.28414E-01	6.78538E-02	1.20087E-01	1.15211E-01	5.38519E-02	5.26225E-02	7.32940E-02	5.91288E-02	3.19082E-01
2.61802E-01	1.69983E-01	1.18996E-01	4.76037E-02	2.75553E-02	2.35074E-02	1.67790E-02	1.35317E-01	2.14963E-01	2.81449E-01
3.26041E-01	3.70977E-01	3.38230E-01	5.63410E-01	4.89327E-01	4.16329E-01	3.16000E-01	3.60904E-01	3.27104E-01	2.82522E-01
2.33481E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at X= 60.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:

1.50442E-04	7.68226E-04	2.81588E-03	7.75373E-03	1.70518E-02	3.07101E-02	4.20909E-02	6.00729E-02	8.69099E-02	3.05797E-02
2.68062E-02	4.64041E-02	1.01705E-01	1.10033E-01	1.14573E-01	1.07213E-01	1.46861E-01	1.81613E-01	1.23685E-01	4.32404E-02
1.21040E-01	1.59890E-01	6.82400E-03	2.46647E-03	5.06886E-03	4.46975E-02	1.36019E-01	1.07774E-01	6.99621E-02	1.13650E-01
8.73315E-02	1.98023E-01	3.15220E-02	5.92577E-02	5.03772E-02	2.03508E-02	2.28804E-02	3.25231E-02	2.55339E-02	1.37979E-01
1.12913E-01	7.20010E-02	5.10351E-02	2.13871E-02	1.25278E-02	1.03315E-02	7.31139E-03	5.39852E-02	8.31967E-02	1.07965E-01
1.22513E-01	1.39101E-01	1.21372E-01	2.10828E-01	1.77309E-01	1.49139E-01	1.10560E-01	1.38930E-01	1.29598E-01	1.09644E-01
1.03136E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at X= 80.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:

7.73178E-05	3.86985E-04	1.40016E-03	3.72708E-03	8.00995E-03	1.40723E-02	1.87286E-02	2.64411E-02	3.77585E-02	1.38133E-02
1.17430E-02	2.03709E-02	4.51125E-02	4.86775E-02	4.97953E-02	4.93343E-02	6.17570E-02	7.80393E-02	5.25637E-02	1.89233E-02
5.54697E-02	7.10782E-02	2.92702E-03	1.05067E-03	2.14322E-03	1.94863E-02	6.16283E-02	4.76675E-02	2.95227E-02	5.15699E-02
3.67913E-02	9.18524E-02	1.50903E-02	2.58981E-02	2.49155E-02	1.01060E-02	1.15312E-02	1.65014E-02	1.27134E-02	6.74019E-02
5.50348E-02	3.60781E-02	2.63932E-02	1.12785E-02	6.77489E-03	5.66811E-03	3.84067E-03	2.64692E-02	3.95122E-02	5.09221E-02
5.77973E-02	6.55700E-02	5.65369E-02	9.97084E-02	8.32968E-02	6.96784E-02	5.12179E-02	6.56041E-02	6.19158E-02	5.40860E-02
6.69311E-02									

Flux (n/s/cm²/watt) by group (ig=1,61) at X=100.00, Y= .00, Z= 30.00 cm past the IVFS slab is as follows:

2.40672E-05	1.19870E-04	4.28141E-04	1.17143E-03	2.56470E-03	4.48200E-03	5.49939E-03	7.75553E-03	1.20645E-02	4.30457E-03
3.88093E-03	6.21055E-03	1.30388E-02	1.36924E-02	1.40607E-02	1.04624E-02	1.82965E-02	2.18164E-02	1.57131E-02	4.94276E-03
1.21929E-02	1.74389E-02	8.07604E-04	2.95164E-04	6.02181E-04	5.12640E-03	1.40271E-02	1.24829E-02	9.69267E-03	1.14851E-02
1.29862E-02	1.89891E-02	2.93142E-03	1.03832E-02	5.07962E-03	1.52829E-03	1.49723E-03	2.19005E-03	1.84713E-03	1.19389E-02
1.10149E-02	8.71495E-03	6.53285E-03	3.09124E-03	2.14988E-03	2.02457E-03	1.35376E-03	6.99579E-03	7.98661E-03	9.11213E-03
9.92085E-03	1.08521E-02	1.01323E-02	1.71331E-02	1.59079E-02	1.48565E-02	1.32625E-02	1.47443E-02	1.46876E-02	1.64156E-02
5.12395E-02

Fig. G.15. Computational model used for Configuration IIB.1 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration by itself). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.15. Detailed description of the calculational model for Configuration IIIB.1 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
477.840	489.840	15	0.0	62	----->							157.100
422.550	477.840	50	0.0	62	----->							157.100
385.873	422.550	33	0.0	62	----->							157.100
384.440	385.873	2	0.0	62	----->							157.100
372.440	384.440	16	0.0	62	----->							157.100
363.300	372.440	15	0.0	62	----->							157.100
343.200	363.300	30	0.0	62	----->							157.100
340.873	343.200	5	0.0	62	----->	58.707	33	89.190	34	----->		157.100
339.440	340.873	2	0.0	62	----->	58.707	33	89.190	34	----->		157.100
336.900	339.440	2	0.0	27	----->	58.707	33	89.190	34	----->		157.100
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	89.190	34	----->		157.100
329.120	332.580	3	0.0	27	----->	58.707	33	89.190	34	----->		157.100
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	89.190	34	----->		157.100
323.300	325.840	2	0.0	27	----->	58.707	33	89.190	34	----->		157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.15. Results for Config IIIB.1

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.39440E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.62297E+01	5.32332E+01	8.64984E+01	8.79129E+01	5.72740E+01	3.28877E+01	1.65571E-02	1.48003E-02
.00	.70	0.00000E+00	1.37991E+01	4.50590E+01	7.47004E+01	8.08846E+01	5.30037E+01	3.13614E+01	1.58370E-02	1.40910E-02
.00	30.00	0.00000E+00	6.30334E+00	1.52053E+01	2.05197E+01	1.67318E+01	1.02321E+01	5.78407E+00	1.50492E-02	9.09699E-03
.00	150.00	0.00000E+00	9.46152E-01	2.28764E+00	3.07522E+00	2.42312E+00	1.44015E+00	7.89490E-01	1.66415E-03	1.39159E-03
.00	30.00	0.00000E+00	6.30334E+00	1.52053E+01	2.05197E+01	1.67318E+01	1.02321E+01	5.78407E+00	1.50492E-02	9.09699E-03
5.00	30.00	0.00000E+00	6.23132E+00	1.50738E+01	2.03929E+01	1.66286E+01	1.01675E+01	5.74787E+00	1.48816E-02	9.14574E-03
10.00	30.00	0.00000E+00	6.10154E+00	1.48055E+01	2.00575E+01	1.63359E+01	9.98492E+00	5.64793E+00	1.35763E-02	9.03933E-03
15.00	30.00	0.00000E+00	5.96336E+00	1.44560E+01	1.95597E+01	1.58923E+01	9.70141E+00	5.48981E+00	1.27602E-02	8.80164E-03
20.00	30.00	0.00000E+00	5.77368E+00	1.39906E+01	1.89071E+01	1.53027E+01	9.33140E+00	5.27861E+00	1.23895E-02	8.49369E-03
25.00	30.00	0.00000E+00	5.56601E+00	1.33814E+01	1.80597E+01	1.45801E+01	8.88393E+00	5.02429E+00	1.20876E-02	8.26928E-03
30.00	30.00	0.00000E+00	5.30853E+00	1.27039E+01	1.70740E+01	1.37368E+01	8.36160E+00	4.72965E+00	1.17993E-02	7.87688E-03
35.00	30.00	0.00000E+00	5.04804E+00	1.19331E+01	1.59665E+01	1.27659E+01	7.77010E+00	4.39710E+00	1.18656E-02	7.72148E-03
40.00	30.00	0.00000E+00	4.71508E+00	1.10525E+01	1.47201E+01	1.17019E+01	7.11663E+00	4.03316E+00	1.13405E-02	7.12395E-03
45.00	30.00	0.00000E+00	4.27544E+00	9.99258E+00	1.33009E+01	1.05571E+01	6.42041E+00	3.64426E+00	1.04930E-02	6.70289E-03
50.00	30.00	0.00000E+00	4.19814E+00	9.36647E+00	1.21295E+01	9.39771E+00	5.70400E+00	3.24075E+00	1.25987E-02	7.20861E-03
55.00	30.00	0.00000E+00	3.47298E+00	8.03437E+00	1.05757E+01	8.19542E+00	4.96890E+00	2.83093E+00	7.94559E-03	4.89998E-03
60.00	30.00	0.00000E+00	2.99140E+00	6.72332E+00	8.81677E+00	6.96370E+00	4.24074E+00	2.41672E+00	8.73680E-03	5.27079E-03
65.00	30.00	0.00000E+00	2.66666E+00	5.93289E+00	7.61556E+00	5.79328E+00	3.54042E+00	2.03306E+00	6.19908E-03	3.58506E-03
70.00	30.00	0.00000E+00	1.83727E+00	4.28105E+00	5.79308E+00	4.74292E+00	2.91439E+00	1.67541E+00	4.99771E-03	2.87577E-03
75.00	30.00	0.00000E+00	1.51799E+00	3.50442E+00	4.62803E+00	3.70415E+00	2.32910E+00	1.35597E+00	4.03406E-03	2.15503E-03
78.00	30.00	0.00000E+00	1.24161E+00	2.98373E+00	4.03121E+00	3.26961E+00	2.03509E+00	1.18752E+00	3.59741E-03	1.87088E-03
79.50	30.00	0.00000E+00	1.14047E+00	2.71435E+00	3.70523E+00	3.06755E+00	1.91559E+00	1.11169E+00	3.51297E-03	1.79010E-03
80.00	30.00	0.00000E+00	1.11270E+00	2.64112E+00	3.59582E+00	3.00170E+00	1.87742E+00	1.08846E+00	3.48933E-03	1.76908E-03
85.00	30.00	0.00000E+00	8.79343E-01	2.10141E+00	2.82860E+00	2.36794E+00	1.51408E+00	8.88915E-01	2.92553E-03	1.34312E-03
88.00	30.00	0.00000E+00	7.59221E-01	1.81284E+00	2.46855E+00	2.08176E+00	1.31736E+00	7.82761E-01	2.73700E-03	1.20666E-03
90.00	30.00	0.00000E+00	7.00134E-01	1.66115E+00	2.24865E+00	1.91967E+00	1.21352E+00	7.18630E-01	2.67392E-03	1.12024E-03
95.00	30.00	0.00000E+00	5.70599E-01	1.35934E+00	1.84256E+00	1.57612E+00	1.01547E+00	6.00953E-01	2.30645E-03	8.78800E-04
100.00	30.00	0.00000E+00	4.71009E-01	1.08576E+00	1.44053E+00	1.29172E+00	8.32758E-01	4.93222E-01	2.23728E-03	7.86515E-04

Flux (n/s/cm²/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the IVFS slab is as follows:

1.04557E-03	5.56833E-03	2.10196E-02	5.93580E-02	1.34751E-01	2.47696E-01	3.53833E-01	5.12915E-01	7.37079E-01	2.69988E-01
2.29104E-01	4.14077E-01	9.18655E-01	9.98314E-01	1.03182E-01	1.03336E+00	1.26056E+00	1.61957E+00	1.05811E+00	4.03622E-01
1.14629E+00	1.41673E+00	5.63693E-02	2.01155E-02	4.11315E-02	3.95682E-01	1.24173E+00	9.41316E-01	4.83411E-01	1.07879E+00
5.56017E-01	1.86068E+00	2.84076E-01	3.18508E-01	4.88809E-01	1.49852E-01	1.83935E-01	2.68181E-01	2.12517E-01	1.14472E+00
8.98057E-01	5.23859E-01	3.63300E-01	1.52200E-01	8.47623E-02	6.38949E-02	4.33743E-02	3.19818E-01	5.15816E-01	6.74806E-01
7.14188E-01	8.10160E-01	5.27828E-01	1.15188E+00	7.43571E-01	5.02464E-01	1.81122E-01	6.41144E-01	6.58080E-01	4.00053E-01
6.46848E-02									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the IVFS slab is as follows:

5.29269E-04	2.81862E-03	1.05925E-02	2.98667E-02	6.74243E-02	1.24162E-01	1.79935E-01	2.60376E-01	3.66787E-01	1.27485E-01
1.11706E-01	2.03398E-01	4.50126E-01	4.89802E-01	5.11862E-01	4.89070E-01	6.37903E-01	7.75455E-01	5.15754E-01	1.88153E-01
5.37358E-01	6.94441E-01	2.85052E-02	1.02251E-02	2.09872E-02	1.93109E-01	5.79603E-01	4.54947E-01	2.52680E-01	4.91695E-01
2.98818E-01	8.40773E-01	1.30652E-01	1.79868E-01	2.08709E-01	5.53738E-02	8.44690E-02	1.23325E-01	9.71939E-02	5.49168E-01
4.43288E-01	2.72799E-01	1.87195E-01	8.03313E-02	4.63777E-02	3.71058E-02	2.59369E-02	1.88205E-01	2.93610E-01	3.78216E-01
3.97368E-01	4.52549E-01	3.11356E-01	6.65361E-01	4.57804E-01	3.44651E-01	1.72586E-01	4.29989E-01	4.27545E-01	3.08177E-01
2.46975E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the IVFS slab is as follows:

9.15689E-05	4.79325E-04	1.78830E-03	4.96390E-03	1.10837E-02	2.03895E-02	2.96823E-02	4.29277E-02	5.95344E-02	2.04697E-02
1.81359E-02	3.30277E-02	7.31486E-02	7.91325E-02	8.24831E-02	7.73029E-02	1.00634E-01	1.21393E-01	8.05722E-02	2.92601E-02
8.17977E-02	1.06856E-01	4.38383E-03	1.57984E-03	3.27324E-03	2.95609E-02	8.80810E-02	6.83900E-02	3.85748E-02	7.28473E-02
4.56375E-02	1.24190E-01	1.93005E-02	2.65882E-02	2.89407E-02	7.68702E-03	1.30863E-02	1.89814E-02	1.48810E-02	8.34778E-02
6.72610E-02	4.00898E-02	2.67760E-02	1.11112E-02	6.05710E-03	4.61809E-03	3.39806E-03	2.84796E-02	4.78472E-02	6.31866E-02
6.62076E-02	7.60568E-02	5.17568E-02	1.12683E-01	7.49041E-02	5.55564E-02	2.18826E-02	7.10761E-02	6.88851E-02	4.45751E-02
1.05806E-02									

Table R.15 (cont)

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 10.00, Z= 30.00 cm past the IVFS slab is as follows:

5.12867E-04	2.73006E-03	1.02590E-02	2.89111E-02	6.53088E-02	1.20450E-01	1.74981E-01	2.53907E-01	3.58958E-01	1.25016E-01
1.09708E-01	2.00516E-01	4.44450E-01	4.84201E-01	5.06377E-01	4.86598E-01	6.29188E-01	7.68099E-01	5.10819E-01	1.87116E-01
5.37937E-01	6.85615E-01	2.81316E-02	1.00916E-02	2.07180E-02	1.91462E-01	5.73257E-01	4.51538E-01	2.49249E-01	4.94572E-01
2.93524E-01	8.42234E-01	1.29178E-01	1.74997E-01	2.08664E-01	5.55826E-02	8.44084E-02	1.22577E-01	9.57016E-02	5.39065E-01
4.38044E-01	2.67975E-01	1.84637E-01	7.89545E-02	4.51884E-02	3.54687E-02	2.51404E-02	1.86322E-01	2.93089E-01	3.79728E-01
4.00004E-01	4.57381E-01	3.18757E-01	6.73876E-01	4.67238E-01	3.52179E-01	1.75570E-01	4.30745E-01	4.26006E-01	3.03324E-01
1.86655E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 20.00, Z= 30.00 cm past the IVFS slab is as follows:

4.90648E-04	2.61076E-03	9.81029E-03	2.76218E-02	6.23551E-02	1.14989E-01	1.67022E-01	2.42238E-01	3.41869E-01	1.19034E-01
1.04423E-01	1.90803E-01	4.22992E-01	4.60655E-01	4.81355E-01	4.62963E-01	5.95895E-01	7.27989E-01	4.83235E-01	1.77240E-01
5.09432E-01	6.47997E-01	2.65275E-02	9.51269E-02	1.95300E-02	1.80753E-01	5.41816E-01	4.25308E-01	2.33355E-01	4.66542E-01
2.73946E-01	7.93353E-01	1.21559E-01	1.61885E-01	1.96977E-01	5.25701E-02	7.95061E-02	1.15771E-01	9.03801E-02	5.07710E-01
4.12237E-01	2.51354E-01	1.72881E-01	7.38403E-02	4.20827E-02	3.29017E-02	2.33394E-02	1.74751E-01	2.76774E-01	3.59520E-01
3.78265E-01	4.33276E-01	3.00856E-01	6.39088E-01	4.41360E-01	3.31233E-01	1.60963E-01	4.08448E-01	4.04063E-01	2.84557E-01
1.59713E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 40.00, Z= 30.00 cm past the IVFS slab is as follows:

3.88146E-04	2.05398E-03	7.70791E-03	2.15807E-02	4.84931E-02	8.89877E-02	1.28093E-01	1.84922E-01	2.61306E-01	9.17540E-02
7.99139E-02	1.45207E-01	3.21458E-01	3.49004E-01	3.62375E-01	3.49188E-01	4.44048E-01	5.43349E-01	3.58294E-01	1.31840E-01
3.77868E-01	4.80797E-01	1.95379E-02	6.99844E-03	1.43593E-02	1.33222E-01	4.02564E-01	3.12379E-01	1.69818E-01	3.42774E-01
1.99246E-01	5.84738E-01	9.01111E-02	1.18618E-01	1.46186E-01	3.97973E-02	5.90067E-02	8.66167E-02	6.79762E-02	3.82812E-01
3.13851E-01	1.94623E-01	1.35726E-01	5.85346E-02	3.40315E-02	2.71179E-02	1.91136E-02	1.39993E-01	2.17417E-01	2.81261E-01
2.96123E-01	3.40832E-01	2.45679E-01	5.11769E-01	3.68193E-01	2.87699E-01	1.59360E-01	3.42283E-01	3.36155E-01	2.51502E-01
1.74285E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 60.00, Z= 30.00 cm past the IVFS slab is as follows:

2.34907E-04	1.22051E-03	4.55847E-03	1.25356E-02	2.78891E-02	5.07906E-02	7.20795E-02	1.03716E-01	1.48092E-01	5.33208E-02
4.57319E-02	8.24883E-02	1.83456E-01	1.98910E-01	2.04237E-01	2.00917E-01	2.44329E-01	3.03283E-01	1.97696E-01	7.42312E-02
2.12410E-01	2.70812E-01	1.07088E-02	3.82845E-03	7.93475E-03	7.34470E-02	2.29695E-01	1.71509E-01	9.01154E-02	1.91884E-01
1.05386E-01	3.35028E-01	5.18472E-02	6.32631E-02	8.11064E-02	2.25935E-02	3.81708E-02	5.97485E-02	4.60361E-02	2.46375E-01
1.98931E-01	1.16656E-01	8.29616E-02	3.56313E-02	2.05778E-02	1.64574E-02	1.20620E-02	9.60240E-02	1.50690E-01	1.96174E-01
1.94507E-01	2.42018E-01	1.90864E-01	3.65035E-01	2.87799E-01	2.35497E-01	1.56487E-01	2.39618E-01	2.28858E-01	1.84482E-01
1.43764E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 80.00, Z= 30.00 cm past the IVFS slab is as follows:

1.19588E-04	6.09919E-04	2.24564E-03	6.12439E-03	1.34690E-02	2.41530E-02	3.33201E-02	4.71407E-02	6.72275E-02	2.45561E-02
2.06823E-02	3.66020E-02	8.04673E-02	8.62797E-02	8.70632E-02	8.42355E-02	1.03463E-01	1.27657E-01	8.25408E-02	3.05039E-02
8.60346E-02	1.12579E-01	4.43948E-03	1.58145E-03	3.21333E-03	3.00959E-02	9.50760E-02	7.07927E-02	3.85538E-02	7.62072E-02
4.58884E-02	1.32091E-01	2.13438E-02	2.98876E-02	3.39874E-02	9.97648E-03	1.38822E-02	2.13798E-02	1.67684E-02	9.33451E-02
7.65692E-02	4.87753E-02	3.48527E-02	1.52754E-02	9.19564E-03	7.58873E-03	5.26222E-03	3.55637E-02	5.20245E-02	6.60272E-02
6.90137E-02	7.96637E-02	5.97466E-02	1.18447E-01	8.86616E-02	6.98498E-02	4.27260E-02	7.80844E-02	7.79899E-02	6.24156E-02
7.20179E-02									

Flux (n/s/cm²/watt) by group (ig=1,61) at R=100.00, Z= 30.00 cm past the IVFS slab is as follows:

4.62684E-05	2.31490E-04	8.37612E-04	2.27871E-03	4.95860E-03	8.82019E-03	1.18258E-02	2.43223E-02	9.03667E-03
7.68403E-03	1.32328E-02	2.93023E-02	3.12297E-02	3.17786E-02	2.94437E-02	3.76782E-02	4.66039E-02	3.11402E-02
3.23799E-02	4.11012E-02	1.65725E-03	6.02518E-04	1.22737E-03	1.12857E-02	3.46980E-02	2.71360E-02	1.70700E-02
2.18088E-02	4.86041E-02	8.02344E-03	1.74896E-02	1.34200E-02	4.07405E-03	4.61034E-03	6.96446E-03	5.73779E-03
3.08378E-02	2.25543E-02	1.64537E-02	7.47946E-03	4.90136E-03	4.45545E-03	2.96047E-03	1.68077E-02	2.12185E-02
2.65217E-02	2.89931E-02	2.29239E-02	4.33165E-02	3.48879E-02	2.91159E-02	2.09792E-02	3.16552E-02	3.22090E-02
6.12640E-02

Fig. G.16. Calculational model used for Configuration IIB.2 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration, with extended concrete ring in analytic model to simulate background radiation). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.16. Detailed description of the calculational model for Configuration IIIB.2 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
477.840	489.840	15	0.0	62	----->							157.100
422.550	477.840	50	0.0	62	----->							157.100
385.873	422.550	33	0.0	62	----->							157.100
384.440	385.873	2	0.0	62	----->					135.400	34	157.100
372.440	384.440	16	0.0	62	----->					135.400	34	157.100
363.300	372.440	15	0.0	62	----->					135.400	34	157.100
343.200	363.300	30	0.0	62	----->					96.140	34	157.100
340.873	343.200	5	0.0	62	----->	58.707	33	89.190	34	----->		157.100
339.440	340.873	2	0.0	62	----->	58.707	33	89.190	34	----->		157.100
336.900	339.440	2	0.0	27	----->	58.707	33	89.190	34	----->		157.100
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	89.190	34	----->		157.100
329.120	332.580	3	0.0	27	----->	58.707	33	89.190	34	----->		157.100
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	89.190	34	----->		157.100
323.300	325.840	2	0.0	27	----->	58.707	33	89.190	34	----->		157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.16. Results for Config IIIB.2

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.39440E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.64140E+01	5.36323E+01	8.69956E+01	8.82384E+01	5.74435E+01	3.29683E+01	1.87692E-02	1.52680E-02
.00	.70	0.00000E+00	1.39973E+01	4.54820E+01	7.52195E+01	8.12192E+01	5.31788E+01	3.14449E+01	1.81882E-02	1.45796E-02
.00	30.00	0.00000E+00	6.47940E+00	1.55661E+01	2.09469E+01	1.69799E+01	1.03553E+01	5.84260E+00	1.75896E-02	9.55527E-03
.00	150.00	0.00000E+00	1.08766E+00	2.57547E+00	3.41714E+00	2.62084E+00	1.53743E+00	8.34524E-01	3.37879E-03	1.71799E-03
.00	30.00	0.00000E+00	6.47940E+00	1.55661E+01	2.09469E+01	1.69799E+01	1.03553E+01	5.84260E+00	1.75896E-02	9.55527E-03
5.00	30.00	0.00000E+00	6.40814E+00	1.54343E+01	2.08205E+01	1.68764E+01	1.02907E+01	5.80657E+00	1.74390E-02	9.60940E-03
10.00	30.00	0.00000E+00	6.28003E+00	1.51676E+01	2.04862E+01	1.65835E+01	1.01087E+01	5.70784E+00	1.61735E-02	9.51277E-03
15.00	30.00	0.00000E+00	6.14279E+00	1.48196E+01	1.99886E+01	1.61409E+01	9.82762E+00	5.55148E+00	1.53251E-02	9.26781E-03
20.00	30.00	0.00000E+00	5.95267E+00	1.43536E+01	1.93360E+01	1.55547E+01	9.46090E+00	5.34168E+00	1.49635E-02	8.96084E-03
25.00	30.00	0.00000E+00	5.72435E+00	1.37429E+01	1.84889E+01	1.48373E+01	9.01598E+00	5.08839E+00	1.46637E-02	8.73643E-03
30.00	30.00	0.00000E+00	5.48736E+00	1.30678E+01	1.75085E+01	1.39983E+01	8.49571E+00	4.79453E+00	1.43588E-02	8.33926E-03
35.00	30.00	0.00000E+00	5.22940E+00	1.23033E+01	1.64080E+01	1.30308E+01	7.90564E+00	4.46243E+00	1.44454E-02	8.18597E-03
40.00	30.00	0.00000E+00	4.90151E+00	1.14298E+01	1.51682E+01	1.19697E+01	7.25299E+00	4.09871E+00	1.39915E-02	7.60250E-03
45.00	30.00	0.00000E+00	4.66707E+00	1.03785E+01	1.37574E+01	1.08269E+01	6.55724E+00	3.70981E+00	1.32588E-02	7.20339E-03
50.00	30.00	0.00000E+00	4.39442E+00	9.76051E+00	1.25944E+01	9.66933E+00	5.84110E+00	3.30621E+00	1.54078E-02	7.71428E-03
55.00	30.00	0.00000E+00	3.67282E+00	8.43435E+00	1.10471E+01	8.46868E+00	5.10636E+00	2.89636E+00	1.08507E-02	5.42271E-03
60.00	30.00	0.00000E+00	3.19407E+00	7.12737E+00	9.29191E+00	7.23956E+00	4.37919E+00	2.48227E+00	1.16916E-02	5.79959E-03
65.00	30.00	0.00000E+00	2.87126E+00	6.33986E+00	8.09374E+00	6.07202E+00	3.68044E+00	2.09901E+00	9.23045E-03	4.12531E-03
70.00	30.00	0.00000E+00	2.04508E+00	4.69374E+00	6.27780E+00	5.02463E+00	3.05583E+00	1.74192E+00	8.09013E-03	3.42256E-03
75.00	30.00	0.00000E+00	1.73147E+00	3.92597E+00	5.12145E+00	3.99007E+00	2.47221E+00	1.42312E+00	7.25012E-03	2.72092E-03
78.00	30.00	0.00000E+00	1.45962E+00	3.41282E+00	4.53202E+00	3.55836E+00	2.17939E+00	1.25514E+00	6.87809E-03	2.44836E-03
79.50	30.00	0.00000E+00	1.36080E+00	3.14765E+00	4.21031E+00	3.35795E+00	2.06053E+00	1.17955E+00	6.83023E-03	2.37370E-03
80.00	30.00	0.00000E+00	1.33380E+00	3.07585E+00	4.10236E+00	3.29267E+00	2.02259E+00	1.15640E+00	6.81977E-03	2.35520E-03
85.00	30.00	0.00000E+00	1.10827E+00	2.55064E+00	3.35118E+00	2.66604E+00	1.66204E+00	9.57743E-01	6.40888E-03	1.95600E-03
88.00	30.00	0.00000E+00	9.93248E-01	2.27223E+00	3.00254E+00	2.38565E+00	1.46722E+00	8.52008E-01	6.28963E-03	1.83141E-03
90.00	30.00	0.00000E+00	9.37768E-01	2.12774E+00	2.79143E+00	2.22739E+00	1.36455E+00	7.88099E-01	6.28892E-03	1.75524E-03
95.00	30.00	0.00000E+00	8.21676E-01	1.85092E+00	2.41340E+00	1.89248E+00	1.16908E+00	6.71063E-01	6.16014E-03	1.55586E-03
100.00	30.00	0.00000E+00	7.39028E-01	1.61212E+00	2.05260E+00	1.61830E+00	9.88962E-01	5.63803E-01	6.39540E-03	1.50970E-03

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the IVFS slab is as follows:

1.05071E-03	5.59636E-03	2.11256E-02	5.96530E-02	1.35403E-01	2.48887E-01	3.55768E-01	5.16271E-01	7.43742E-01	2.72212E-01
2.31084E-01	4.17838E-01	9.26837E-01	1.00776E+00	1.04194E+00	1.04359E+00	1.27796E+00	1.63482E+00	1.06925E+00	4.07412E-01
1.15886E+00	1.43429E+00	5.72309E-02	2.04310E-02	4.17656E-02	4.01283E-01	1.25734E+00	9.55809E-01	4.94275E-01	1.09389E+00
5.70140E-01	1.88528E+00	2.87700E-01	3.31226E-01	4.98681E-01	1.52382E-01	1.85921E-01	2.70740E-01	2.14651E-01	1.16133E+00
9.14816E-01	5.38543E-01	3.74889E-01	1.57654E-01	8.86188E-02	6.76232E-02	4.58357E-02	3.31472E-01	5.27304E-01	6.86291E-01
7.25934E-01	8.22072E-01	5.39066E-01	1.16961E+00	7.60455E-01	5.17835E-01	1.94570E-01	6.55321E-01	6.73200E-01	4.18972E-01
1.43778E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the IVFS slab is as follows:

5.31155E-04	2.82895E-03	1.06316E-02	2.99774E-02	6.76736E-02	1.24671E-01	1.80914E-01	2.62251E-01	3.70962E-01	1.28800E-01
1.12937E-01	2.05764E-01	4.55197E-01	4.95833E-01	5.18450E-01	4.95356E-01	6.49908E-01	7.85176E-01	5.23454E-01	1.90591E-01
5.45612E-01	7.06864E-01	2.91505E-02	1.04619E-02	2.14607E-02	1.97101E-01	5.90396E-01	4.65335E-01	2.61256E-01	5.01382E-01
3.10385E-01	8.56638E-01	1.33223E-01	1.90975E-01	2.14659E-01	5.68724E-02	8.56654E-02	1.24931E-01	9.86346E-02	5.61761E-01
4.56232E-01	2.84468E-01	1.96118E-01	8.46183E-02	4.94611E-02	4.01251E-02	2.79241E-02	1.97698E-01	3.03040E-01	3.87755E-01
4.07159E-01	4.62552E-01	3.21054E-01	6.80421E-01	4.72431E-01	3.58306E-01	1.84918E-01	4.42627E-01	4.40867E-01	3.25331E-01
3.35471E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the IVFS slab is as follows:

9.26140E-05	4.85184E-04	1.81065E-03	5.03255E-03	1.12835E-02	2.08137E-02	3.03615E-02	4.41250E-02	6.18283E-02	2.11760E-02
1.88624E-02	3.43353E-02	7.60514E-02	8.28036E-02	8.65428E-02	8.06487E-02	1.07120E-01	1.28021E-01	8.62118E-02	3.09458E-02
8.74518E-02	1.15465E-01	4.80730E-03	1.73367E-03	3.58374E-03	3.22242E-02	9.53810E-02	7.54949E-02	4.47749E-02	7.86495E-02
5.40973E-02	1.34277E-01	2.11075E-02	3.48927E-02	3.22759E-02	8.67250E-03	1.37801E-02	1.99481E-02	1.58675E-02	9.25842E-02
7.64260E-02	4.82700E-02	3.28940E-02	1.40695E-02	8.20125E-03	6.71326E-03	4.75599E-03	3.50580E-02	5.45434E-02	7.01592E-02
7.33912E-02	8.34918E-02	5.89832E-02	1.23963E-01	8.58393E-02	6.57652E-02	3.10526E-02	8.05807E-02	7.88133E-02	5.72173E-02
6.95610E-02									

Table R.16 (cont)

Flux (n/s/cm ² /watt) by group (ig=1,61) at R= 10.00, Z= 30.00 cm past the IVFS slab is as follows:													
5.14699E-04	2.74010E-03	1.02970E-02	2.90187E-02	6.55513E-02	1.20960E-01	1.75958E-01	2.55794E-01	3.63191E-01	1.26349E-01				
1.10956E-01	2.02918E-01	4.49608E-01	4.90354E-01	5.13115E-01	4.93053E-01	6.41514E-01	7.78071E-01	5.18729E-01	1.89625E-01				
5.46478E-01	6.98401E-01	2.87966E-02	1.03355E-02	2.12062E-02	1.95580E-01	5.84366E-01	4.62269E-01	2.58117E-01	5.04617E-01				
3.05495E-01	8.58687E-01	1.31837E-01	1.86497E-01	2.14864E-01	5.71464E-02	8.56560E-02	1.24240E-01	9.71878E-02	5.52070E-01				
4.51449E-01	2.80101E-01	1.93905E-01	8.34153E-02	4.83860E-02	3.86066E-02	2.72070E-02	1.96188E-01	3.02892E-01	3.89670E-01				
4.10239E-01	4.67813E-01	3.28876E-01	6.89571E-01	4.82488E-01	3.66416E-01	1.88422E-01	4.43897E-01	4.39836E-01	3.21103E-01				
2.76915E-01													
Flux (n/s/cm ² /watt) by group (ig=1,61) at R= 20.00, Z= 30.00 cm past the IVFS slab is as follows:													
4.92465E-04	2.62072E-03	9.84793E-03	2.77283E-02	6.25947E-02	1.15499E-01	1.67987E-01	2.44093E-01	3.46017E-01	1.20342E-01				
1.05646E-01	1.93155E-01	4.28042E-01	4.66676E-01	4.87938E-01	4.69256E-01	6.07890E-01	7.37722E-01	4.90952E-01	1.79687E-01				
5.17740E-01	6.60455E-01	2.71749E-02	9.75010E-03	2.00050E-02	1.84762E-01	5.52645E-01	4.35767E-01	2.42012E-01	4.76323E-01				
2.85662E-01	8.09404E-01	1.24158E-01	1.73185E-01	2.03029E-01	5.41054E-02	8.07244E-02	1.17394E-01	9.18327E-02	5.20443E-01				
4.25368E-01	2.63247E-01	1.82004E-01	7.82199E-02	4.52403E-02	3.59930E-02	2.53717E-02	1.84450E-01	2.86407E-01	3.69289E-01				
3.88303E-01	4.43531E-01	3.10805E-01	6.54516E-01	4.56358E-01	3.45250E-01	1.73632E-01	4.21400E-01	4.17679E-01	3.02085E-01				
2.49254E-01													
Flux (n/s/cm ² /watt) by group (ig=1,61) at R= 40.00, Z= 30.00 cm past the IVFS slab is as follows:													
3.89562E-04	2.06173E-03	7.73722E-03	2.16638E-02	4.86832E-02	8.94175E-02	1.28918E-01	1.86596E-01	2.65264E-01	9.29938E-02				
8.10747E-02	1.47433E-01	3.26227E-01	3.54739E-01	3.68664E-01	3.55196E-01	4.55809E-01	5.52554E-01	3.65717E-01	1.34160E-01				
3.85789E-01	4.92977E-01	2.01763E-02	7.23267E-03	1.48268E-02	1.37127E-01	4.13115E-01	3.22548E-01	1.78421E-01	3.52018E-01				
2.10971E-01	5.99977E-01	9.26461E-02	1.30082E-01	1.51845E-01	4.12721E-02	6.01456E-02	8.81564E-02	6.93846E-02	3.95455E-01				
3.26927E-01	2.06517E-01	1.44799E-01	6.29055E-02	3.71914E-02	3.02204E-02	2.11496E-02	1.49728E-01	2.27114E-01	2.91144E-01				
3.06288E-01	3.51251E-01	2.55869E-01	5.27520E-01	3.83568E-01	3.02123E-01	1.72452E-01	3.55576E-01	3.50100E-01	2.69480E-01				
2.66617E-01													
Flux (n/s/cm ² /watt) by group (ig=1,61) at R= 60.00, Z= 30.00 cm past the IVFS slab is as follows:													
2.35691E-04	1.22483E-03	4.57484E-03	1.25837E-02	2.80096E-02	5.11051E-02	7.27460E-02	1.05214E-01	1.51994E-01	5.45446E-02				
4.68822E-02	8.46741E-02	1.88113E-01	2.04573E-01	2.10467E-01	2.06729E-01	2.56251E-01	3.12394E-01	2.05236E-01	7.65387E-02				
2.20233E-01	2.83244E-01	1.13665E-02	4.06978E-03	8.41487E-03	7.74265E-02	2.40447E-01	1.81925E-01	9.92173E-02	2.01009E-01				
1.17959E-01	3.50236E-01	5.44610E-02	7.57946E-02	8.66250E-02	2.40950E-02	3.92915E-02	6.12895E-02	4.74830E-02	2.59707E-01				
2.12834E-01	1.29417E-01	9.26558E-02	4.03181E-02	2.39832E-02	1.98107E-02	1.42559E-02	1.06550E-01	1.61172E-01	2.06889E-01				
2.05527E-01	2.53346E-01	2.02062E-01	3.82259E-01	3.04727E-01	2.51512E-01	1.71150E-01	2.54349E-01	2.44238E-01	2.04422E-01				
2.46876E-01													
Flux (n/s/cm ² /watt) by group (ig=1,61) at R= 80.00, Z= 30.00 cm past the IVFS slab is as follows:													
1.20001E-04	6.12208E-04	2.25459E-03	6.15501E-03	1.35621E-02	2.44329E-02	3.39242E-02	4.85577E-02	7.10707E-02	2.57625E-02				
2.18255E-02	3.87558E-02	8.50541E-02	9.19288E-02	9.33002E-02	8.99384E-02	1.15555E-01	1.36898E-01	9.03360E-02	3.28455E-02				
9.39265E-02	1.25464E-01	5.12690E-03	1.83360E-03	3.71433E-03	3.42263E-02	1.06240E-01	8.16632E-02	4.82823E-02	8.54308E-02				
5.94714E-02	1.47640E-01	2.40938E-02	4.35855E-02	3.94985E-02	1.15319E-02	1.49903E-02	2.29314E-02	1.82810E-02	1.07604E-01				
9.14855E-02	6.25495E-02	4.52795E-02	2.03209E-02	1.28763E-02	1.12219E-02	7.63345E-03	4.69892E-02	6.34262E-02	7.77068E-02				
8.10138E-02	9.20127E-02	7.20135E-02	1.37250E-01	1.07218E-01	8.75001E-02	5.89592E-02	9.43370E-02	9.48977E-02	8.44592E-02				
1.88672E-01													
Flux (n/s/cm ² /watt) by group (ig=1,61) at R=100.00, Z= 30.00 cm past the IVFS slab is as follows:													
4.64501E-05	2.32816E-04	8.43746E-04	2.30696E-03	5.05713E-03	9.13433E-03	1.25065E-02	1.84261E-02	2.86907E-02	1.04130E-02				
9.00255E-03	1.56897E-02	3.45328E-02	3.77567E-02	3.90018E-02	3.59057E-02	5.16964E-02	5.76899E-02	4.05041E-02	1.39131E-02				
4.16204E-02	5.64776E-02	2.48235E-03	9.04784E-04	1.82826E-03	1.62503E-02	4.81643E-02	4.02975E-02	2.90114E-02	3.88386E-02				
3.84921E-02	6.72023E-02	1.13391E-02	3.43533E-02	1.99214E-02	5.93804E-03	5.90547E-03	8.78824E-03	7.54889E-03	5.26346E-02				
4.89364E-02	3.92717E-02	2.90698E-02	1.36057E-02	9.37856E-03	8.87817E-03	5.84040E-03	3.06886E-02	3.50832E-02	3.93973E-02				
4.11194E-02	4.40270E-02	3.78739E-02	6.62291E-02	5.75237E-02	5.06809E-02	4.08959E-02	5.15958E-02	5.29913E-02	5.75242E-02				
2.07281E-01

Fig. G.17. Computational model used for Configuration 111B.3 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration, with extended concrete ring and Cd hut). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.17. Detailed description of the calculational model for Configuration IIIB.3 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration, with extended concrete ring and Cd hut).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
477.840	489.840	15	0.0	62	----->							157.100
422.550	477.840	50	0.0	62	----->							157.100
385.873	422.550	33	0.0	62	----->							157.100
384.440	385.873	2	0.0	67	----->							157.100
372.440	384.440	16	0.0	62	----->							157.100
363.300	372.440	15	0.0	62	----->							157.100
343.200	363.300	30	0.0	62	----->							157.100
340.873	343.200	5	0.0	62	----->							157.100
339.440	340.873	2	0.0	62	----->							157.100
336.900	339.440	2	0.0	27	----->							157.100
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707 33	----->					157.100
329.120	332.580	3	0.0	27	----->							157.100
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707 33	----->					157.100
323.300	325.840	2	0.0	27	----->							157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.17. Results for Config IIIB.3

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.39440E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.64437E+01	5.37006E+01	8.70651E+01	8.82452E+01	5.74342E+01	3.29587E+01	1.58561E-02	1.50647E-02
.00	.70	0.00000E+00	1.40266E+01	4.55545E+01	7.52955E+01	8.12302E+01	5.31703E+01	3.14353E+01	1.51112E-02	1.43622E-02
.00	30.00	0.00000E+00	6.53136E+00	1.57061E+01	2.11304E+01	1.70936E+01	1.04065E+01	5.86217E+00	1.44035E-02	9.35705E-03
.00	150.00	0.00000E+00	1.05420E+00	2.52188E+00	3.35690E+00	2.58368E+00	1.51663E+00	8.23768E-01	2.82510E-03	1.60318E-03
.00	30.00	0.00000E+00	6.53136E+00	1.57061E+01	2.11304E+01	1.70936E+01	1.04065E+01	5.86217E+00	1.44035E-02	9.35705E-03
5.00	30.00	0.00000E+00	6.45971E+00	1.55739E+01	2.10042E+01	1.69906E+01	1.03422E+01	5.82629E+00	1.42619E-02	9.41238E-03
10.00	30.00	0.00000E+00	6.33131E+00	1.53068E+01	2.06698E+01	1.66985E+01	1.01611E+01	5.72804E+00	1.29711E-02	9.31681E-03
15.00	30.00	0.00000E+00	6.19354E+00	1.49582E+01	2.01719E+01	1.62569E+01	9.88101E+00	5.57236E+00	1.21396E-02	9.07539E-03
20.00	30.00	0.00000E+00	6.00255E+00	1.44917E+01	1.95190E+01	1.56714E+01	9.51522E+00	5.36334E+00	1.17762E-02	8.76868E-03
25.00	30.00	0.00000E+00	5.77383E+00	1.38801E+01	1.86710E+01	1.49543E+01	9.07103E+00	5.11074E+00	1.14932E-02	8.54447E-03
30.00	30.00	0.00000E+00	5.53648E+00	1.32038E+01	1.76887E+01	1.41151E+01	8.55119E+00	4.81742E+00	1.12125E-02	8.14992E-03
35.00	30.00	0.00000E+00	5.27745E+00	1.24370E+01	1.65855E+01	1.31466E+01	7.96121E+00	4.48568E+00	1.12714E-02	7.99505E-03
40.00	30.00	0.00000E+00	4.94801E+00	1.15608E+01	1.53425E+01	1.20839E+01	7.30831E+00	4.12213E+00	1.07219E-02	7.40117E-03
45.00	30.00	0.00000E+00	4.51189E+00	1.05061E+01	1.39279E+01	1.09392E+01	6.61199E+00	3.73322E+00	9.84991E-03	6.98821E-03
50.00	30.00	0.00000E+00	4.43739E+00	9.88455E+00	1.27608E+01	9.77931E+00	5.89492E+00	3.32941E+00	1.19555E-02	7.49335E-03
55.00	30.00	0.00000E+00	3.71413E+00	8.55469E+00	1.12088E+01	8.57599E+00	5.15898E+00	2.91918E+00	7.34106E-03	5.19448E-03
60.00	30.00	0.00000E+00	3.23355E+00	7.24402E+00	9.44906E+00	7.34380E+00	4.43036E+00	2.50456E+00	8.13500E-03	5.56543E-03
65.00	30.00	0.00000E+00	2.90865E+00	6.45224E+00	8.24580E+00	6.17317E+00	3.73001E+00	2.12065E+00	5.60276E-03	3.88189E-03
70.00	30.00	0.00000E+00	2.08000E+00	4.80157E+00	6.42460E+00	5.12295E+00	3.10395E+00	1.76292E+00	4.37284E-03	3.16843E-03
75.00	30.00	0.00000E+00	1.76362E+00	4.02971E+00	5.26392E+00	4.08604E+00	2.51916E+00	1.44359E+00	3.36731E-03	2.44870E-03
78.00	30.00	0.00000E+00	1.49018E+00	3.51476E+00	4.67279E+00	3.65383E+00	2.22612E+00	1.27547E+00	2.91609E-03	2.16618E-03
79.50	30.00	0.00000E+00	1.39049E+00	3.24882E+00	4.35098E+00	3.45376E+00	2.10743E+00	1.19993E+00	2.80690E-03	2.08390E-03
80.00	30.00	0.00000E+00	1.36328E+00	3.17703E+00	4.24327E+00	3.38872E+00	2.06960E+00	1.17681E+00	2.77519E-03	2.06299E-03
85.00	30.00	0.00000E+00	1.13755E+00	2.65764E+00	3.49960E+00	2.76501E+00	1.70977E+00	9.78093E-01	1.68826E-03	1.59095E-03
88.00	30.00	0.00000E+00	1.00622E+00	2.36166E+00	3.14019E+00	2.48281E+00	1.51403E+00	8.71786E-01	3.80337E-03	1.60490E-03
90.00	30.00	0.00000E+00	9.42919E-01	2.19234E+00	2.90447E+00	2.31789E+00	1.40910E+00	8.07069E-01	3.83518E-03	1.53148E-03
95.00	30.00	0.00000E+00	8.25160E-01	1.89479E+00	2.48479E+00	1.95393E+00	1.20266E+00	6.85673E-01	3.93109E-03	1.36426E-03
100.00	30.00	0.00000E+00	7.43283E-01	1.65371E+00	2.11777E+00	1.66216E+00	1.00958E+00	5.72494E-01	4.19375E-03	1.32328E-03

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the IVFS slab is as follows:

1.04738E-03	5.57810E-03	2.10566E-02	5.94620E-02	1.34983E-01	2.48136E-01	3.54664E-01	5.14746E-01	7.41804E-01	2.71590E-01
2.30606E-01	4.16954E-01	9.25095E-01	1.00625E+00	1.04081E+00	1.04273E+00	1.27769E+00	1.63659E+00	1.07156E+00	4.08395E-01
1.16332E+00	1.43938E+00	5.74667E-02	2.05200E-02	4.19577E-02	4.02890E-01	1.26227E+00	9.60481E-01	4.97144E-01	1.09934E+00
5.73542E-01	1.89495E+00	2.89119E-01	3.33368E-01	5.01500E-01	1.53213E-01	1.86576E-01	2.71939E-01	2.15733E-01	1.16730E+00
9.19712E-01	5.41514E-01	3.76911E-01	1.58500E-01	8.91298E-02	6.80280E-02	4.60907E-02	3.32768E-01	5.28821E-01	6.88256E-01
7.27950E-01	8.24030E-01	5.40663E-01	1.17126E+00	7.62047E-01	5.19533E-01	1.95609E-01	6.58162E-01	6.75700E-01	4.10156E-01
2.19140E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the IVFS slab is as follows:

5.30100E-04	2.82354E-03	1.06152E-02	2.99330E-02	6.75776E-02	1.24502E-01	1.80712E-01	2.62000E-01	3.70705E-01	1.28768E-01
1.12982E-01	2.05859E-01	4.55660E-01	4.96679E-01	5.19684E-01	4.96909E-01	6.52747E-01	7.91427E-01	5.29257E-01	1.92833E-01
5.54222E-01	7.16414E-01	2.95942E-02	1.06279E-02	2.18137E-02	1.99837E-01	5.98663E-01	4.72563E-01	2.65774E-01	5.08720E-01
3.15772E-01	8.69126E-01	1.35197E-01	1.94122E-01	2.17739E-01	5.77642E-02	8.63600E-02	1.26592E-01	1.00169E-01	5.69578E-01
4.62496E-01	2.88280E-01	1.98666E-01	8.57087E-02	5.01129E-02	4.06322E-02	2.82513E-02	1.99624E-01	3.05416E-01	3.90823E-01
4.10242E-01	4.65661E-01	3.23580E-01	6.83625E-01	4.75420E-01	3.61252E-01	1.86703E-01	4.47215E-01	4.44961E-01	3.17554E-01
2.08109E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the IVFS slab is as follows:

9.14609E-05	4.78771E-04	1.78751E-03	4.96813E-03	1.11385E-02	2.05411E-02	2.99533E-02	4.35197E-02	6.09723E-02	2.08779E-02
1.85972E-02	3.38414E-02	7.49444E-02	8.15960E-02	8.52794E-02	7.94626E-02	1.05386E-01	1.25741E-01	8.45452E-02	3.03008E-02
8.58141E-02	1.13369E-01	4.72725E-03	1.70463E-03	3.52301E-03	3.16660E-02	9.37284E-02	7.43064E-02	4.42045E-02	7.73917E-02
5.34570E-02	1.32135E-01	2.07723E-02	3.64381E-02	3.18466E-02	8.55885E-03	1.35233E-02	1.95855E-02	1.55926E-02	9.11261E-02
7.53057E-02	4.77109E-02	3.25498E-02	1.39409E-02	8.15590E-03	6.70228E-03	4.74200E-03	3.47149E-02	5.36686E-02	6.90750E-02
7.19338E-02	8.10401E-02	5.80354E-02	1.17793E-01	8.36718E-02	6.50944E-02	3.09079E-02	7.90927E-02	7.60534E-02	4.46163E-02
5.10489E-02									

Table R.17 (cont)

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 10.00, Z= 30.00 cm past the IVFS slab is as follows:

5.13706E-04	2.73527E-03	1.02804E-02	2.89748E-02	6.54582E-02	1.20803E-01	1.75762E-01	2.55552E-01	3.62947E-01	1.26319E-01
1.11001E-01	2.03013E-01	4.50065E-01	4.91189E-01	5.14333E-01	4.94591E-01	6.44357E-01	7.84247E-01	5.24469E-01	1.91847E-01
5.55045E-01	7.07906E-01	2.92384E-02	1.05007E-02	2.15571E-02	1.98305E-01	5.92600E-01	4.69478E-01	2.62636E-01	5.11950E-01
3.10893E-01	8.71170E-01	1.33807E-01	1.89683E-01	2.17958E-01	5.80526E-02	8.63715E-02	1.25911E-01	9.87265E-02	5.59945E-01
4.57804E-01	2.84021E-01	1.96531E-01	8.45415E-02	4.90602E-02	3.91383E-02	2.75515E-02	1.98198E-01	3.05349E-01	3.92826E-01
4.13421E-01	4.71035E-01	3.31523E-01	6.92974E-01	4.85662E-01	3.69521E-01	1.90392E-01	4.48617E-01	4.44071E-01	3.13608E-01
1.48755E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 20.00, Z= 30.00 cm past the IVFS slab is as follows:

4.91528E-04	2.61608E-03	9.83161E-03	2.76835E-02	6.25041E-02	1.15361E-01	1.67809E-01	2.43875E-01	3.45810E-01	1.20323E-01
1.05701E-01	1.93271E-01	4.28544E-01	4.67566E-01	4.89215E-01	4.70861E-01	6.10873E-01	7.43997E-01	4.96764E-01	1.81934E-01
5.26392E-01	6.70103E-01	2.76241E-02	9.91775E-03	2.03604E-02	1.87521E-01	5.60976E-01	4.43040E-01	2.46565E-01	4.83695E-01
2.91095E-01	8.21923E-01	1.26138E-01	1.76397E-01	2.06120E-01	5.50123E-02	8.14468E-02	1.19085E-01	9.33904E-02	5.28419E-01
4.31794E-01	2.67196E-01	1.84657E-01	7.93539E-02	4.59213E-02	3.65288E-02	2.57182E-02	1.86488E-01	2.88907E-01	3.72508E-01
3.91531E-01	4.46830E-01	3.13540E-01	6.58038E-01	4.59660E-01	3.48479E-01	1.75709E-01	4.26241E-01	4.22018E-01	2.94874E-01
1.21575E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 40.00, Z= 30.00 cm past the IVFS slab is as follows:

3.88804E-04	2.05853E-03	7.72856E-03	2.16419E-02	4.86451E-02	8.93594E-02	1.28838E-01	1.86493E-01	2.65173E-01	9.30083E-02
8.11492E-02	1.47591E-01	3.26805E-01	3.55683E-01	3.69964E-01	3.56803E-01	4.58741E-01	5.58587E-01	3.71259E-01	1.36304E-01
3.93987E-01	5.02166E-01	2.06043E-02	7.39194E-03	1.51628E-02	1.39737E-01	4.20984E-01	3.29367E-01	1.82703E-01	3.58861E-01
2.16080E-01	6.11542E-01	9.44843E-02	1.33144E-01	1.54690E-01	4.21109E-02	6.08221E-02	8.97332E-02	7.08430E-02	4.02966E-01
3.33013E-01	2.10305E-01	1.47359E-01	6.40072E-02	3.78605E-02	3.07562E-02	2.14979E-02	1.51776E-01	2.29590E-01	2.94307E-01
3.09420E-01	3.54426E-01	2.58607E-01	5.30805E-01	3.86844E-01	3.05447E-01	1.74717E-01	3.60357E-01	3.54253E-01	2.61563E-01
1.35829E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 60.00, Z= 30.00 cm past the IVFS slab is as follows:

2.35249E-04	1.22293E-03	4.57111E-03	1.25816E-02	2.80192E-02	5.11327E-02	7.27815E-02	1.05242E-01	1.52019E-01	5.45897E-02
4.69686E-02	8.48618E-02	1.88731E-01	2.05521E-01	2.11727E-01	2.08275E-01	2.59030E-01	3.17884E-01	2.10228E-01	7.84737E-02
2.27543E-01	2.91555E-01	1.17549E-02	4.21342E-03	8.71509E-03	7.97630E-02	2.47479E-01	1.87951E-01	1.03028E-01	2.06955E-01
1.22506E-01	3.60198E-01	5.60580E-02	7.85969E-02	8.90590E-02	2.48210E-02	3.99025E-02	6.26580E-02	4.87419E-02	2.66285E-01
2.18199E-01	1.32817E-01	9.49706E-02	4.13226E-02	2.46023E-02	2.03173E-02	1.45864E-02	1.08462E-01	1.63422E-01	2.09738E-01
2.08302E-01	2.56082E-01	2.04525E-01	3.84823E-01	3.07542E-01	2.54540E-01	1.73273E-01	2.58546E-01	2.47694E-01	1.95037E-01
1.05271E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 80.00, Z= 30.00 cm past the IVFS slab is as follows:

1.19751E-04	6.11044E-04	2.25120E-03	6.14994E-03	1.35767E-02	2.44679E-02	3.39840E-02	4.86126E-02	7.10986E-02	2.58091E-02
2.19079E-02	3.89504E-02	8.57135E-02	9.29474E-02	9.46619E-02	9.16267E-02	1.18473E-01	1.42429E-01	9.52639E-02	3.47642E-02
1.01016E-01	1.33564E-01	5.50581E-03	1.97278E-03	4.00246E-03	3.64760E-02	1.13049E-01	8.73835E-02	5.18985E-02	9.09825E-02
6.37851E-02	1.56850E-01	2.55856E-02	4.62681E-02	4.17345E-02	1.22096E-02	1.55737E-02	2.41888E-02	1.94364E-02	1.13686E-01
9.64343E-02	6.57064E-02	4.74248E-02	2.12476E-02	1.34495E-02	1.16935E-02	7.93967E-03	4.87334E-02	6.54140E-02	8.02488E-02
8.34086E-02	9.41950E-02	7.41288E-02	1.38596E-01	1.09332E-01	9.01674E-02	6.08010E-02	9.79760E-02	9.74966E-02	7.10065E-02
2.87917E-02									

Flux (n/s/cm²/watt) by group (ig=1,61) at R=100.00, Z= 30.00 cm past the IVFS slab is as follows:

4.59397E-05	2.30118E-04	8.33601E-04	2.27779E-03	4.99752E-03	9.03263E-03	1.23797E-02	1.82389E-02	2.83971E-02	1.03325E-02
8.96039E-03	1.56613E-02	3.46565E-02	3.81451E-02	3.96586E-02	3.68139E-02	5.31239E-02	6.02844E-02	4.28282E-02	1.47893E-02
4.50055E-02	6.04952E-02	2.67671E-03	9.74887E-04	1.97131E-03	1.73864E-02	5.15200E-02	4.32356E-02	3.10242E-02	4.15881E-02
4.09524E-02	7.17144E-02	1.20709E-02	3.60307E-02	2.10313E-02	6.26960E-03	6.17357E-03	9.34814E-03	8.07344E-03	5.56410E-02
5.14578E-02	4.09698E-02	3.02176E-02	1.41105E-02	9.70475E-03	9.16144E-03	6.02360E-03	3.16510E-02	3.60149E-02	4.05715E-02
4.20439E-02	4.44717E-02	3.87648E-02	6.48506E-02	5.77680E-02	5.18460E-02	4.17242E-02	5.30374E-02	5.32674E-02	4.55119E-02
1.21497E-01

Fig. G.18. Calculational model used for Configuration IIIB.4 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration, with extended concrete ring and Cd plate). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.18. Detailed description of the calculational model for Configuration IIIB.4 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration, with extended concrete ring and Cd plate).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
477.840	489.840	15	0.0	62	----->							157.100
422.550	477.840	50	0.0	62	----->							157.100
385.873	422.550	33	0.0	62	----->						135.400	34 157.100
384.440	385.873	2	0.0	62	----->						135.400	34 157.100
372.440	384.440	16	0.0	62	----->						135.400	34 157.100
363.300	372.440	15	0.0	62	----->						135.400	34 157.100
343.200	363.300	30	0.0	62	----->						96.140	34 157.100
340.873	343.200	5	0.0	62	----->	85.980	33	89.190	34	----->		157.100
339.440	340.873	2	0.0	67	----->	85.980	33	89.190	34	----->		157.100
336.900	339.440	2	0.0	27	----->	58.707	33	----->	89.190	34	----->	157.100
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	----->	89.190	34	----->	157.100
329.120	332.580	3	0.0	27	----->	58.707	33	----->	89.190	34	----->	157.100
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	----->	89.190	34	----->	157.100
323.300	325.840	2	0.0	27	----->	58.707	33	----->	89.190	34	----->	157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.18. Results for Config IIIB.4

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.39440E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.67364E+01	5.45177E+01	8.81494E+01	8.89105E+01	5.77434E+01	3.30874E+01	1.55954E-02	1.51182E-02
.00	2.13	0.00000E+00	1.15318E+01	3.48464E+01	5.70870E+01	6.81960E+01	4.58738E+01	2.80402E+01	1.53648E-02	1.31446E-02
.00	30.00	0.00000E+00	6.24247E+00	1.53107E+01	2.07246E+01	1.68588E+01	1.02703E+01	5.78365E+00	1.14426E-02	8.43274E-03
.00	150.00	0.00000E+00	1.06186E+00	2.54198E+00	3.38949E+00	2.61196E+00	1.53206E+00	8.31151E-01	3.04373E-03	1.63179E-03
.00	30.00	0.00000E+00	6.24247E+00	1.53107E+01	2.07246E+01	1.68588E+01	1.02703E+01	5.78365E+00	1.14426E-02	8.43274E-03
5.00	30.00	0.00000E+00	6.15594E+00	1.51609E+01	2.05827E+01	1.67517E+01	1.02049E+01	5.74722E+00	1.14352E-02	8.42183E-03
10.00	30.00	0.00000E+00	5.99033E+00	1.48410E+01	2.02056E+01	1.64498E+01	1.00207E+01	5.64768E+00	1.14219E-02	8.42088E-03
15.00	30.00	0.00000E+00	5.86219E+00	1.44726E+01	1.96805E+01	1.60002E+01	9.73728E+00	5.49104E+00	1.13404E-02	8.35269E-03
20.00	30.00	0.00000E+00	5.71082E+00	1.40444E+01	1.90388E+01	1.54114E+01	9.36978E+00	5.28223E+00	1.10822E-02	8.10359E-03
25.00	30.00	0.00000E+00	5.48524E+00	1.34496E+01	1.82119E+01	1.46885E+01	8.92228E+00	5.02986E+00	1.07681E-02	7.82946E-03
30.00	30.00	0.00000E+00	5.23169E+00	1.27470E+01	1.72141E+01	1.38478E+01	8.40028E+00	4.73733E+00	1.03953E-02	7.48765E-03
35.00	30.00	0.00000E+00	4.99068E+00	1.19927E+01	1.61077E+01	1.28816E+01	7.81178E+00	4.40692E+00	1.02129E-02	7.27700E-03
40.00	30.00	0.00000E+00	4.66036E+00	1.11135E+01	1.48684E+01	1.18162E+01	7.16261E+00	4.04583E+00	9.82156E-03	6.79818E-03
45.00	30.00	0.00000E+00	4.23649E+00	1.00770E+01	1.34600E+01	1.06721E+01	6.46859E+00	3.65987E+00	9.55847E-03	6.41486E-03
50.00	30.00	0.00000E+00	4.18836E+00	9.48246E+00	1.23126E+01	9.52253E+00	5.75825E+00	3.25977E+00	1.00092E-02	6.81165E-03
55.00	30.00	0.00000E+00	3.49915E+00	8.19831E+00	1.08107E+01	8.33842E+00	5.03403E+00	2.85658E+00	8.10428E-03	4.90719E-03
60.00	30.00	0.00000E+00	3.07564E+00	6.97707E+00	9.13582E+00	7.15911E+00	4.33301E+00	2.45476E+00	8.50852E-03	5.25489E-03
65.00	30.00	0.00000E+00	2.93468E+00	6.41289E+00	8.13390E+00	6.05806E+00	3.66686E+00	2.09037E+00	7.71911E-03	4.42630E-03
70.00	30.00	0.00000E+00	2.07001E+00	4.85093E+00	6.53722E+00	5.10449E+00	3.08634E+00	1.75510E+00	6.62045E-03	3.26274E-03
75.00	30.00	0.00000E+00	1.85827E+00	4.13898E+00	5.34504E+00	4.13096E+00	2.54762E+00	1.45785E+00	6.56576E-03	3.05900E-03
78.00	30.00	0.00000E+00	1.63660E+00	3.73519E+00	4.85410E+00	3.71183E+00	2.26436E+00	1.30112E+00	6.05028E-03	2.49526E-03
79.50	30.00	0.00000E+00	1.51582E+00	3.49386E+00	4.58092E+00	3.53044E+00	2.14879E+00	1.22942E+00	5.99797E-03	2.40992E-03
80.00	30.00	0.00000E+00	1.47785E+00	3.41285E+00	4.48382E+00	3.47165E+00	2.11298E+00	1.20676E+00	6.01353E-03	2.40882E-03
85.00	30.00	0.00000E+00	1.24697E+00	2.81809E+00	3.67062E+00	2.89775E+00	1.78352E+00	1.01854E+00	5.84391E-03	2.08602E-03
88.00	30.00	0.00000E+00	1.12334E+00	2.57748E+00	3.35622E+00	2.60166E+00	1.60294E+00	9.19831E-01	5.70382E-03	1.91089E-03
90.00	30.00	0.00000E+00	1.04776E+00	2.39962E+00	3.14848E+00	2.44861E+00	1.49666E+00	8.58065E-01	5.61519E-03	1.80948E-03
95.00	30.00	0.00000E+00	9.29780E-01	2.08178E+00	2.70598E+00	2.14564E+00	1.30375E+00	7.36213E-01	5.65285E-03	1.71706E-03
100.00	30.00	0.00000E+00	8.22163E-01	1.83465E+00	2.34403E+00	1.83485E+00	1.11115E+00	6.28217E-01	5.67227E-03	1.51392E-03

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 2.13 cm past the IVFS slab is as follows:

1.01706E-03	5.41515E-03	2.04241E-02	5.76648E-02	1.30849E-01	2.40544E-01	3.44226E-01	4.99721E-01	7.20209E-01	2.62633E-01
2.23843E-01	4.05284E-01	9.00183E-01	9.81321E-01	1.01763E+00	1.01777E+00	1.25209E+00	1.59896E+00	1.04962E+00	3.97650E-01
1.14714E+00	1.41698E+00	5.70421E-02	2.03860E-02	4.16795E-02	3.97483E-01	1.23896E+00	9.51665E-01	4.96520E-01	1.08024E+00
5.71571E-01	1.85850E+00	2.82368E-01	3.32163E-01	4.90808E-01	1.47124E-01	1.79516E-01	2.62828E-01	2.09172E-01	1.13442E+00
8.93431E-01	5.28819E-01	3.65789E-01	1.53363E-01	8.66285E-02	6.67130E-02	4.48930E-02	3.22768E-01	5.07906E-01	6.64651E-01
6.97422E-01	7.71391E-01	5.21175E-01	1.04488E+00	7.21179E-01	5.07725E-01	1.91939E-01	6.34452E-01	6.24509E-01	2.33314E-01
8.77168E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the IVFS slab is as follows:

5.24948E-04	2.79412E-03	1.04958E-02	2.95869E-02	6.67727E-02	1.23076E-01	1.78507E-01	2.58795E-01	3.66482E-01	1.27280E-01
1.11685E-01	2.03498E-01	4.50463E-01	4.91375E-01	5.14317E-01	4.92025E-01	6.45566E-01	7.80194E-01	5.20774E-01	1.89462E-01
5.46747E-01	7.06458E-01	2.92516E-02	1.04998E-02	1.55338E-02	1.97507E-01	5.91224E-01	4.68277E-01	2.63756E-01	5.04730E-01
3.13026E-01	8.60763E-01	1.33483E-01	1.92815E-01	2.16098E-01	5.73703E-02	8.53103E-02	1.24594E-01	9.86098E-02	5.61096E-01
4.54707E-01	2.82886E-01	1.94964E-01	8.38555E-02	4.89834E-02	3.96026E-02	2.74591E-02	1.93199E-01	2.95232E-01	3.79631E-01
3.96662E-01	4.45288E-01	3.13424E-01	6.34575E-01	4.52989E-01	3.48213E-01	1.75753E-01	4.26624E-01	4.14239E-01	2.07032E-01
1.23086E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the IVFS slab is as follows:

9.17241E-05	4.80625E-04	1.79306E-03	4.98432E-03	1.11749E-02	2.06153E-02	3.00684E-02	4.37063E-02	6.12820E-02	2.09921E-02
1.87121E-02	3.40546E-02	7.54684E-02	8.22365E-02	8.60175E-02	8.02129E-02	1.06451E-01	1.27170E-01	8.56939E-02	3.07243E-02
8.74792E-02	1.15196E-01	4.80859E-03	1.73428E-03	3.58459E-03	3.22384E-02	9.53236E-02	7.58667E-02	4.51479E-02	7.91283E-02
5.45364E-02	1.34938E-01	2.11583E-02	3.53029E-02	3.26726E-02	8.76629E-03	1.37307E-02	1.98659E-02	1.58336E-02	9.26683E-02
7.66158E-02	4.85542E-02	3.30945E-02	1.41575E-02	8.27118E-03	6.78224E-03	4.79751E-03	3.49622E-02	5.39680E-02	6.94914E-02
7.24337E-02	8.16432E-02	5.85889E-02	1.18774E-01	8.45737E-02	6.58835E-02	3.12570E-02	7.96868E-02	7.66507E-02	4.47961E-02
5.91491E-02									

Table R.18 (cont)

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 10.00, Z= 30.00 cm past the IVFS slab is as follows:

5.08288E-04	2.70442E-03	1.01588E-02	2.86217E-02	6.46333E-02	1.19280E-01	1.73456E-01	2.52211E-01	3.58490E-01	1.24760E-01
1.09622E-01	2.00418E-01	4.44354E-01	4.85312E-01	5.08360E-01	4.88980E-01	6.36781E-01	7.71986E-01	5.15178E-01	1.88131E-01
5.46081E-01	6.97001E-01	2.88573E-02	1.03596E-02	2.12508E-02	1.95764E-01	5.84387E-01	4.64520E-01	2.59857E-01	5.07284E-01
3.06611E-01	8.61390E-01	1.31802E-01	1.86520E-01	2.16161E-01	5.74443E-02	8.51252E-02	1.23626E-01	9.68939E-02	5.49806E-01
4.48347E-01	2.76667E-01	1.90424E-01	8.15754E-02	4.70322E-02	3.73620E-02	2.63010E-02	1.89882E-01	2.93614E-01	3.79702E-01
3.97278E-01	4.47316E-01	3.17876E-01	6.37972E-01	4.57423E-01	3.50891E-01	1.73959E-01	4.22784E-01	4.09562E-01	2.04071E-01
1.22751E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 20.00, Z= 30.00 cm past the IVFS slab is as follows:

4.86101E-04	2.58528E-03	9.71093E-03	2.73375E-02	6.17073E-02	1.13870E-01	1.65607E-01	2.40748E-01	3.41832E-01	1.18889E-01
1.04448E-01	1.90967E-01	4.23460E-01	4.62418E-01	4.84071E-01	4.66161E-01	6.04849E-01	7.32743E-01	4.88330E-01	1.78481E-01
5.18551E-01	6.60654E-01	2.73120E-02	9.80216E-03	2.01079E-02	1.85392E-01	5.53744E-01	4.39225E-01	2.44979E-01	4.79724E-01
2.88663E-01	8.13695E-01	1.24501E-01	1.75546E-01	2.04879E-01	5.45857E-02	8.03450E-02	1.16985E-01	9.17589E-02	5.20759E-01
4.25097E-01	2.62785E-01	1.81267E-01	7.77582E-02	4.49792E-02	3.58040E-02	2.51658E-02	1.81691E-01	2.80671E-01	3.62975E-01
3.79443E-01	4.27779E-01	3.04472E-01	6.11762E-01	4.39913E-01	3.38384E-01	1.68025E-01	4.09392E-01	3.96566E-01	1.99764E-01
1.21947E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 40.00, Z= 30.00 cm past the IVFS slab is as follows:

3.84290E-04	2.03232E-03	7.62346E-03	2.13440E-02	4.79655E-02	8.80866E-02	1.26983E-01	1.83885E-01	2.61903E-01	9.17857E-02
8.00847E-02	1.45644E-01	3.22402E-01	3.51129E-01	3.65325E-01	3.52382E-01	4.52946E-01	5.47930E-01	3.63153E-01	1.33004E-01
3.85579E-01	4.92154E-01	2.02463E-02	7.25979E-03	1.48791E-02	1.37367E-01	4.13114E-01	3.24498E-01	1.80295E-01	3.53808E-01
2.12628E-01	6.01743E-01	9.26551E-02	1.31267E-01	1.52673E-01	4.14720E-02	5.97091E-02	8.76200E-02	6.91349E-02	3.94477E-01
3.25548E-01	2.05124E-01	1.43424E-01	6.21656E-02	3.67281E-02	2.98271E-02	2.08276E-02	1.46889E-01	2.22012E-01	2.85593E-01
2.98627E-01	3.38014E-01	2.49981E-01	4.91800E-01	3.68622E-01	2.95036E-01	1.66454E-01	3.44627E-01	3.31786E-01	1.81755E-01
1.24494E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 60.00, Z= 30.00 cm past the IVFS slab is as follows:

2.33948E-04	1.21251E-03	4.52299E-03	1.24206E-02	2.76215E-02	5.03918E-02	7.17033E-02	1.03814E-01	1.50523E-01	5.39272E-02
4.64176E-02	8.38787E-02	1.86372E-01	2.03145E-01	2.09274E-01	2.05666E-01	2.56251E-01	3.10510E-01	2.04607E-01	7.60330E-02
2.20861E-01	2.84133E-01	1.14979E-02	4.11857E-03	8.50907E-03	7.80566E-02	2.41414E-01	1.84377E-01	1.01677E-01	2.02612E-01
1.20756E-01	3.52093E-01	5.46837E-02	7.84416E-02	8.74382E-02	2.43270E-02	3.89338E-02	6.07137E-02	4.72034E-02	2.59923E-01
2.13136E-01	1.30117E-01	9.29972E-02	4.04951E-02	2.42045E-02	2.00904E-02	1.43783E-02	1.06152E-01	1.59106E-01	2.04437E-01
2.01913E-01	2.45227E-01	1.99105E-01	3.58770E-01	2.95923E-01	2.49078E-01	1.69336E-01	2.49997E-01	2.34906E-01	1.43713E-01
1.35322E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R= 80.00, Z= 30.00 cm past the IVFS slab is as follows:

1.23814E-04	6.25885E-04	2.29806E-03	6.21035E-03	1.36260E-02	2.45580E-02	3.41846E-02	4.90979E-02	7.21936E-02	2.61586E-02
2.22334E-02	3.95619E-02	8.70909E-02	9.45754E-02	9.62098E-02	9.31841E-02	1.19560E-01	1.40957E-01	9.33887E-02	3.39015E-02
9.83601E-02	1.31272E-01	5.40226E-03	1.93255E-03	3.91519E-03	3.59697E-02	1.11561E-01	8.62806E-02	5.16389E-02	8.99407E-02
6.36670E-02	1.55872E-01	2.54104E-02	4.72069E-02	4.15940E-02	1.22104E-02	1.60998E-02	2.50060E-02	1.98472E-02	1.16111E-01
9.87495E-02	6.74113E-02	4.89712E-02	2.19966E-02	1.40508E-02	1.23223E-02	8.38085E-03	5.16047E-02	6.93043E-02	8.51786E-02
8.76109E-02	9.90712E-02	8.07761E-02	1.43869E-01	1.19148E-01	1.01105E-01	7.07237E-02	1.05842E-01	1.02909E-01	6.97677E-02
1.52179E-01									

Flux (n/s/cm²/watt) by group (ig=1,61) at R=100.00, Z= 30.00 cm past the IVFS slab is as follows:

5.19281E-05	2.59494E-04	9.40236E-04	2.56996E-03	5.63776E-03	1.02361E-02	1.41081E-02	2.07938E-02	3.19170E-02	1.16145E-02
1.00790E-02	1.75296E-02	3.88267E-02	4.23702E-02	4.38134E-02	4.05045E-02	5.70374E-02	6.39872E-02	4.48750E-02	1.53989E-02
4.64615E-02	6.25378E-02	2.74664E-03	9.98026E-04	2.01346E-03	1.79083E-02	5.34221E-02	4.44131E-02	3.15993E-02	4.29895E-02
4.16745E-02	7.46149E-02	1.25510E-02	3.65726E-02	2.17406E-02	6.50833E-03	6.78199E-03	1.04031E-02	8.71853E-03	5.86897E-02
5.41164E-02	4.25226E-02	3.13942E-02	1.46295E-02	9.99268E-03	3.39544E-03	6.19495E-03	3.30849E-02	3.82820E-02	4.36000E-02
4.50858E-02	4.83969E-02	4.24189E-02	7.08215E-02	6.32931E-02	5.66058E-02	4.53957E-02	5.68089E-02	5.67081E-02	4.96738E-02
1.76353E-01

Fig. G.19. Calculational model used for Configuration 111C.1 (Fe/AL/Boral/2m Na/ Radial-Blanket assembly; basic configuration by itself). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.19. Detailed description of the calculational model for Configuration IIIC.1 (Fe/AL/Boral/2m Na/Radial-Blanket assemblies; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE																		
ZMIN	ZMAX	N	R	M	(etc) ...																
473.300	485.300	15	0.0	62													157.100				
418.010	473.300	52	0.0	62													157.100				
381.333	418.010	35	0.0	62													157.100				
379.900	381.333	2	0.0	62													157.100				
367.900	379.900	14	0.0	62													157.100				
363.300	367.900	6	0.0	62													157.100				
343.460	363.300	26	0.0	62													157.100				
336.333	343.460	10	0.0	62													157.100				
334.900	336.333	2	0.0	62													157.100				
334.424	334.900	1	0.0	64													157.100				
333.300	334.424	3	0.0	32	68.452	63	69.007	64													157.100
332.818	333.300	2	0.0	32	68.452	63	69.007	64													157.100
325.932	332.818	21	0.0	32	68.452	63	69.007	64													157.100
324.324	325.932	5	0.0	32	68.452	63	69.007	64													157.100
323.850	324.324	1	0.0	64													157.100				
323.300	323.850	1	0.0	62													157.100				
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)																		

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.19. Results for Config IIIC.1

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.34900E+02											
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)	
.00	.00	0.00000E+00	3.15290E+01	6.63473E+01	8.39455E+01	5.97535E+01	3.34269E+01	1.65703E+01	3.77521E-02	2.81508E-02	
.00	.70	0.00000E+00	2.58876E+01	5.61729E+01	7.22316E+01	5.38314E+01	3.10658E+01	1.57434E+01	3.16288E-02	2.25569E-02	
.00	30.00	0.00000E+00	8.10828E+00	1.51916E+01	1.74841E+01	1.04938E+01	5.70294E+00	2.99314E+00	2.19179E-02	1.47206E-02	
.00	150.00	0.00000E+00	1.40013E+00	2.58555E+00	2.94858E+00	1.69712E+00	8.95416E-01	4.58417E-01	4.01066E-03	2.46278E-03	
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the radial blanket assembly is as follows:											
5.74497E-04	2.97805E-03	1.10892E-02	3.11783E-02	6.93469E-02	1.25901E-01	1.71365E-01	2.45158E-01	3.60618E-01	1.14728E-01		
1.08517E-01	1.81155E-01	3.94928E-01	4.28854E-01	4.52312E-01	3.49583E-01	5.95298E-01	6.69282E-01	4.91308E-01	1.62059E-01		
4.09158E-01	6.15618E-01	2.73977E-02	1.08003E-02	2.45338E-02	1.92859E-01	4.91199E-01	4.59148E-01	3.88325E-01	4.33709E-01		
5.14831E-01	7.85983E-01	9.43945E-02	4.21541E-01	1.94195E-01	4.62286E-02	1.15476E-01	1.60732E-01	9.72490E-02	7.17079E-01		
6.68248E-01	5.41720E-01	2.87160E-01	5.61223E-02	1.61249E-02	3.98004E-02	5.35769E-02	4.30726E-01	7.13317E-01	9.92390E-01		
1.22993E+00	1.45220E+00	8.90847E-01	2.48768E+00	1.82643E+00	1.26984E+00	3.91617E-01	1.20076E+00	1.36586E+00	1.27683E+00		
3.82429E-01											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the radial blanket assembly is as follows:											
5.40463E-04	2.78725E-03	1.03332E-02	2.89146E-02	6.40483E-02	1.15961E-01	1.58074E-01	2.26748E-01	3.32906E-01	1.06243E-01		
1.00906E-01	1.68272E-01	3.69219E-01	4.01022E-01	4.25283E-01	3.30876E-01	5.55450E-01	6.32871E-01	4.64133E-01	1.50075E-01		
3.74811E-01	5.86008E-01	2.61776E-02	1.02867E-02	2.33516E-02	1.82839E-01	4.61982E-01	4.19883E-01	3.63925E-01	4.00267E-01		
4.67137E-01	7.11340E-01	8.30327E-02	3.67451E-01	1.28528E-01	1.67010E-02	1.00871E-01	1.54133E-01	9.45112E-02	6.83412E-01		
6.02813E-01	4.28825E-01	2.49091E-01	4.95513E-02	1.50633E-02	3.23557E-02	4.37055E-02	3.58241E-01	5.79099E-01	7.97848E-01		
9.08097E-01	1.14362E+00	7.13678E-01	1.96004E+00	1.44984E+00	1.02086E+00	3.29241E-01	9.53479E-01	1.07253E+00	1.00410E+00		
3.65612E-01											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the radial blanket assembly is as follows:											
3.15240E-04	1.62485E-03	6.01961E-03	1.68061E-02	3.72969E-02	6.81666E-02	9.53058E-02	1.37005E-01	1.94090E-01	6.03574E-02		
5.77228E-02	9.87770E-02	2.18444E-01	2.38309E-01	2.53729E-01	1.98783E-01	3.33748E-01	3.69486E-01	2.76946E-01	9.13683E-02		
2.30814E-01	3.51140E-01	1.57388E-02	6.27355E-03	1.45531E-02	1.12829E-01	2.82670E-01	2.56325E-01	2.22801E-01	2.44308E-01		
2.92539E-01	4.39059E-01	5.14037E-02	2.31455E-01	8.98411E-02	1.04016E-02	4.86459E-02	7.43918E-02	5.55549E-02	4.25792E-01		
3.80198E-01	2.69304E-01	1.55971E-01	3.02312E-02	9.78688E-03	2.20913E-02	2.85288E-02	2.28505E-01	3.69833E-01	5.07959E-01		
5.76836E-01	7.24983E-01	4.51862E-01	1.25570E+00	9.27579E-01	6.63662E-01	2.17638E-01	6.38426E-01	7.12551E-01	6.73935E-01		
2.92831E-01											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the radial blanket assembly is as follows:											
4.89042E-05	2.39001E-04	8.68518E-04	2.30245E-03	4.92400E-03	8.95511E-03	1.26269E-02	1.82452E-02	2.50897E-02	7.77143E-03		
7.54283E-03	1.30815E-02	2.96720E-02	3.24996E-02	3.46321E-02	2.71677E-02	4.47262E-02	4.96880E-02	3.82576E-02	1.31279E-02		
3.31692E-02	4.91806E-02	2.15095E-03	8.86048E-04	2.21971E-03	1.63124E-02	4.00334E-02	3.65658E-02	3.23206E-02	3.58663E-02		
4.36530E-02	6.60049E-02	7.70030E-03	3.58517E-02	1.45628E-02	1.78649E-03	6.27961E-03	1.04187E-02	8.42984E-03	6.66416E-02		
6.02694E-02	4.26190E-02	2.55573E-02	5.91998E-03	2.52364E-03	4.15214E-03	4.87711E-03	3.81504E-02	6.04690E-02	8.15648E-02		
8.93616E-02	1.12617E-01	7.49447E-02	1.97264E-01	1.49662E-01	1.15535E-01	4.84223E-02	1.11028E-01	1.16849E-01	1.12107E-01		
6.36863E-02

Fig. G.20. Calculational model used for Configuration IIC.2 (Fe/AL/Boral/2m Na/ Radial-Blanket assembly; basic configuration, with extended concrete ring in analytic model to simulate background radiation). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.20. Detailed description of the calculational model for Configuration IIIC.2 (Fe/AL/Boral/2m Na/Radial-Blanket assemblies; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
473.300	485.300	15	0.0	62	----->							157.100
418.010	473.300	52	0.0	62	----->							157.100
381.333	418.010	35	0.0	62	----->						135.400	34 157.100
379.900	381.333	2	0.0	62	----->						135.400	34 157.100
367.900	379.900	14	0.0	62	----->						135.400	34 157.100
363.300	367.900	6	0.0	62	----->						135.400	34 157.100
343.460	363.300	26	0.0	62	----->					96.140	34	157.100
336.333	343.460	10	0.0	62	----->					96.140	34	157.100
334.900	336.333	2	0.0	62	----->					96.140	34	157.100
334.424	334.900	1	0.0	64	----->	69.791	62	74.149	64	85.980	62	96.140 34 157.100
333.300	334.424	3	0.0	32	68.452 63 69.007 64	----->				85.980	62	96.140 34 157.100
332.818	333.300	2	0.0	32	68.452 63 69.007 64	----->				85.980	33	96.140 34 157.100
325.932	332.818	21	0.0	32	68.452 63 69.007 64	----->	74.149	65	82.007 64	84.547 62	85.980	33 96.140 34 157.100
324.324	325.932	5	0.0	32	68.452 63 69.007 64	----->				85.980	33	96.140 34 157.100
323.850	324.324	1	0.0	64	----->	69.791	62	74.149	64	85.980	33	96.140 34 157.100
323.300	323.850	1	0.0	62	----->					85.980	33	96.140 34 157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.20. Results for Config IIIC.2

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.34900E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	3.16731E+01	6.66188E+01	8.42594E+01	5.99317E+01	3.35133E+01	1.66096E+01	4.09485E-02	2.87975E-02
.00	.70	0.00000E+00	2.60612E+01	5.64817E+01	7.25805E+01	5.40224E+01	3.11574E+01	1.57849E+01	3.54838E-02	2.32928E-02
.00	30.00	0.00000E+00	8.31241E+00	1.55395E+01	1.78546E+01	1.06690E+01	5.78401E+00	3.02992E+00	2.59157E-02	1.53835E-02
.00	150.00	0.00000E+00	1.57580E+00	2.88656E+00	3.27368E+00	1.85687E+00	9.70226E-01	4.91915E-01	6.66883E-03	2.95019E-03
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the radial blanket assembly is as follows:										
5.77958E-04	2.99664E-03	1.11585E-02	3.13720E-02	6.97712E-02	1.26663E-01	1.72582E-01	2.47237E-01	3.64738E-01	1.16013E-01	
1.09736E-01	1.83394E-01	3.99689E-01	4.34292E-01	4.58288E-01	3.54990E-01	6.05145E-01	6.78148E-01	4.98188E-01	1.64188E-01	
4.15973E-01	6.26205E-01	2.79552E-02	1.10097E-02	2.49593E-02	1.96293E-01	5.00439E-01	4.68259E-01	3.96547E-01	4.42474E-01	
5.26899E-01	8.02162E-01	9.67576E-02	4.33510E-01	1.98628E-01	4.73624E-02	1.17567E-01	1.63421E-01	9.87707E-02	7.30568E-01	
6.82517E-01	5.52869E-01	2.94864E-01	5.96509E-02	1.85323E-02	4.25261E-02	5.55066E-02	4.38732E-01	7.21338E-01	1.00129E+00	
1.24024E+00	1.46449E+00	9.03354E-01	2.51129E+00	1.85131E+00	1.29280E+00	4.10700E-01	1.22054E+00	1.38757E+00	1.30628E+00	
4.90645E-01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the radial blanket assembly is as follows:										
5.43608E-04	2.80402E-03	1.03953E-02	2.90872E-02	6.44250E-02	1.16639E-01	1.59177E-01	2.28691E-01	3.36897E-01	1.07492E-01	
1.02090E-01	1.70452E-01	3.73862E-01	4.06358E-01	4.31171E-01	3.36260E-01	5.65302E-01	6.41615E-01	4.70953E-01	1.52171E-01	
3.81595E-01	5.96627E-01	2.67414E-02	1.04982E-02	2.37802E-02	1.86294E-01	4.71278E-01	4.29027E-01	3.72185E-01	4.09029E-01	
4.79279E-01	7.27290E-01	8.54013E-02	3.79569E-01	1.32846E-01	1.77646E-02	1.02912E-01	1.56786E-01	9.60206E-02	6.96948E-01	
6.17193E-01	4.40701E-01	2.57254E-01	5.33677E-02	1.77208E-02	3.51956E-02	4.56863E-02	3.66888E-01	5.87993E-01	8.07792E-01	
9.19768E-01	1.15712E+00	7.27606E-01	1.98542E+00	1.47685E+00	1.04628E+00	3.50974E-01	9.75470E-01	1.09655E+00	1.03680E+00	
4.98063E-01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the radial blanket assembly is as follows:										
3.16754E-04	1.63306E-03	6.05034E-03	1.68929E-02	3.74906E-02	6.85582E-02	9.59958E-02	1.38253E-01	1.96751E-01	6.11856E-02	
5.85193E-02	1.00280E-01	2.21622E-01	2.42006E-01	2.57793E-01	2.02451E-01	3.40587E-01	3.75492E-01	2.81876E-01	9.28773E-02	
2.35743E-01	3.58741E-01	1.61478E-02	6.42595E-03	1.48623E-02	1.15358E-01	2.89516E-01	2.63043E-01	2.28974E-01	2.50662E-01	
3.01620E-01	4.50206E-01	5.31466E-02	2.40491E-01	9.34254E-02	1.13538E-02	4.97022E-02	7.57345E-02	5.65737E-02	4.35529E-01	
3.90727E-01	2.78865E-01	1.62937E-01	3.34733E-02	1.20649E-02	2.45526E-02	3.02095E-02	2.36391E-01	3.77949E-01	5.16723E-01	
5.86717E-01	7.36083E-01	4.63147E-01	1.27581E+00	9.48824E-01	6.83970E-01	2.35552E-01	6.56858E-01	7.32699E-01	7.01865E-01	
4.34584E-01										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the radial blanket assembly is as follows:										
4.95958E-05	2.42810E-04	8.82962E-04	2.34752E-03	5.05620E-03	9.23598E-03	1.30705E-02	1.90206E-02	2.65779E-02	8.23287E-03	
8.02475E-03	1.39272E-02	3.15167E-02	3.47791E-02	3.71678E-02	2.91939E-02	4.84966E-02	5.38762E-02	4.18513E-02	1.42057E-02	
3.67895E-02	5.44983E-02	2.42337E-03	9.85273E-04	2.42088E-03	1.80379E-02	4.48553E-02	4.11755E-02	3.66623E-02	4.01273E-02	
5.00101E-02	7.34649E-02	8.97852E-03	4.22236E-02	1.71027E-02	2.48942E-03	6.77306E-03	1.10786E-02	9.09796E-03	7.40086E-02	
6.80620E-02	4.97509E-02	3.08464E-02	8.43257E-03	4.26730E-03	5.83564E-03	5.98442E-03	4.39701E-02	6.68473E-02	8.87449E-02	
9.73226E-02	1.21655E-01	8.40367E-02	2.13471E-01	1.66689E-01	1.31905E-01	6.27259E-02	1.25904E-01	1.32825E-01	1.33485E-01	
1.55893E-01

Fig. G.21. Calculational model used for Configuration IIC.3 (Fe/AL/Boral/2m Na/ Radial-Blanket assembly; basic configuration, with extended concrete ring and Cd hut). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.21. Detailed description of the calculational model for Configuration IIIC.3 (Fe/AL/Boral/2m Na/Radial-Blanket assemblies; basic configuration, with extended concrete ring and Cd hut).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
473.300	485.300	15	0.0	62	----->							157.100
418.010	473.300	52	0.0	62	----->							157.100
381.333	418.010	35	0.0	62	----->							157.100
379.900	381.333	2	0.0	67	----->							157.100
367.900	379.900	14	0.0	62	----->	84.547	67	85.980	62	----->	135.400	34 157.100
363.300	367.900	6	0.0	62	----->	84.547	67	85.980	62	----->	135.400	34 157.100
343.460	363.300	26	0.0	62	----->	84.547	67	85.980	62	96.140	34	-----> 157.100
336.333	343.460	10	0.0	62	----->	84.547	67	85.980	33	96.140	34	-----> 157.100
334.900	336.333	2	0.0	62	----->	84.547	67	85.980	33	96.140	34	-----> 157.100
334.424	334.900	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980	33 96.140 34 -----> 157.100
333.300	334.424	3	0.0	32	68.452 63 69.007 64	----->						85.980 33 96.140 34 -----> 157.100
332.818	333.300	2	0.0	32	68.452 63 69.007 64	----->						85.980 33 96.140 34 -----> 157.100
325.932	332.818	21	0.0	32	68.452 63 69.007 64	----->	74.149	65	82.007	64	84.547	62 85.980 33 96.140 34 -----> 157.100
324.324	325.932	5	0.0	32	68.452 63 69.007 64	----->						85.980 33 96.140 34 -----> 157.100
323.850	324.324	1	0.0	64	----->	69.791	62	74.149	64	----->	85.980	33 96.140 34 -----> 157.100
323.300	323.850	1	0.0	62	----->							85.980 33 96.140 34 -----> 157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.21. Results for Config IIIC.3

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.34900E+02											
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)	
.00	.00	0.00000E+00	3.16997E+01	6.66663E+01	8.42992E+01	5.99221E+01	3.34993E+01	1.65993E+01	3.50557E-02	2.82550E-02	
.00	.70	0.00000E+00	2.60688E+01	5.65107E+01	7.26029E+01	5.40094E+01	3.11430E+01	1.57744E+01	2.76309E-02	2.25559E-02	
.00	30.00	0.00000E+00	8.18541E+00	1.53609E+01	1.77058E+01	1.06456E+01	5.77851E+00	3.02695E+00	1.81254E-02	1.46384E-02	
.00	150.00	0.00000E+00	1.49868E+00	2.79223E+00	3.18550E+00	1.81740E+00	9.49830E-01	4.81259E-01	4.51016E-03	2.58043E-03	
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the radial blanket assembly is as follows:											
5.74830E-04	2.97983E-03	1.10959E-02	3.11972E-02	6.93898E-02	1.25978E-01	1.71608E-01	2.45866E-01	3.62763E-01	1.15433E-01		
1.09189E-01	1.82418E-01	3.97682E-01	4.32211E-01	4.56231E-01	3.53315E-01	6.02793E-01	6.77181E-01	4.97969E-01	1.64282E-01		
4.16566E-01	6.26902E-01	2.79437E-02	1.10061E-02	2.49567E-02	1.96324E-01	5.00305E-01	4.68591E-01	3.96877E-01	4.42927E-01		
5.26785E-01	8.02083E-01	9.66922E-02	4.32611E-01	1.98278E-01	4.72563E-02	1.17391E-01	1.63696E-01	9.92738E-02	7.28000E-01		
6.79579E-01	5.52782E-01	2.94538E-01	5.88742E-02	1.77453E-02	4.19871E-02	5.53731E-02	4.39198E-01	7.22299E-01	1.00288E+00		
1.24190E+00	1.46586E+00	9.02739E-01	2.50934E+00	1.84811E+00	1.28915E+00	4.04904E-01	1.21844E+00	1.38586E+00	1.28196E+00		
2.62788E-01											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the radial blanket assembly is as follows:											
5.40795E-04	2.78902E-03	1.03398E-02	2.89331E-02	6.40900E-02	1.16036E-01	1.58317E-01	2.27470E-01	3.35117E-01	1.06966E-01		
1.01597E-01	1.69575E-01	3.72051E-01	4.04473E-01	4.29299E-01	3.34729E-01	5.63122E-01	6.40891E-01	4.70883E-01	1.52319E-01		
3.82351E-01	5.97547E-01	2.67422E-02	1.04986E-02	2.37846E-02	1.86368E-01	4.71221E-01	4.29370E-01	3.72580E-01	4.09521E-01		
4.79085E-01	7.27289E-01	8.53140E-02	3.78453E-01	1.32320E-01	1.76045E-02	1.02729E-01	1.57122E-01	9.65815E-02	6.94554E-01		
6.14004E-01	4.39563E-01	2.56373E-01	5.23261E-02	1.67137E-02	3.43674E-02	4.53588E-02	3.66425E-01	5.87951E-01	8.08394E-01		
9.20217E-01	1.15743E+00	7.26055E-01	1.98139E+00	1.47173E+00	1.04085E+00	3.43212E-01	9.71451E-01	1.09246E+00	1.00451E+00		
1.95008E-01											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the radial blanket assembly is as follows:											
3.15290E-04	1.62539E-03	6.01827E-03	1.68042E-02	3.72882E-02	6.82122E-02	9.54813E-02	1.37477E-01	1.95495E-01	6.08221E-02		
5.81912E-02	9.97046E-02	2.20508E-01	2.40792E-01	2.56602E-01	2.01575E-01	3.39136E-01	3.76097E-01	2.82773E-01	9.34411E-02		
2.37804E-01	3.60841E-01	1.61867E-02	6.44111E-03	1.48985E-02	1.15705E-01	2.90028E-01	2.63888E-01	2.29758E-01	2.51650E-01		
3.01865E-01	4.51966E-01	5.31997E-02	2.39605E-01	9.29268E-02	1.11424E-02	4.96163E-02	7.66493E-02	5.75357E-02	4.33987E-01		
3.88462E-01	2.76917E-01	1.60919E-01	3.18200E-02	1.06137E-02	2.32450E-02	2.95539E-02	2.34289E-01	3.76634E-01	5.16553E-01		
5.86703E-01	7.36257E-01	4.60927E-01	1.27194E+00	9.43091E-01	6.77049E-01	2.25314E-01	6.52124E-01	7.28011E-01	6.70117E-01		
1.34541E-01											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the radial blanket assembly is as follows:											
4.92538E-05	2.40794E-04	8.74532E-04	2.32185E-03	4.99369E-03	9.11445E-03	1.28886E-02	1.87476E-02	2.61879E-02	8.11023E-03		
7.90157E-03	1.37092E-02	3.10253E-02	3.42451E-02	3.65989E-02	2.87512E-02	4.76515E-02	5.28352E-02	4.09648E-02	1.38854E-02		
3.60088E-02	5.35601E-02	2.38683E-03	9.69235E-04	2.37894E-03	1.77288E-02	4.40698E-02	4.03846E-02	3.60090E-02	3.94286E-02		
4.91021E-02	7.20713E-02	8.80739E-03	4.12971E-02	1.66783E-02	2.40623E-03	6.59377E-03	1.08800E-02	8.96808E-03	7.26884E-02		
6.68729E-02	4.88867E-02	3.02759E-02	8.23743E-03	4.14388E-03	5.66568E-03	5.82512E-03	4.28272E-02	6.50100E-02	8.65917E-02		
9.44761E-02	1.16982E-01	8.15585E-02	2.00365E-01	1.59843E-01	1.27867E-01	5.94952E-02	1.20851E-01	1.25165E-01	9.63415E-02		
8.01917E-02

Fig. G.22. Calculational model used for Configuration IIIC-4 (Fe/AL/Boral/2m Na/ Radial-Blanket assembly; basic configuration, with extended concrete ring and Cd plate). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.22. Detailed description of the calculational model for Configuration IIIC.4 (Fe/AL/Boral/2m Na/Radial-Blanket assemblies; basic configuration, with extended concrete ring and Cd plate).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
473.300	485.300	15	0.0	62	----->							157.100
418.010	473.300	52	0.0	62	----->							157.100
381.333	418.010	35	0.0	62	----->							157.100
379.900	381.333	2	0.0	62	----->						135.400 34	157.100
367.900	379.900	14	0.0	62	----->						135.400 34	157.100
363.300	367.900	6	0.0	62	----->						135.400 34	157.100
343.460	363.300	26	0.0	62	----->						135.400 34	157.100
336.333	343.460	10	0.0	62	----->						96.140 34	157.100
334.900	336.333	2	0.0	67	----->						85.980 33 96.140 34	157.100
334.424	334.900	1	0.0	64	----->	69.791 62 74.149 64					85.980 33 96.140 34	157.100
333.300	334.424	3	0.0	32	68.452 63 69.007 64	----->					85.980 33 96.140 34	157.100
332.818	333.300	2	0.0	32	68.452 63 69.007 64	----->					85.980 33 96.140 34	157.100
325.932	332.818	21	0.0	32	68.452 63 69.007 64	----->	74.149 65 82.007 64 84.547 62				85.980 33 96.140 34	157.100
324.324	325.932	5	0.0	32	68.452 63 69.007 64	----->					85.980 33 96.140 34	157.100
323.850	324.324	1	0.0	64	----->	69.791 62 74.149 64					85.980 33 96.140 34	157.100
323.300	323.850	1	0.0	62	----->						85.980 33 96.140 34	157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.22. Results for Config IIIC.4

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.34900E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	3.18681E+01	6.70410E+01	8.47453E+01	6.01572E+01	3.36016E+01	1.66402E+01	3.32225E-02	2.81026E-02
.00	2.13	0.00000E+00	1.73367E+01	3.99595E+01	5.38918E+01	4.41554E+01	2.64698E+01	1.41342E+01	2.38001E-02	1.97089E-02
.00	30.00	0.00000E+00	7.65297E+00	1.46477E+01	1.70101E+01	1.03455E+01	5.63864E+00	2.96261E+00	1.76479E-02	1.33347E-02
.00	150.00	0.00000E+00	1.50002E+00	2.79583E+00	3.19056E+00	1.82032E+00	9.50976E-01	4.81543E-01	4.62678E-03	2.59170E-03

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the radial blanket assembly is as follows:

5.76413E-04	2.98961E-03	1.11351E-02	3.13058E-02	6.96435E-02	1.26476E-01	1.72397E-01	2.47136E-01	3.64991E-01	1.16303E-01
1.10173E-01	1.84332E-01	4.02753E-01	4.38930E-01	4.64854E-01	3.61496E-01	6.16982E-01	6.99187E-01	5.16904E-01	1.70954E-01
4.37457E-01	6.55394E-01	2.92780E-02	1.14982E-02	2.59814E-02	2.04970E-01	5.22821E-01	4.90038E-01	4.15324E-01	4.62802E-01
5.49734E-01	8.34692E-01	1.00916E-01	4.48522E-01	2.03251E-01	4.83182E-02	1.19657E-01	1.70028E-01	1.03988E-01	7.54976E-01
7.01752E-01	5.67388E-01	3.02198E-01	6.02615E-02	1.78842E-02	4.25630E-02	5.62761E-02	4.46485E-01	7.31515E-01	1.01608E+00
1.25518E+00	1.47895E+00	9.13201E-01	2.51529E+00	1.86346E+00	1.30404E+00	4.07548E-01	1.23540E+00	1.40126E+00	1.21727E+00
1.92047E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 2.13 cm past the radial blanket assembly is as follows:

5.25037E-04	2.70576E-03	1.00241E-02	2.80460E-02	6.21146E-02	1.12489E-01	1.53684E-01	2.20850E-01	3.24981E-01	1.03566E-01
9.84745E-02	1.64741E-01	3.61763E-01	3.94075E-01	4.18982E-01	3.27626E-01	5.50042E-01	6.24950E-01	4.59785E-01	1.48988E-01
3.78021E-01	5.85781E-01	2.63075E-02	1.03061E-02	2.33229E-02	1.83172E-01	4.63801E-01	4.23583E-01	3.67147E-01	4.03358E-01
4.73106E-01	7.14783E-01	8.43656E-02	3.72677E-01	1.29086E-01	1.62038E-02	9.75145E-02	1.50248E-01	9.42113E-02	6.77329E-01
5.99340E-01	4.30097E-01	2.49815E-01	5.10584E-02	1.64023E-02	3.34331E-02	4.40270E-02	3.55430E-01	5.64796E-01	7.80292E-01
8.81475E-01	1.08061E+00	6.98206E-01	1.76002E+00	1.38521E+00	1.01575E+00	3.32904E-01	9.33832E-01	1.00814E+00	5.60932E-01
1.60453E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the radial blanket assembly is as follows:

3.11855E-04	1.60635E-03	5.94475E-03	1.65939E-02	3.68031E-02	6.72836E-02	9.41428E-02	1.35516E-01	1.92712E-01	5.99406E-02
5.73453E-02	9.82433E-02	2.17282E-01	2.37341E-01	2.53047E-01	1.98865E-01	3.33589E-01	3.68875E-01	2.76320E-01	9.11248E-02
2.32498E-01	3.52824E-01	1.58355E-02	6.29493E-03	1.45546E-02	1.13066E-01	2.83736E-01	2.58695E-01	2.25021E-01	2.46523E-01
2.95581E-01	4.42316E-01	5.20982E-02	2.34524E-01	9.07883E-02	1.09419E-02	4.87285E-02	7.49084E-02	5.58726E-02	4.22232E-01
3.78120E-01	2.69848E-01	1.56449E-01	3.09357E-02	1.02941E-02	2.26108E-02	2.87544E-02	2.27871E-01	3.65307E-01	5.02536E-01
5.67532E-01	7.02674E-01	4.47167E-01	1.17727E+00	9.03208E-01	6.60952E-01	2.18048E-01	6.29422E-01	6.86063E-01	4.47245E-01
1.73498E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the radial blanket assembly is as follows:

4.92555E-05	2.40836E-04	8.74771E-04	2.32334E-03	4.99746E-03	9.12171E-03	1.28984E-02	1.87610E-02	2.62038E-02	8.11518E-03
7.90645E-03	1.37179E-02	3.10528E-02	3.42914E-02	3.66694E-02	2.88315E-02	4.78180E-02	5.31185E-02	4.12218E-02	1.39809E-02
3.63152E-02	5.39774E-02	2.40531E-03	9.76274E-04	2.39442E-03	1.78629E-02	4.44158E-02	4.07431E-02	3.63032E-02	3.97766E-02
4.94712E-02	7.26598E-02	8.87609E-03	4.15117E-02	1.67263E-02	2.40443E-03	6.64688E-03	1.09683E-02	9.02992E-03	7.31023E-02
6.71772E-02	4.90431E-02	3.03229E-02	8.21120E-03	4.10301E-03	5.63623E-03	5.81733E-03	4.28318E-02	6.50577E-02	8.66817E-02
9.46043E-02	1.17175E-01	8.15420E-02	2.00651E-01	1.59840E-01	1.27605E-01	5.90885E-02	1.20688E-01	1.25201E-01	9.73158E-02
8.46704E-02

Fig. G.23. Computational model used for Configuration IIID.1 (Fe/AL/Boral/2m Na/Homog IVFS/B4C slab; basic configuration by itself). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.23. Detailed description of the calculational model for Configuration IIID.1 (Fe/AL/Boral/2m Na/Homog IVFS/B4C slab; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
488.500	500.500	15	0.0	62	----->							157.100
433.210	488.500	47	0.0	62	----->							157.100
396.533	433.210	31	0.0	62	----->							157.100
395.100	396.533	2	0.0	62	----->							157.100
383.100	395.100	12	0.0	62	----->							157.100
363.300	383.100	25	0.0	62	----->							157.100
353.360	363.300	13	0.0	62	----->							157.100
351.533	353.360	3	0.0	62	----->							157.100
350.100	351.533	2	0.0	62	----->							157.100
349.462	350.100	1	0.0	39	----->							157.100
343.840	349.462	12	0.0	38	----->							157.100
343.200	343.840	1	0.0	39	----->							157.100
339.440	343.200	4	0.0	62	----->							157.100
336.900	339.440	2	0.0	27	----->							157.100
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707 33	----->					157.100
329.120	332.580	3	0.0	27	----->							157.100
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707 33	----->					157.100
323.300	325.840	2	0.0	27	----->							157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.23. Results for Config IIID.1

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.50100E+02											
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)	
.00	.00	0.00000E+00	3.88906E+00	1.92512E+01	3.58604E+01	4.27444E+01	2.70507E+01	1.62909E+01	1.13525E-03	1.13339E-03	
.00	.70	0.00000E+00	3.16090E+00	1.61659E+01	3.03000E+01	3.90858E+01	2.51033E+01	1.49911E+01	9.95378E-04	9.93804E-04	
.00	30.00	0.00000E+00	8.75546E-01	3.98459E+00	6.69194E+00	6.83601E+00	4.35766E+00	2.49625E+00	5.27676E-04	5.07505E-04	
.00	150.00	0.00000E+00	1.32077E-01	6.09258E-01	1.03026E+00	1.05767E+00	6.74499E-01	3.85467E-01	9.23520E-05	8.25455E-05	
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the B4C slab is as follows:											
4.62783E-04	2.42581E-03	9.39605E-03	2.75754E-02	6.14709E-02	1.11660E-01	1.66050E-01	2.25802E-01	2.83735E-01	9.14182E-02		
9.79551E-02	2.02286E-01	4.45463E-01	4.68643E-01	4.48659E-01	7.05251E-01	7.19105E-01	7.77946E-01	5.40638E-01	1.74367E-01		
5.73095E-01	7.15511E-01	3.26235E-02	1.17398E-02	2.39412E-02	1.88605E-01	5.34225E-01	4.94102E-01	4.34456E-01	4.77818E-01		
6.00372E-01	7.88073E-01	1.20633E-01	4.96115E-01	1.37448E-01	3.11000E-02	7.57456E-02	1.08720E-01	7.21580E-02	4.46167E-01		
3.78266E-01	2.22472E-01	1.30840E-01	5.21069E-02	2.87832E-02	2.04527E-02	1.38699E-02	4.16546E-02	2.52958E-02	1.64735E-02		
8.53913E-03	4.54883E-03	1.43428E-03	4.77936E-04	4.47588E-05	3.06747E-06	3.74541E-07	1.86436E-07	1.49619E-07	1.67906E-07		
7.27873E-07											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the B4C slab is as follows:											
4.41544E-04	2.30958E-03	8.91880E-03	2.60172E-02	5.77311E-02	1.04291E-01	1.54515E-01	2.10677E-01	2.64758E-01	8.56349E-02		
9.13829E-02	1.87607E-01	4.14160E-01	4.34793E-01	4.17663E-01	6.55928E-01	6.64398E-01	7.26142E-01	5.03265E-01	1.59340E-01		
5.14158E-01	6.62808E-01	3.05400E-02	1.09252E-02	2.22092E-02	1.71752E-01	4.88068E-01	4.35325E-01	3.85222E-01	4.22235E-01		
5.17562E-01	6.95509E-01	1.02708E-01	4.16030E-01	9.09259E-02	1.25621E-02	6.66041E-02	1.02075E-01	6.70460E-02	3.83469E-01		
3.13152E-01	1.60067E-01	9.89075E-02	4.12465E-02	2.23306E-02	1.48415E-02	1.07973E-02	3.39195E-02	2.05757E-02	1.34587E-02		
6.51523E-03	3.72581E-03	1.15612E-03	3.94810E-04	3.69293E-05	2.64288E-06	3.53509E-07	1.85519E-07	1.49839E-07	1.68650E-07		
7.47674E-07											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the B4C slab is as follows:											
2.37124E-04	1.24106E-03	4.75218E-03	1.37128E-02	3.04127E-02	5.51346E-02	8.15028E-02	1.11966E-01	1.41866E-01	4.58095E-02		
4.77778E-02	9.59050E-02	2.10908E-01	2.22607E-01	2.13464E-01	3.14113E-01	3.34867E-01	3.60918E-01	2.50513E-01	8.08615E-02		
2.56827E-01	3.28636E-01	1.49751E-02	5.41017E-03	1.11386E-02	8.85859E-02	2.46099E-01	2.19210E-01	1.87548E-01	2.11922E-01		
2.53959E-01	3.48049E-01	5.26694E-02	2.02569E-01	5.10885E-02	6.27750E-03	2.62065E-02	4.18437E-02	3.23530E-02	1.96083E-01		
1.56410E-01	8.14729E-02	4.97443E-02	2.05558E-02	1.16883E-02	7.75479E-03	5.40609E-03	1.85626E-02	1.21200E-02	8.24672E-03		
3.98402E-03	2.47676E-03	9.46568E-04	5.82147E-04	3.03976E-04	2.31378E-04	1.89442E-04	1.59585E-04	1.39011E-04	1.59625E-04		
8.22982E-04											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the B4C slab is as follows:											
5.59381E-05	2.89251E-04	1.09301E-03	3.06081E-03	6.66141E-03	1.18400E-02	1.71458E-02	2.33208E-02	2.87453E-02	9.21965E-03		
9.35611E-03	1.81009E-02	3.90132E-02	4.01926E-02	3.75489E-02	5.21362E-02	5.72487E-02	6.13039E-02	4.08123E-02	1.31787E-02		
3.90368E-02	5.19960E-02	2.32592E-03	8.40184E-04	1.72999E-02	1.38566E-02	3.85705E-02	3.31809E-02	2.69959E-02	3.27515E-02		
3.57251E-02	5.31471E-02	7.90410E-03	2.75725E-02	7.82181E-03	8.94940E-04	3.65557E-03	6.36090E-03	5.15654E-03	2.92781E-02		
2.27834E-02	1.14660E-02	7.00128E-03	2.91897E-03	1.64946E-03	1.08016E-03	7.46172E-04	2.85701E-03	2.08854E-03	1.53159E-03		
6.96398E-04	4.83536E-04	1.60204E-04	9.34855E-05	4.10552E-05	3.58794E-05	3.40405E-05	3.25879E-05	3.19037E-05	4.17044E-05		
4.12148E-04

Fig. G.24. Computational model used for Configuration 111D.2 (Fe/AL/Boral/2m Na/Homog IVFS/B4C slab; basic configuration, with extended concrete ring in analytic model to simulate background radiation). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.24. Detailed description of the calculational model for Configuration IIID.2 (Fe/AL/Boral/2m Na/Homog IVFS/B4C slab; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
488.500	500.500	15	0.0	62	----->							157.100
433.210	488.500	47	0.0	62	----->							157.100
396.533	433.210	31	0.0	62	----->							157.100
395.100	396.533	2	0.0	62	----->						135.400	34 157.100
383.100	395.100	12	0.0	62	----->						135.400	34 157.100
363.300	383.100	25	0.0	62	----->						135.400	34 157.100
353.360	363.300	13	0.0	62	----->						135.400	34 157.100
351.533	353.360	3	0.0	62	----->						96.140	34 157.100
350.100	351.533	2	0.0	62	----->					85.980	33 96.140	34 157.100
349.462	350.100	1	0.0	39	----->					85.980	33 96.140	34 157.100
343.840	349.462	12	0.0	38	----->					85.980	33 96.140	34 157.100
343.200	343.840	1	0.0	39	----->					85.980	33 96.140	34 157.100
339.440	343.200	4	0.0	62	----->					85.980	33 96.140	34 157.100
336.900	339.440	2	0.0	27	----->					89.190	34 157.100	157.100
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	----->		89.190	34 157.100	157.100
329.120	332.580	3	0.0	27	----->					89.190	34 157.100	157.100
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	----->		89.190	34 157.100	157.100
323.300	325.840	2	0.0	27	----->					89.190	34 157.100	157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.24. Results for Config IIID.2

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.50100E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	3.90875E+00	1.93012E+01	3.59151E+01	4.27635E+01	2.70575E+01	1.62919E+01	1.60769E-03	1.24517E-03
.00	.70	0.00000E+00	3.19555E+00	1.62454E+01	3.03901E+01	3.91232E+01	2.51174E+01	1.49949E+01	1.64171E-03	1.13681E-03
.00	30.00	0.00000E+00	9.32732E-01	4.12135E+00	6.86251E+00	6.93765E+00	4.40655E+00	2.51804E+00	1.07795E-03	6.21016E-04
.00	150.00	0.00000E+00	1.73662E-01	7.14847E-01	1.16897E+00	1.15201E+00	7.23014E-01	4.07776E-01	4.38823E-04	1.54760E-04
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the B4C slab is as follows:										
4.62648E-04	2.42509E-03	9.39324E-03	2.75671E-02	6.14522E-02	1.11629E-01	1.66083E-01	2.26203E-01	2.85385E-01	9.19273E-02	
9.84133E-02	2.03198E-01	4.47776E-01	4.71841E-01	4.52386E-01	7.09112E-01	7.29905E-01	7.85239E-01	5.46372E-01	1.76060E-01	
5.79222E-01	7.25551E-01	3.31730E-02	1.19412E-02	2.43362E-02	1.91699E-01	5.42770E-01	5.02033E-01	4.41981E-01	4.85317E-01	
6.11375E-01	7.99859E-01	1.22502E-01	5.06378E-01	1.40855E-01	3.20438E-02	7.69973E-02	1.10223E-01	7.30843E-02	4.54544E-01	
3.87099E-01	2.30012E-01	1.36372E-01	5.47689E-02	3.06404E-02	2.22032E-02	1.51225E-02	4.70852E-02	3.01131E-02	2.08104E-02	
1.24341E-02	8.08294E-03	4.55918E-03	4.54884E-03	3.59064E-03	3.14072E-03	2.79094E-03	2.51642E-03	2.33541E-03	2.88070E-03	
1.53246E-02										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the B4C slab is as follows:										
4.41418E-04	2.30890E-03	8.91619E-03	2.60095E-02	5.77139E-02	1.04263E-01	1.54559E-01	2.11111E-01	2.66519E-01	8.61774E-02	
9.18690E-02	1.88569E-01	4.16581E-01	4.38167E-01	4.21575E-01	6.59920E-01	6.75904E-01	7.33708E-01	5.09250E-01	1.61123E-01	
5.20622E-01	6.73349E-01	3.11090E-02	1.11350E-02	2.26222E-02	1.75046E-01	4.97104E-01	4.43850E-01	3.93240E-01	4.30281E-01	
5.29450E-01	7.08254E-01	1.04772E-01	4.27405E-01	9.50481E-02	1.37450E-02	6.79661E-02	1.03636E-01	6.80230E-02	3.92849E-01	
3.23258E-01	1.69244E-01	1.05615E-01	4.44186E-02	2.45683E-02	1.69891E-02	1.22987E-02	4.03010E-02	2.63028E-02	1.86575E-02	
1.13743E-02	8.02823E-03	5.07657E-03	5.55965E-03	4.58677E-03	4.04689E-03	3.61381E-03	3.27381E-03	3.05458E-03	3.79662E-03	
2.13923E-02										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the B4C slab is as follows:										
2.37087E-04	1.24087E-03	4.75142E-03	1.37106E-02	3.04077E-02	5.51674E-02	8.16328E-02	1.12386E-01	1.43120E-01	4.61955E-02	
4.81348E-02	9.65654E-02	2.12515E-01	2.24755E-01	2.15932E-01	3.16446E-01	3.41169E-01	3.65753E-01	2.54373E-01	8.20271E-02	
2.60917E-01	3.34724E-01	1.52952E-02	5.52756E-03	1.13729E-02	9.05385E-02	2.51477E-01	2.24401E-01	1.92422E-01	2.16784E-01	
2.61298E-01	3.56197E-01	5.40230E-02	2.09847E-01	5.39265E-02	7.12373E-03	2.69329E-02	4.27008E-02	3.30269E-02	2.02353E-01	
1.63087E-01	8.76720E-02	5.43162E-02	2.26961E-02	1.32115E-02	9.26829E-03	6.41601E-03	2.30389E-02	1.62146E-02	1.20055E-02	
7.54154E-03	5.67422E-03	3.91036E-03	4.58212E-03	3.90362E-03	3.49083E-03	3.15166E-03	2.88628E-03	2.72256E-03	3.41523E-03	
1.93881E-02										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the B4C slab is as follows:										
5.61903E-05	2.91144E-04	1.10038E-03	3.08509E-03	6.73666E-03	1.20023E-02	1.74105E-02	2.38029E-02	2.96389E-02	9.48221E-03	
9.62602E-03	1.85784E-02	4.01951E-02	4.17897E-02	3.93098E-02	5.35989E-02	6.08177E-02	6.48420E-02	4.36869E-02	1.40209E-02	
4.18571E-02	5.62211E-02	2.53484E-03	9.16052E-04	1.88294E-03	1.51663E-02	4.21435E-02	3.65660E-02	3.01722E-02	3.58378E-02	
4.03869E-02	5.84566E-02	8.79900E-03	3.22344E-02	9.68688E-03	1.41016E-03	4.00743E-03	6.82571E-03	5.60577E-03	3.34502E-02	
2.71001E-02	1.53423E-02	9.84123E-03	4.27459E-03	2.62623E-03	2.03685E-03	1.36905E-03	5.72452E-03	4.72040E-03	3.95244E-03	
2.93912E-03	2.54138E-03	2.06280E-03	2.66971E-03	2.35606E-03	2.12167E-03	1.91988E-03	1.75974E-03	1.65817E-03	2.07891E-03	
1.20698E-02

Fig. G.25. Calculational model used for Configuration IIID.3 (Fe/AL/Boral/2m Na/Homog IVFS/B4C slab; basic configuration, with extended concrete ring and Cd hut). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.25. Detailed description of the calculational model for Configuration IIID.3 (Fe/AL/Boral/2m Na/Homog IVFS/B4C slab; basic configuration, with extended concrete ring and Cd hut).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
488.500	500.500	15	0.0	62	----->							157.10
433.210	488.500	47	0.0	62	----->							157.10
396.533	433.210	31	0.0	62	----->							157.10
395.100	396.533	2	0.0	67	----->							157.10
383.100	395.100	12	0.0	62	----->	84.547	67	----->	85.98	62	----->	157.10
363.300	383.100	25	0.0	62	----->	84.547	67	----->	85.98	62	----->	157.10
353.360	363.300	13	0.0	62	----->	84.547	67	----->	85.98	62	----->	157.10
351.533	353.360	3	0.0	62	----->	84.547	67	----->	85.98	33	----->	157.10
350.100	351.533	2	0.0	62	----->	84.547	67	----->	85.98	33	----->	157.10
349.462	350.100	1	0.0	39	----->			----->	85.98	33	----->	157.10
343.840	349.462	12	0.0	38	----->			----->	85.307	39	----->	157.10
343.200	343.840	1	0.0	39	----->			----->	85.98	33	----->	157.10
339.440	343.200	4	0.0	62	----->	58.707	33	----->			----->	157.10
336.900	339.440	2	0.0	27	----->	58.707	33	----->			----->	157.10
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	----->			----->	157.10
329.120	332.580	3	0.0	27	----->	58.707	33	----->			----->	157.10
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	----->			----->	157.10
323.300	325.840	2	0.0	27	----->	58.707	33	----->			----->	157.10
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.25. Results for Config IIID.3

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.50100E+02											
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)	
.00	.00	0.00000E+00	3.92285E+00	1.93578E+01	3.60034E+01	4.28351E+01	2.70943E+01	1.63095E+01	1.22305E-03	1.21935E-03	
.00	.70	0.00000E+00	3.20836E+00	1.62984E+01	3.04725E+01	3.91918E+01	2.51528E+01	1.50118E+01	1.10230E-03	1.09853E-03	
.00	30.00	0.00000E+00	9.44255E-01	4.17054E+00	6.93856E+00	6.99728E+00	4.43720E+00	2.53192E+00	5.88181E-04	5.85930E-04	
.00	150.00	0.00000E+00	1.72325E-01	7.08061E-01	1.15735E+00	1.14010E+00	7.15444E-01	4.03492E-01	3.98182E-04	1.51526E-04	
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the B4C slab is as follows:											
4.62826E-04	2.42604E-03	9.39696E-03	2.75781E-02	6.14768E-02	1.11678E-01	1.66158E-01	2.26327E-01	2.85559E-01	9.19868E-02		
9.84898E-02	2.03385E-01	4.48286E-01	4.72511E-01	4.53184E-01	7.10452E-01	7.31555E-01	7.87718E-01	5.48521E-01	1.76827E-01		
5.82365E-01	7.29400E-01	3.33522E-02	1.20066E-02	2.44713E-02	1.92754E-01	5.45792E-01	5.04964E-01	4.44665E-01	4.88191E-01		
6.15278E-01	8.04976E-01	1.23297E-01	5.09908E-01	1.41810E-01	3.22676E-02	7.74295E-02	1.10938E-01	7.35993E-02	4.57653E-01		
3.89869E-01	2.31722E-01	1.37405E-01	5.51892E-02	3.08791E-02	2.23787E-02	1.52430E-02	4.74456E-02	3.02883E-02	2.09139E-02		
1.24636E-02	8.04491E-03	4.56063E-03	4.36892E-03	3.52972E-03	3.15422E-03	2.80516E-03	2.51630E-03	2.27722E-03	1.97635E-03		
3.08075E-05											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the B4C slab is as follows:											
4.41585E-04	2.30980E-03	8.91965E-03	2.60197E-02	5.77366E-02	1.04308E-01	1.54627E-01	2.11228E-01	2.66684E-01	8.62346E-02		
9.19437E-02	1.88753E-01	4.17087E-01	4.38834E-01	4.22372E-01	6.61251E-01	6.77545E-01	7.36217E-01	5.11419E-01	1.61898E-01		
5.23783E-01	6.77208E-01	3.12889E-02	1.12005E-02	2.27574E-02	1.76095E-01	5.00112E-01	4.46742E-01	3.95884E-01	4.33108E-01		
5.33224E-01	7.13203E-01	1.05530E-01	4.30722E-01	9.58444E-02	1.38979E-02	6.83666E-02	1.04338E-01	6.85321E-02	3.95766E-01		
3.25817E-01	1.70705E-01	1.06520E-01	4.47977E-02	2.47814E-02	1.71382E-02	1.24067E-02	4.06274E-02	2.64577E-02	1.87546E-02		
1.13962E-02	7.97651E-03	5.07624E-03	5.32795E-03	4.50893E-03	4.06305E-03	3.62994E-03	3.27100E-03	2.97693E-03	2.60200E-03		
3.17727E-05											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the B4C slab is as follows:											
2.37144E-04	1.24124E-03	4.75529E-03	1.37250E-02	3.04452E-02	5.52488E-02	8.17665E-02	1.12586E-01	1.43402E-01	4.62982E-02		
4.82619E-02	9.68591E-02	2.13279E-01	2.25718E-01	2.17020E-01	3.18121E-01	3.43566E-01	3.69497E-01	2.57712E-01	8.32398E-02		
2.65544E-01	3.40143E-01	1.55502E-02	5.62221E-03	1.15721E-02	9.20664E-02	2.55657E-01	2.28330E-01	1.95882E-01	2.20420E-01		
2.66019E-01	3.62038E-01	5.49472E-02	2.13475E-01	5.48884E-02	7.31527E-03	2.71588E-02	4.33420E-02	3.36072E-02	2.05540E-01		
1.65674E-01	8.90891E-02	5.51436E-02	2.30333E-02	1.34068E-02	9.40806E-03	6.50764E-03	2.33160E-02	1.63290E-02	1.20904E-02		
7.54756E-03	5.58832E-03	3.90823E-03	4.24576E-03	3.80149E-03	3.52331E-03	3.17643E-03	2.87906E-03	2.59904E-03	1.93244E-03		
1.42654E-05											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the B4C slab is as follows:											
5.55736E-05	2.87867E-04	1.08758E-03	3.04933E-03	6.65829E-03	1.18602E-02	1.71996E-02	2.35066E-02	2.92623E-02	9.35697E-03		
9.49866E-03	1.83308E-02	3.96512E-02	4.12251E-02	3.87843E-02	5.28632E-02	5.98828E-02	6.37345E-02	4.28716E-02	1.37422E-02		
4.11238E-02	5.52358E-02	2.49264E-03	9.01022E-04	1.85194E-03	1.49143E-02	4.14510E-02	3.60091E-02	2.97564E-02	3.52771E-02		
3.98636E-02	5.75523E-02	8.66901E-03	3.18701E-02	9.59091E-03	1.41276E-03	3.94804E-03	6.71255E-03	5.51303E-03	3.29716E-02		
2.67631E-02	1.52329E-02	9.78546E-03	4.25478E-03	2.62166E-03	2.04501E-03	1.37469E-03	5.75658E-03	4.75070E-03	3.99300E-03		
2.98733E-03	2.58141E-03	2.11462E-03	2.72420E-03	2.41245E-03	2.17899E-03	1.97334E-03	1.80885E-03	1.69942E-03	2.06765E-03		
1.04739E-02

Fig. G.26. Calculational model used for Configuration 111D.4 (Fe/AL/Boral/2m Na/Homog IVFS/B4C slab; basic configuration, with extended concrete ring and Cd plate). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.26. Detailed description of the calculational model for Configuration IIID.4 (Fe/AL/Boral/2m Na/Homog IVFS/B4C slab; basic configuration, with extended concrete ring and Cd plate).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE										
ZMIN	ZMAX	N	R	M	(etc) ...								
488.500	500.500	15	0.0	62	----->							157.100	
433.210	488.500	47	0.0	62	----->							157.100	
396.533	433.210	31	0.0	62	----->							157.100	
395.100	396.533	2	0.0	62	----->						135.400	34 157.100	
383.100	395.100	12	0.0	62	----->						135.400	34 157.100	
363.300	383.100	25	0.0	62	----->						135.400	34 157.100	
353.360	363.300	13	0.0	62	----->							157.100	
351.533	353.360	3	0.0	62	----->						96.140	34 157.100	
350.100	351.533	2	0.0	67	----->					85.980	33 96.140	34 157.100	
349.462	350.100	1	0.0	39	----->					85.980	33 96.140	34 157.100	
343.840	349.462	12	0.0	38	----->					85.307	39 85.980	33 96.140	34 157.100
343.200	343.840	1	0.0	39	----->					85.980	33 96.140	34 157.100	
339.440	343.200	4	0.0	62	----->								157.100
336.900	339.440	2	0.0	27	----->					58.707	33 89.190	34 157.100	
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27					58.707	33 89.190	34 157.100	
329.120	332.580	3	0.0	27	----->					58.707	33 89.190	34 157.100	
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27					58.707	33 89.190	34 157.100	
323.300	325.840	2	0.0	27	----->					58.707	33 89.190	34 157.100	
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)										

- For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.26. Results for Config IIID.4

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.50100E+02											
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)	
.00	.00	0.00000E+00	3.97102E+00	1.95436E+01	3.62675E+01	4.30068E+01	2.71751E+01	1.63431E+01	1.24970E-03	1.24664E-03	
.00	2.13	0.00000E+00	2.24316E+00	1.17926E+01	2.25328E+01	3.21415E+01	2.17393E+01	1.28661E+01	1.49946E-03	1.10222E-03	
.00	30.00	0.00000E+00	9.27798E-01	4.10023E+00	6.82469E+00	6.89018E+00	4.37199E+00	2.49599E+00	1.01550E-03	6.11666E-04	
.00	150.00	0.00000E+00	1.72262E-01	7.09047E-01	1.15911E+00	1.14132E+00	7.15958E-01	4.03670E-01	4.19852E-04	1.52004E-04	
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the B4C slab is as follows:											
4.62863E-04	2.42756E-03	9.40624E-03	2.76109E-02	6.15716E-02	1.11897E-01	1.66600E-01	2.27057E-01	2.86837E-01	9.25079E-02		
9.91508E-02	2.05056E-01	4.53077E-01	4.78959E-01	4.60979E-01	7.23250E-01	7.47427E-01	8.10766E-01	5.68077E-01	1.83665E-01		
6.09135E-01	7.61031E-01	3.48500E-02	1.25578E-02	2.56059E-02	2.01123E-01	5.69526E-01	5.26983E-01	4.64601E-01	5.08845E-01		
6.41997E-01	8.36790E-01	1.28068E-01	5.29857E-01	1.46244E-01	3.32273E-02	7.91198E-02	1.14977E-01	7.68044E-02	4.73307E-01		
4.02517E-01	2.38007E-01	1.40853E-01	5.65552E-02	3.16259E-02	2.28632E-02	1.55711E-02	4.81942E-02	3.03973E-02	2.08887E-02		
1.22953E-02	7.77988E-03	4.38663E-03	3.89699E-03	3.25438E-03	2.99565E-03	2.65179E-03	2.34776E-03	2.04525E-03	1.13047E-03		
1.60679E-05											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 2.13 cm past the B4C slab is as follows:											
4.27327E-04	2.23535E-03	8.62104E-03	2.51172E-02	5.57575E-02	1.00801E-01	1.49537E-01	2.04529E-01	2.58638E-01	8.36776E-02		
8.91384E-02	1.82861E-01	4.04642E-01	4.26798E-01	4.11613E-01	6.40987E-01	6.58963E-01	7.16758E-01	4.97893E-01	1.57999E-01		
5.14545E-01	6.62286E-01	3.05835E-02	1.09757E-02	2.23398E-02	1.73161E-01	4.90597E-01	4.39447E-01	3.88752E-01	4.25338E-01		
5.23865E-01	6.98217E-01	1.03433E-01	4.21776E-01	9.36414E-02	1.32316E-02	6.48812E-02	9.99276E-02	6.68738E-02	3.86142E-01		
3.17089E-01	1.66942E-01	1.03626E-01	4.33236E-02	2.39944E-02	1.67328E-02	1.19896E-02	3.96421E-02	2.55350E-02	1.81639E-02		
1.09157E-02	7.54161E-03	4.87197E-03	5.07174E-03	4.33890E-03	3.92626E-03	3.51049E-03	3.16693E-03	2.88460E-03	3.04232E-03		
1.68140E-02											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the B4C slab is as follows:											
2.34905E-04	1.22880E-03	4.70255E-03	1.35668E-02	3.00817E-02	5.45655E-02	8.07180E-02	1.11113E-01	1.41513E-01	4.56734E-02		
4.76041E-02	9.55313E-02	2.10372E-01	2.22713E-01	2.14244E-01	3.14035E-01	3.38247E-01	3.62677E-01	2.52084E-01	8.12837E-02		
2.60152E-01	3.33218E-01	1.52369E-02	5.50908E-03	1.13353E-02	9.01596E-02	2.50661E-01	2.24148E-01	1.92488E-01	2.16422E-01		
2.61528E-01	3.55169E-01	5.38778E-02	2.09940E-01	5.39075E-02	7.25596E-03	2.67979E-02	4.25705E-02	3.28915E-02	2.01173E-01		
1.62321E-01	8.73861E-02	5.40134E-02	2.25377E-02	1.31168E-02	9.22537E-03	6.38588E-03	2.28373E-02	1.59520E-02	1.18181E-02		
7.38263E-03	5.50965E-03	3.83753E-03	4.41705E-03	3.81233E-03	3.44237E-03	3.11214E-03	2.84779E-03	2.66467E-03	3.12357E-03		
1.71283E-02											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the B4C slab is as follows:											
5.56839E-05	2.88309E-04	1.08917E-03	3.05321E-03	6.66519E-03	1.18716E-02	1.72161E-02	2.35302E-02	2.92940E-02	9.36803E-03		
9.51154E-03	1.83615E-02	3.97310E-02	4.13236E-02	3.88968E-02	5.30809E-02	6.01088E-02	6.40209E-02	4.31064E-02	1.38269E-02		
4.15098E-02	5.56628E-02	2.51185E-03	9.07830E-04	1.86616E-03	1.50275E-02	4.17862E-02	3.63410E-02	3.00596E-02	3.55955E-02		
4.02878E-02	5.80356E-02	8.74044E-03	3.21747E-02	9.64675E-03	1.42288E-03	3.98473E-03	6.77148E-03	5.54921E-03	3.31599E-02		
2.68996E-02	1.52639E-02	9.77520E-03	4.24136E-03	2.60623E-03	2.02521E-03	1.36122E-03	5.67521E-03	4.66396E-03	3.90743E-03		
2.90424E-03	2.50443E-03	2.04222E-03	2.63005E-03	2.32859E-03	2.10177E-03	1.90221E-03	1.74302E-03	1.63839E-03	1.99177E-03		
1.13796E-02

Fig. G.27. Computational model used for Configuration IIIE.1 (Fe/AL/Boral/2m Na/B4C/Homog IVfs slab; basic configuration by itself). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.27. Detailed description of the calculational model for Configuration III E.1 (Fe/AL/Boral/2m Na/B4C/Homog IVFS slab; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
484.740	496.740	15	0.0	62	----->							157.100
429.450	484.740	50	0.0	62	----->							157.100
392.773	429.450	33	0.0	62	----->							157.100
391.340	392.773	2	0.0	62	----->							157.100
379.340	391.340	12	0.0	62	----->							157.100
363.300	379.340	20	0.0	62	----->							157.100
353.620	363.300	12	0.0	62	----->							157.100
350.100	353.620	5	0.0	62	----->							157.100
347.773	350.100	3	0.0	62	----->	58.707	33	----->	85.980	33	96.140	34 157.100
346.340	347.773	2	0.0	62	----->	58.707	33	----->			96.140	34 157.100
343.800	346.340	2	0.0	27	----->	58.707	33	----->			96.140	34 157.100
339.480	343.800	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	----->			96.140	34 157.100
336.020	339.480	3	0.0	27	----->	58.707	33	----->			96.140	34 157.100
332.740	336.020	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	----->			96.140	34 157.100
330.200	332.740	2	0.0	27	----->	58.707	33	----->			96.140	34 157.100
329.562	330.200	1	0.0	39	----->							
323.940	329.562	12	0.0	38	----->							
323.300	323.940	1	0.0	39	----->							
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.27. Results for Config III E.1

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.46340E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	4.45510E-01	1.73397E+00	2.78195E+00	2.47263E+00	1.39457E+00	7.17215E-01	1.77929E-04	1.75610E-04
.00	.70	0.00000E+00	3.77786E-01	1.46606E+00	2.39091E+00	2.25544E+00	1.28114E+00	6.69812E-01	1.69139E-04	1.67227E-04
.00	30.00	0.00000E+00	1.77801E-01	5.19735E-01	6.93120E-01	4.60802E-01	2.37631E-01	1.16043E-01	2.39202E-04	1.42719E-04
.00	150.00	0.00000E+00	2.46257E-02	7.71886E-02	1.04619E-01	6.92664E-02	3.55675E-02	1.74642E-02	1.81758E-05	1.54497E-05
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the IVFS slab is as follows:										
2.79860E-05	1.19094E-04	4.29092E-04	1.04591E-03	2.09329E-03	3.61656E-03	4.76113E-03	6.71520E-03	9.42876E-03	3.42523E-03	
2.95353E-03	5.34686E-03	1.29823E-02	1.50317E-02	1.55948E-02	1.65710E-02	2.12136E-02	2.83851E-02	1.90892E-02	7.41109E-03	
2.12321E-02	2.85016E-02	1.17990E-03	4.25554E-04	8.89099E-04	8.63414E-03	2.91240E-02	2.48622E-02	1.39046E-02	3.48318E-02	
2.02605E-02	9.23493E-02	1.53222E-02	1.98199E-02	3.23228E-02	9.25201E-03	1.29144E-02	2.14346E-02	1.78387E-02	1.12229E-01	
1.03042E-01	6.33374E-02	4.89098E-02	2.29121E-02	1.40759E-02	1.08783E-02	7.44745E-03	2.77960E-02	2.22102E-02	1.71274E-02	
1.11604E-02	7.51797E-03	2.92383E-03	2.69475E-03	7.45488E-04	1.89193E-04	5.07442E-05	4.26331E-05	3.79564E-05	3.33091E-05	
6.85004E-05										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the IVFS slab is as follows:										
2.70062E-05	1.14653E-04	4.13017E-04	1.00243E-03	1.99804E-03	3.44096E-03	4.51260E-03	6.34518E-03	8.84479E-03	3.24112E-03	
2.76908E-03	5.00097E-03	1.21788E-02	1.40819E-02	1.45178E-02	1.55548E-02	1.94188E-02	2.61860E-02	1.74056E-02	6.84950E-03	
1.93213E-02	2.63244E-02	1.06586E-03	3.82370E-04	7.94824E-04	7.82473E-03	2.71544E-02	2.23697E-02	1.18867E-02	3.07449E-02	
1.72849E-02	8.35890E-02	1.44583E-02	1.65192E-02	2.79401E-02	8.85996E-03	1.25104E-02	2.09838E-02	1.75485E-02	1.09773E-01	
9.99726E-02	6.13009E-02	4.71065E-02	2.18946E-02	1.34080E-02	1.04524E-02	7.13214E-03	2.68796E-02	2.15134E-02	1.65987E-02	
1.08116E-02	7.27899E-03	2.81589E-03	2.59416E-03	7.07449E-04	1.74939E-04	4.36617E-05	3.91037E-05	3.57115E-05	2.95916E-05	
5.22356E-05										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the IVFS slab is as follows:										
1.92781E-05	7.86121E-05	2.77423E-04	6.36864E-04	1.18825E-03	1.97375E-03	2.51347E-03	3.47819E-03	4.73039E-03	1.65059E-03	
1.45660E-03	2.63006E-03	6.52365E-03	7.57444E-03	7.78321E-03	8.09504E-03	1.06081E-02	1.34350E-02	9.07780E-03	3.44782E-03	
9.68961E-03	1.40939E-02	5.86316E-04	2.11923E-04	4.47083E-04	4.15251E-03	1.40958E-02	1.17012E-02	6.71282E-03	1.53997E-02	
1.00731E-02	4.19064E-02	7.40466E-03	9.97503E-03	1.29721E-02	3.54363E-03	6.50854E-03	1.09146E-02	8.90198E-03	5.59948E-02	
5.12034E-02	3.19718E-02	2.41821E-02	1.14792E-02	7.06743E-03	5.60984E-03	3.90856E-03	1.53308E-02	1.29690E-02	1.06698E-02	
7.72473E-03	5.92188E-03	3.55447E-03	4.42689E-03	3.17800E-03	2.68370E-03	2.32732E-03	2.30766E-03	2.10699E-03	2.31827E-03	
4.05351E-03										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the IVFS slab is as follows:										
6.47662E-06	2.47245E-05	8.34185E-05	1.66827E-04	2.68960E-04	4.08271E-04	4.71556E-04	6.29448E-04	8.24715E-04	2.84637E-04	
2.55514E-04	4.53952E-04	1.18756E-03	1.36656E-03	1.34330E-03	1.38545E-03	1.77191E-03	2.22250E-03	1.49847E-03	5.83591E-04	
1.52027E-03	2.35288E-03	9.61713E-05	3.52626E-05	7.74886E-05	6.87860E-04	2.36669E-03	1.89090E-03	1.10403E-03	2.45590E-03	
1.68757E-03	6.81424E-03	1.23501E-03	1.64909E-03	1.96922E-03	5.37924E-04	1.13608E-03	1.91021E-03	1.52331E-03	9.35558E-03	
8.44151E-03	5.09842E-03	3.81543E-03	1.79342E-03	1.07562E-03	8.17268E-04	5.80063E-04	2.25634E-03	1.90299E-03	1.53558E-03	
9.82180E-04	7.01826E-04	2.81774E-04	3.04418E-04	1.17612E-04	5.94452E-05	2.99873E-05	5.58039E-05	5.90280E-05	4.97787E-05	
1.12797E-04

Fig. G.28. Calculational model used for Configuration 111E.2 (Fe/AL/Boral/2m Na/B4C/Homog IVFS slab; basic configuration, with extended concrete ring in analytic model to simulate background radiation). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.28. Detailed description of the calculational model for Configuration IIIE.2 (Fe/AL/Boral/2m Na/B4C/Homog IVFS slab; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
484.740	496.740	15	0.0	62	----->							157.100
429.450	484.740	50	0.0	62	----->							157.100
392.773	429.450	33	0.0	62	----->						135.400	34 157.100
391.340	392.773	2	0.0	62	----->						135.400	34 157.100
379.340	391.340	12	0.0	62	----->						135.400	34 157.100
363.300	379.340	20	0.0	62	----->						135.400	34 157.100
353.620	363.300	12	0.0	62	----->							157.100
350.100	353.620	5	0.0	62	----->					85.980	33 96.140	34 157.100
347.773	350.100	3	0.0	62	----->	58.707	33	----->			96.140	34 157.100
346.340	347.773	2	0.0	62	----->	58.707	33	----->			96.140	34 157.100
343.800	346.340	2	0.0	27	----->	58.707	33	----->			96.140	34 157.100
339.480	343.800	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	----->			96.140	34 157.100
336.020	339.480	3	0.0	27	----->	58.707	33	----->			96.140	34 157.100
332.740	336.020	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	----->			96.140	34 157.100
330.200	332.740	2	0.0	27	----->	58.707	33	----->			96.140	34 157.100
329.562	330.200	1	0.0	39	----->					85.980	33 96.140	34 157.100
323.940	329.562	12	0.0	38	----->				85.307	39 85.980	33 96.140	34 157.100
323.300	323.940	1	0.0	39	----->					85.980	33 96.140	34 157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.28. Results for Config III E.2

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.46340E+02										
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	4.53093E-01	1.74930E+00	2.79938E+00	2.48227E+00	1.39932E+00	7.19413E-01	2.61194E-04	1.95080E-04
.00	.70	0.00000E+00	3.86399E-01	1.48319E+00	2.41006E+00	2.26560E+00	1.28612E+00	6.72109E-01	2.59234E-04	1.87898E-04
.00	30.00	0.00000E+00	1.84554E-01	5.33246E-01	7.08409E-01	4.68374E-01	2.41101E-01	1.17610E-01	3.15238E-04	1.58295E-04
.00	150.00	0.00000E+00	3.01915E-02	8.85667E-02	1.17605E-01	7.58292E-02	3.84351E-02	1.86366E-02	7.00374E-05	2.62448E-05
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the IVFS slab is as follows:										
2.81531E-05	1.19996E-04	4.32503E-04	1.05541E-03	2.11435E-03	3.65453E-03	4.82084E-03	6.81048E-03	9.59448E-03	3.47974E-03	
3.00163E-03	5.43896E-03	1.31842E-02	1.52641E-02	1.58446E-02	1.68292E-02	2.16480E-02	2.87618E-02	1.93623E-02	7.50466E-03	
2.15481E-02	2.89612E-02	1.20267E-03	4.33891E-04	9.05841E-04	8.78148E-03	2.95392E-02	2.52640E-02	1.42157E-02	3.52764E-02	
2.07093E-02	9.31972E-02	1.54631E-02	2.03645E-02	3.27264E-02	9.35224E-03	1.29952E-02	2.15424E-02	1.79315E-02	1.13226E-01	
1.04232E-01	6.44701E-02	4.98337E-02	2.33619E-02	1.44031E-02	1.12014E-02	7.66062E-03	2.87650E-02	2.31040E-02	1.79441E-02	
1.19148E-02	8.20142E-03	3.51774E-03	3.51080E-03	1.44260E-03	7.87646E-04	5.67740E-04	5.40638E-04	5.11767E-04	6.03780E-04	
2.77789E-03										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the IVFS slab is as follows:										
2.71601E-05	1.15495E-04	4.16189E-04	1.01128E-03	2.01760E-03	3.47616E-03	4.56832E-03	6.43556E-03	9.00664E-03	3.29433E-03	
2.81600E-03	5.09087E-03	1.23755E-02	1.43104E-02	1.47649E-02	1.58108E-02	1.98685E-02	2.65598E-02	1.76812E-02	6.94260E-03	
1.96393E-02	2.68020E-02	1.09004E-03	3.91227E-04	8.12553E-04	7.97810E-03	2.75831E-02	2.27906E-02	1.22245E-02	3.11978E-02	
1.77801E-02	8.44593E-02	1.46068E-02	1.71409E-02	2.83436E-02	8.96178E-03	1.25928E-02	2.10942E-02	1.76445E-02	1.10823E-01	
1.01225E-01	6.25000E-02	4.80754E-02	2.23665E-02	1.37521E-02	1.07929E-02	7.35590E-03	2.78988E-02	2.24531E-02	1.74580E-02	
1.16053E-02	7.99715E-03	3.44210E-03	3.44904E-03	1.43934E-03	8.06648E-04	5.91781E-04	5.63931E-04	5.34752E-04	6.33765E-04	
3.00106E-03										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the IVFS slab is as follows:										
1.93377E-05	7.89327E-05	2.78632E-04	6.40310E-04	1.19603E-03	1.98956E-03	2.53980E-03	3.52252E-03	4.81289E-03	1.67649E-03	
1.48060E-03	2.67568E-03	6.62245E-03	7.69089E-03	7.91184E-03	8.22000E-03	1.08369E-02	1.36309E-02	9.23114E-03	3.49736E-03	
9.85846E-03	1.43486E-02	5.99744E-04	2.16849E-04	4.56958E-04	4.23595E-03	1.43265E-02	1.19335E-02	6.91182E-03	1.56355E-02	
1.03709E-02	4.23677E-02	7.48686E-03	1.03552E-02	1.31739E-02	3.59419E-03	6.55041E-03	1.09722E-02	8.95399E-03	5.65970E-02	
5.19277E-02	3.26757E-02	2.47420E-02	1.17560E-02	7.27138E-03	5.81338E-03	4.04290E-03	1.59548E-02	1.35586E-02	1.12211E-02	
8.24214E-03	6.40145E-03	3.98739E-03	5.02751E-03	3.71218E-03	3.16082E-03	2.75529E-03	2.71516E-03	2.49697E-03	2.80239E-03	
6.62280E-03										
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the IVFS slab is as follows:										
6.48900E-06	2.48673E-05	8.39368E-05	1.68384E-04	2.73085E-04	4.16369E-04	4.83821E-04	6.49655E-04	8.61056E-04	2.95785E-04	
2.66817E-04	4.74162E-04	1.23276E-03	1.42490E-03	1.40961E-03	1.44151E-03	1.88242E-03	2.33853E-03	1.59892E-03	6.14036E-04	
1.62383E-03	2.51555E-03	1.04361E-04	3.82394E-05	8.35029E-05	7.39575E-04	2.51343E-03	2.04222E-03	1.24185E-03	2.59160E-03	
1.89948E-03	7.12021E-03	1.29543E-03	1.93173E-03	2.08191E-03	5.73709E-04	1.16168E-03	1.94658E-03	1.56333E-03	9.83370E-03	
8.98131E-03	5.59983E-03	4.20463E-03	1.98830E-03	1.22054E-03	9.60308E-04	6.72741E-04	2.69196E-03	2.31670E-03	1.92678E-03	
1.34786E-03	1.04074E-03	5.91526E-04	7.24530E-04	4.92823E-04	3.96154E-04	3.33500E-04	3.37932E-04	3.25659E-04	3.82269E-04	
1.85785E-03

Fig. G.29. Computational model used for Configuration IIIE.4 (Fe/AL/Boral/2m Na/B4C/Homog IVFS slab; basic configuration, with extended concrete ring and Cd hut). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.29. Detailed description of the calculational model for Configuration III E.4 (Fe/AL/Boral/2m Na/B4C/Homog IVFS slab; basic configuration, with extended concrete ring and Cd hut).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
484.740	496.740	15	0.0	62								157.100
429.450	484.740	50	0.0	62								157.100
392.773	429.450	33	0.0	62							135.400	34 157.100
391.340	392.773	2	0.0	67						85.980	62	135.400 34 157.100
379.340	391.340	12	0.0	62			84.547	67		85.980	62	135.400 34 157.100
363.300	379.340	20	0.0	62			84.547	67		85.980	62	135.400 34 157.100
353.620	363.300	12	0.0	62			84.547	67		85.980	62	96.140 34 157.100
350.100	353.620	5	0.0	62			84.547	67		85.980	33	96.140 34 157.100
347.773	350.100	3	0.0	62				58.707	33			96.140 34 157.100
346.340	347.773	2	0.0	62				58.707	33			96.140 34 157.100
343.800	346.340	2	0.0	27				58.707	33			96.140 34 157.100
339.480	343.800	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27			58.707	33			96.140 34 157.100
336.020	339.480	3	0.0	27				58.707	33			96.140 34 157.100
332.740	336.020	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27			58.707	33			96.140 34 157.100
330.200	332.740	2	0.0	27				58.707	33			96.140 34 157.100
329.562	330.200	1	0.0	39						85.980	33	96.140 34 157.100
323.940	329.562	12	0.0	38						85.980	33	96.140 34 157.100
323.300	323.940	1	0.0	39						85.980	33	96.140 34 157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.29. Results for Config III E.4

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.46340E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	4.54461E-01	1.75313E+00	2.80375E+00	2.48364E+00	1.39954E+00	7.19330E-01	1.91521E-04	1.90294E-04
.00	.70	0.00000E+00	3.87746E-01	1.48712E+00	2.41460E+00	2.26709E+00	1.28637E+00	6.72029E-01	1.83838E-04	1.82631E-04
.00	30.00	0.00000E+00	1.86464E-01	5.38985E-01	7.15846E-01	4.72393E-01	2.42727E-01	1.18176E-01	2.43935E-04	1.53668E-04
.00	150.00	0.00000E+00	2.98191E-02	8.74098E-02	1.16074E-01	7.48711E-02	3.79529E-02	1.84054E-02	6.12558E-05	2.54256E-05

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the IVFS slab is as follows:

2.80688E-05	1.19539E-04	4.30765E-04	1.05060E-03	2.10369E-03	3.63562E-03	4.79312E-03	6.77236E-03	9.54640E-03	3.46433E-03
2.98904E-03	5.41525E-03	1.31360E-02	1.52196E-02	1.58066E-02	1.67966E-02	2.16293E-02	2.87772E-02	1.93948E-02	7.51951E-03
2.16210E-02	2.90586E-02	1.20736E-03	4.35654E-04	9.09629E-04	8.81451E-03	2.96528E-02	2.53818E-02	1.42897E-02	3.54414E-02
2.08182E-02	9.36483E-02	1.55352E-02	2.04793E-02	3.28960E-02	9.40185E-03	1.30355E-02	2.16297E-02	1.80190E-02	1.13792E-01
1.04769E-01	6.48178E-02	5.00978E-02	2.34827E-02	1.44797E-02	1.12623E-02	7.69872E-03	2.88995E-02	2.31989E-02	1.80182E-02
1.19652E-02	8.22964E-03	3.53858E-03	3.49994E-03	1.44661E-03	8.03084E-04	5.82069E-04	5.57404E-04	5.16981E-04	4.34433E-04
1.22091E-05									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the IVFS slab is as follows:

2.70818E-05	1.15070E-04	4.14587E-04	1.00683E-03	2.00776E-03	3.45876E-03	4.54292E-03	6.40073E-03	8.96295E-03	3.28019E-03
2.80469E-03	5.06965E-03	1.23330E-02	1.42720E-02	1.47331E-02	1.57837E-02	1.98563E-02	2.65826E-02	1.77190E-02	6.95904E-03
1.97174E-02	2.69045E-02	1.09496E-03	3.93081E-04	8.16544E-04	8.01229E-03	2.76999E-02	2.29108E-02	1.23002E-02	3.13622E-02
1.78909E-02	8.49082E-02	1.46793E-02	1.72559E-02	2.85072E-02	9.01131E-03	1.26328E-02	2.11818E-02	1.77325E-02	1.11393E-01
1.01761E-01	6.28476E-02	4.83376E-02	2.24861E-02	1.38279E-02	1.08533E-02	7.39343E-03	2.80319E-02	2.25466E-02	1.75312E-02
1.16545E-02	8.02355E-03	3.46206E-03	3.43412E-03	1.44148E-03	8.21407E-04	6.05491E-04	5.79813E-04	5.38150E-04	4.48756E-04
1.20407E-05									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the IVFS slab is as follows:

1.93233E-05	7.88605E-05	2.78448E-04	6.39638E-04	1.19397E-03	1.98550E-03	2.53344E-03	3.51361E-03	4.80206E-03	1.67381E-03
1.47918E-03	2.67306E-03	6.62246E-03	7.69794E-03	7.92482E-03	8.24014E-03	1.08807E-02	1.37362E-02	9.33210E-03	3.53711E-03
1.00133E-02	1.45383E-02	6.08661E-04	2.20184E-04	4.64074E-04	4.29305E-03	1.45205E-02	1.21142E-02	7.02696E-03	1.58553E-02
1.05414E-02	4.29608E-02	7.59002E-03	1.05231E-02	1.33574E-02	3.64934E-03	6.59572E-03	1.11043E-02	9.08830E-03	5.73649E-02
5.26256E-02	3.31154E-02	2.50613E-02	1.19045E-02	7.36424E-03	5.88418E-03	4.08719E-03	1.61140E-02	1.36710E-02	1.13155E-02
8.30566E-03	6.43696E-03	4.02018E-03	5.01350E-03	3.72975E-03	3.19695E-03	2.78885E-03	2.74894E-03	2.51109E-03	2.59669E-03
3.78134E-03									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the IVFS slab is as follows:

6.42990E-06	2.46186E-05	8.30396E-05	1.66444E-04	2.69698E-04	4.10927E-04	4.77031E-04	6.40199E-04	8.48341E-04	2.91386E-04
2.62837E-04	4.66890E-04	1.21385E-03	1.40318E-03	1.38828E-03	1.41973E-03	1.85119E-03	2.29582E-03	1.56693E-03	6.00644E-04
1.59244E-03	2.46695E-03	1.02482E-04	3.75398E-05	8.19231E-05	7.25691E-04	2.46533E-03	2.00623E-03	1.22248E-03	2.54476E-03
1.86918E-03	6.98690E-03	1.27066E-03	1.90387E-03	2.04611E-03	5.63912E-04	1.13696E-03	1.90579E-03	1.53161E-03	9.64198E-03
8.80838E-03	5.50007E-03	4.12951E-03	1.95232E-03	1.19991E-03	9.46158E-04	6.62696E-04	2.65523E-03	2.28300E-03	1.90493E-03
1.33290E-03	1.02549E-03	5.94159E-04	7.18926E-04	4.99715E-04	4.05984E-04	3.43704E-04	3.47913E-04	3.33352E-04	3.71354E-04
1.51836E-03

Fig. G.30. Computational model used for Configuration IIE.5 (Fe/AL/Boral/2m Na/B4C/Homog IVFS slab; basic configuration, with extended concrete ring and Cd plate). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.30. Detailed description of the calculational model for Configuration III E.5 (Fe/AL/Boral/2m Na/B4C/Homog IVFS slab; basic configuration, with extended concrete ring and Cd plate).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE																	
ZMIN	ZMAX	N	R	M	(etc) ...															
484.740	496.740	15	0.0	62									157.100							
429.450	484.740	50	0.0	62									157.100							
392.773	429.450	33	0.0	62									157.100							
391.340	392.773	2	0.0	62									135.400 34 157.100							
379.340	391.340	12	0.0	62									135.400 34 157.100							
363.300	379.340	20	0.0	62									135.400 34 157.100							
353.620	363.300	12	0.0	62									96.140 34 157.100							
350.100	353.620	5	0.0	62									85.980 33 96.140 34 157.100							
347.773	350.100	3	0.0	62									85.980 33 96.140 34 157.100							
346.340	347.773	2	0.0	67									85.980 33 96.140 34 157.100							
343.800	346.340	2	0.0	27									58.707 33 96.140 34 157.100							
339.480	343.800	12	0.0	52	51.865	53	52.467	54	55.059	55	55.902	27	58.707	33	96.140	34	157.100			
336.020	339.480	3	0.0	27									58.707	33	96.140	34	157.100			
332.740	336.020	9	0.0	48	51.865	49	52.467	50	55.059	51	55.902	27	58.707	33	96.140	34	157.100			
330.200	332.740	2	0.0	27									58.707	33	96.140	34	157.100			
329.562	330.200	1	0.0	39										85.980	33	96.140	34	157.100		
323.940	329.562	12	0.0	38										85.307	39	85.980	33	96.140	34	157.100
323.300	323.940	1	0.0	39											85.980	33	96.140	34	157.100	
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)																	

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.30. Results for Config III E.5

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.46340E+02											
R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)	
.00	.00	0.00000E+00	4.64494E-01	1.78236E+00	2.83994E+00	2.50163E+00	1.40696E+00	7.22149E-01	1.95650E-04	1.94652E-04	
.00	2.13	0.00000E+00	3.22821E-01	1.14299E+00	1.82029E+00	1.85948E+00	1.09480E+00	5.82104E-01	2.39709E-04	1.82392E-04	
.00	30.00	0.00000E+00	1.80130E-01	5.26425E-01	7.01362E-01	4.64703E-01	2.38999E-01	1.16346E-01	2.05947E-04	1.38614E-04	
.00	150.00	0.00000E+00	3.02055E-02	8.84027E-02	1.17411E-01	7.58270E-02	3.84701E-02	1.86644E-02	6.81097E-05	2.62334E-05	
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the IVFS slab is as follows:											
2.81019E-05	1.19812E-04	4.31947E-04	1.05409E-03	2.11224E-03	3.65276E-03	4.82114E-03	6.81688E-03	9.62234E-03	3.49471E-03		
3.02104E-03	5.48090E-03	1.33160E-02	1.54661E-02	1.61051E-02	1.71604E-02	2.21381E-02	2.96077E-02	2.00831E-02	7.79178E-03		
2.26593E-02	3.02660E-02	1.26299E-03	4.55834E-04	9.51192E-04	9.17875E-03	3.08524E-02	2.64945E-02	1.49314E-02	3.68214E-02		
2.16698E-02	9.71112E-02	1.61004E-02	2.12727E-02	3.41106E-02	9.77788E-03	1.33783E-02	2.23457E-02	1.87264E-02	1.18293E-01		
1.08855E-01	6.73264E-02	5.19531E-02	2.43156E-02	1.50015E-02	1.16584E-02	7.93842E-03	2.96704E-02	2.36660E-02	1.83689E-02		
1.21634E-02	8.30661E-03	3.58695E-03	3.44166E-03	1.42695E-03	7.98373E-04	5.72487E-04	5.38726E-04	4.81398E-04	2.66597E-04		
4.46408E-06											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 2.13 cm past the IVFS slab is as follows:											
2.65040E-05	1.12530E-04	4.05199E-04	9.82853E-04	1.95629E-03	3.36698E-03	4.42403E-03	6.23137E-03	8.71394E-03	3.17673E-03		
2.72535E-03	4.92927E-03	1.20208E-02	1.39697E-02	1.44808E-02	1.54819E-02	1.95523E-02	2.59461E-02	1.73877E-02	6.80562E-03		
1.95932E-02	2.65918E-02	1.09007E-03	3.92197E-04	8.15035E-04	7.99093E-03	2.73579E-02	2.27937E-02	1.23615E-02	3.10901E-02		
1.79035E-02	8.37800E-02	1.42378E-02	1.71686E-02	2.78651E-02	8.68506E-03	1.21927E-02	2.04754E-02	1.72792E-02	1.09444E-01		
1.00069E-01	6.20345E-02	4.75252E-02	2.17928E-02	1.33386E-02	1.06049E-02	7.11050E-03	2.73420E-02	2.17770E-02	1.70123E-02		
1.11943E-02	7.54426E-03	3.36188E-03	3.14218E-03	1.39228E-03	8.16204E-04	6.01953E-04	5.79398E-04	5.34131E-04	5.02065E-04		
2.40611E-03											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the IVFS slab is as follows:											
1.91217E-05	7.79810E-05	2.75125E-04	6.31750E-04	1.17904E-03	1.96063E-03	2.50122E-03	3.46935E-03	4.74730E-03	1.65382E-03		
1.46151E-03	2.64122E-03	6.54230E-03	7.61051E-03	7.83811E-03	8.15464E-03	1.07630E-02	1.35159E-02	9.16293E-03	3.46592E-03		
9.84526E-03	1.42992E-02	6.00152E-04	2.16989E-04	4.56796E-04	4.22906E-03	1.42774E-02	1.19455E-02	6.93026E-03	1.56377E-02		
1.03609E-02	4.22478E-02	7.44242E-03	1.03504E-02	1.31783E-02	3.59941E-03	6.47620E-03	1.08670E-02	8.89571E-03	5.62981E-02		
5.16205E-02	3.23971E-02	2.44507E-02	1.15758E-02	7.15213E-03	5.69683E-03	3.95784E-03	1.55099E-02	1.30312E-02	1.07235E-02		
7.72332E-03	5.84630E-03	3.64862E-03	4.31453E-03	3.23218E-03	2.78437E-03	2.39552E-03	2.34684E-03	2.09019E-03	1.53491E-03		
2.82220E-03											
Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the IVFS slab is as follows:											
6.37771E-06	2.44897E-05	8.26772E-05	1.66307E-04	2.70132E-04	4.12796E-04	4.80841E-04	6.45591E-04	8.55495E-04	2.93616E-04		
2.65123E-04	4.71296E-04	1.22442E-03	1.41694E-03	1.40476E-03	1.43628E-03	1.87564E-03	2.32648E-03	1.59195E-03	6.09466E-04		
1.62891E-03	2.50962E-03	1.04471E-04	3.82668E-05	8.34368E-05	7.39480E-04	2.50575E-03	2.04868E-03	1.25182E-03	2.59637E-03		
1.91010E-03	7.10680E-03	1.28924E-03	1.95353E-03	2.09522E-03	5.76936E-04	1.14899E-03	1.92330E-03	1.54954E-03	9.80520E-03		
8.98495E-03	5.63979E-03	4.23279E-03	1.99994E-03	1.23228E-03	9.74818E-04	6.80662E-04	2.72691E-03	2.33931E-03	1.94924E-03		
1.36511E-03	1.04728E-03	6.04928E-04	7.25512E-04	5.02717E-04	4.06897E-04	3.43138E-04	3.44825E-04	3.30839E-04	3.69446E-04		
1.77626E-03

Fig. G.31. Computational model used for Configuration III.F.1 (Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL slabs; basic configuration by itself). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.31. Detailed description of the calculational model for Configuration IIIF.1 (Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL slabs; basic configuration by itself).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
525.000	537.000	15	0.0	62	----->							157.100
489.450	525.000	19	0.0	62	----->							157.100
433.033	489.450	30	0.0	62	----->							157.100
431.600	433.033	2	0.0	62	----->							157.100
419.600	431.600	7	0.0	62	----->							157.100
394.000	419.600	32	0.0	62	----->							157.100
388.033	394.000	8	0.0	62	----->							157.100
386.600	388.033	2	0.0	62	----->	85.980	33	----->	96.140	34		157.100
384.030	386.600	2	0.0	62	----->	85.980	33	----->	96.140	34		157.100
383.392	384.030	1	0.0	27	----->	85.980	33	----->	96.140	34		157.100
377.770	383.392	12	0.0	39	----->	85.980	33	----->	96.140	34		157.100
377.130	377.770	1	0.0	38	----->	85.307	39	----->	96.140	34		157.100
376.700	377.130	1	0.0	39	----->	85.980	33	----->	96.140	34		157.100
374.020	376.700	4	0.0	62	----->	85.980	33	----->	96.140	34		157.100
343.200	374.020	28	0.0	40	----->	85.980	33	----->	96.140	34		157.100
339.440	343.200	4	0.0	62	----->	85.980	33	----->	96.140	34		157.100
336.900	339.440	2	0.0	62	----->	58.707	33	----->	89.190	34		157.100
332.580	336.900	12	0.0	27	----->	58.707	33	----->	89.190	34		157.100
329.120	332.580	3	0.0	52	----->	51.865	53	----->	89.190	34		157.100
325.840	329.120	9	0.0	27	----->	52.467	54	----->	89.190	34		157.100
323.300	325.840	2	0.0	55	----->	55.059	55	----->	89.190	34		157.100
			0.0	55.902	----->	27	58.707	33	----->	89.190	34	157.100
			0.0	48	----->	51.865	49	----->	89.190	34		157.100
			0.0	27	----->	52.467	50	----->	89.190	34		157.100
			0.0	27	----->	55.059	51	----->	89.190	34		157.100
			0.0	27	----->	55.902	27	----->	89.190	34		157.100
			0.0	27	----->	58.707	33	----->	89.190	34		157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.31. Results for Config IIIF.1

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.86600E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.06395E+00	5.48155E+00	1.01101E+01	1.31520E+01	9.17618E+00	5.25642E+00	3.84293E-04	3.83676E-04
.00	-46.46	0.00000E+00	2.01274E+01	6.01009E+01	9.38742E+01	9.31141E+01	5.91167E+01	3.41513E+01	3.18718E-02	2.36060E-02
.00	.70	0.00000E+00	9.01780E-01	4.73836E+00	8.87600E+00	1.17247E+01	8.39405E+00	4.91966E+00	3.51924E-04	3.51341E-04
.00	30.00	0.00000E+00	3.24260E-01	1.47170E+00	2.45627E+00	2.44870E+00	1.52206E+00	8.47304E-01	1.99478E-04	1.87252E-04
.00	150.00	0.00000E+00	5.73675E-02	2.53319E-01	4.24065E-01	4.31884E-01	2.74321E-01	1.55396E-01	6.87522E-05	4.36743E-05

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last aluminum slab is as follows:

1.23458E-04	6.30884E-04	2.39026E-03	6.85797E-03	1.52764E-02	2.79263E-02	4.28274E-02	6.23513E-02	8.30619E-02	2.96743E-02
2.90184E-02	6.12124E-02	1.45065E-01	1.58122E-01	1.59513E-01	2.63331E-01	2.43517E-01	3.04408E-01	1.99853E-01	7.37798E-02
2.36395E-01	2.78844E-01	1.13906E-02	4.04999E-03	8.21103E-03	7.38078E-02	2.19318E-01	1.71873E-01	1.04859E-01	2.10560E-01
1.33593E-01	3.45857E-01	4.75313E-02	8.57266E-02	1.01244E-01	2.34515E-02	3.48730E-02	4.88021E-02	3.20561E-02	1.47104E-01
1.10416E-01	5.40532E-02	3.48453E-02	1.43683E-02	8.14111E-03	5.49437E-03	3.66483E-03	1.23314E-02	6.95033E-03	4.20373E-03
1.83538E-03	1.06757E-03	3.79937E-04	1.33389E-04	1.62947E-05	1.62253E-06	2.30975E-07	1.00620E-07	7.56828E-08	7.58609E-08
6.44487E-08									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= -46.46 cm past the last aluminum slab (0.7 cm past IVFS) is as follows:

1.14347E-03	6.09984E-03	2.30288E-02	6.50275E-02	1.47838E-01	2.72509E-01	3.93395E-01	5.75790E-01	8.39339E-01	3.06546E-01
2.64855E-01	4.87913E-01	1.10590E+00	1.22114E+00	1.30835E+00	1.35603E+00	1.62764E+00	2.14128E+00	1.40546E+00	5.30559E-01
1.66585E+00	2.04642E+00	8.46165E-02	3.03872E-02	6.08125E-02	5.51437E-01	1.73277E+00	1.40442E+00	8.15195E-01	1.70266E+00
9.71348E-01	2.88643E+00	4.19929E-01	6.37188E-01	7.60451E-01	2.24475E-01	2.89265E-01	4.44726E-01	3.35751E-01	1.68706E+00
1.46348E+00	9.27162E-01	6.90027E-01	3.09492E-01	1.80855E-01	1.39925E-01	1.00223E-01	5.91395E-01	8.16165E-01	1.02510E+00
1.13166E+00	1.24816E+00	8.79423E-01	1.77301E+00	1.24407E+00	8.90782E-01	4.39737E-01	1.00886E+00	1.04128E+00	7.26765E-01
3.35573E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the last aluminum slab is as follows:

1.18531E-04	6.05764E-04	2.29542E-03	6.57377E-03	1.46236E-02	2.66933E-02	4.08283E-02	5.92821E-02	7.85135E-02	2.82600E-02
2.73897E-02	5.75149E-02	1.35994E-01	1.47753E-01	1.48095E-01	2.45917E-01	2.22303E-01	2.79795E-01	1.81212E-01	6.75680E-02
2.12103E-01	2.54675E-01	1.02133E-02	3.61387E-03	7.29679E-03	6.57347E-02	2.01529E-01	1.51935E-01	8.86776E-02	1.81688E-01
1.12851E-01	3.05653E-01	4.42412E-02	7.11145E-02	8.62287E-02	2.22483E-02	3.33316E-02	4.69882E-02	3.10633E-02	1.41704E-01
1.05265E-01	5.13408E-02	3.29974E-02	1.36280E-02	7.72210E-03	5.24592E-03	3.47587E-03	1.18470E-02	6.68849E-03	4.04497E-03
1.76254E-03	1.02897E-03	3.65703E-04	1.28198E-04	1.56279E-05	1.64498E-06	3.20634E-07	1.82887E-07	1.44784E-07	1.46752E-07
1.26618E-07									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last aluminum slab is as follows:

6.92854E-05	3.52018E-04	1.32099E-03	3.71081E-03	8.12905E-03	1.46755E-02	2.22397E-02	3.20693E-02	4.22576E-02	1.48800E-02
1.47549E-02	3.06759E-02	7.20679E-02	7.83969E-02	7.91771E-02	1.28167E-01	1.18813E-01	1.46369E-01	9.65432E-02	3.46186E-02
1.10231E-01	1.36365E-01	5.59508E-03	1.97920E-03	3.98935E-03	3.44500E-02	1.04566E-01	8.09641E-02	5.06840E-02	9.16585E-02
6.61016E-02	1.51729E-01	2.28909E-02	4.28360E-02	3.93547E-02	8.95684E-03	1.42943E-02	2.11448E-02	1.54159E-02	7.60095E-02
5.67160E-02	2.79087E-02	1.73970E-02	7.32042E-03	4.17890E-03	2.79240E-03	1.91204E-03	6.62566E-03	3.83725E-03	2.39694E-03
1.03659E-02	6.53699E-04	2.58763E-04	1.48184E-04	8.00581E-05	6.81947E-05	6.28008E-05	5.82985E-05	5.46987E-05	6.76365E-05
5.07265E-04									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last aluminum slab is as follows:

1.70441E-05	8.53164E-05	3.17929E-04	8.63814E-04	1.82602E-03	3.18810E-03	4.64799E-03	6.53167E-03	8.28493E-03	2.86807E-03
2.81817E-03	5.63754E-03	1.29544E-02	1.36906E-02	1.35559E-02	2.08278E-02	1.94384E-02	2.36356E-02	1.53154E-02	5.32064E-03
1.66206E-02	2.15704E-02	8.89585E-04	3.14627E-04	6.33758E-04	5.22555E-03	1.59980E-02	1.23324E-02	8.21493E-03	1.33430E-02
1.08666E-02	2.22008E-02	3.42171E-03	7.48714E-03	5.19188E-03	1.20511E-03	1.96058E-03	3.74010E-03	2.77355E-03	1.24951E-02
9.68791E-03	5.06769E-03	3.35912E-03	1.52642E-03	9.28945E-04	6.71953E-04	4.82643E-04	2.05902E-03	1.53239E-03	1.21129E-03
7.70683E-04	6.90641E-04	5.32158E-04	6.72438E-04	5.86596E-04	5.31175E-04	4.83732E-04	4.38884E-04	3.95201E-04	4.51121E-04
1.05798E-03

Fig. G.32. Calculational model used for Configuration III F.2 (Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL slabs; basic configuration, with extended concrete ring in analytic model to simulate background radiation). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.32. Detailed description of the calculational model for Configuration IIIF.2 (Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL slabs; basic configuration, with extended concrete ring in analytic model to simulate background radiation).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
525.000	537.000	15	0.0	62	----->							157.100
469.710	525.000	29	0.0	62	----->							157.100
433.033	469.710	20	0.0	62	----->							157.100
431.600	433.033	2	0.0	62	----->						135.400	34 157.100
419.600	431.600	7	0.0	62	----->						135.400	34 157.100
394.000	419.600	32	0.0	62	----->						135.400	34 157.100
388.033	394.000	8	0.0	62	----->							157.100
386.600	388.033	2	0.0	62	----->					85.980	33	96.140 34 157.100
384.030	386.600	2	0.0	27	----->					85.980	33	96.140 34 157.100
383.392	384.030	1	0.0	39	----->					85.980	33	96.140 34 157.100
377.770	383.392	12	0.0	38	----->					85.307	39	85.980 33 96.140 34 157.100
377.130	377.770	1	0.0	39	----->					85.980	33	96.140 34 157.100
376.700	377.130	1	0.0	62	----->					85.980	33	96.140 34 157.100
374.020	376.700	4	0.0	40	----->					85.980	33	96.140 34 157.100
343.200	374.020	28	0.0	62	----->					85.980	33	96.140 34 157.100
339.440	343.200	4	0.0	62	----->					58.707	33	89.190 34 157.100
336.900	339.440	2	0.0	27	----->					58.707	33	89.190 34 157.100
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27					58.707	33	89.190 34 157.100
329.120	332.580	3	0.0	27	----->					58.707	33	89.190 34 157.100
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27					58.707	33	89.190 34 157.100
323.300	325.840	2	0.0	27	----->					58.707	33	89.190 34 157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.32. Results for Config IIIF.2

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.86600E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.09480E+00	5.54825E+00	1.01872E+01	1.31909E+01	9.19301E+00	5.26321E+00	7.62737E-04	4.63928E-04
.00	-46.46	0.00000E+00	2.01319E+01	6.01167E+01	9.38982E+01	9.31335E+01	5.91271E+01	3.41563E+01	3.18783E-02	2.36097E-02
.00	.70	0.00000E+00	9.39080E-01	4.81821E+00	8.96681E+00	1.17693E+01	8.41357E+00	4.92738E+00	7.51800E-04	4.35396E-04
.00	30.00	0.00000E+00	3.58285E-01	1.55203E+00	2.55712E+00	2.50807E+00	1.55006E+00	8.59626E-01	5.67886E-04	2.56770E-04
.00	150.00	0.00000E+00	8.05186E-02	3.10272E-01	4.97799E-01	4.80390E-01	2.98573E-01	1.66327E-01	2.82634E-04	8.67196E-05

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last aluminum slab is as follows:

1.23467E-04	6.30927E-04	2.39042E-03	6.85845E-03	1.52775E-02	2.79391E-02	4.28826E-02	6.25465E-02	8.37403E-02	2.98971E-02
2.92234E-02	6.16242E-02	1.46098E-01	1.59581E-01	1.61214E-01	2.65175E-01	2.48431E-01	3.08042E-01	2.02620E-01	7.46868E-02
2.39650E-01	2.83971E-01	1.16478E-02	4.14439E-03	8.40009E-03	7.54532E-02	2.23838E-01	1.76203E-01	1.08233E-01	2.14991E-01
1.38189E-01	3.53206E-01	4.86332E-02	9.00837E-02	1.04456E-01	2.42528E-02	3.55606E-02	4.96650E-02	3.27144E-02	1.52686E-01
1.15976E-01	5.88799E-02	3.85310E-02	1.60616E-02	9.33135E-03	6.65130E-03	4.42987E-03	1.57362E-02	1.00075E-02	6.96973E-03
4.41048E-03	3.38169E-03	2.50540E-03	2.97211E-03	2.55076E-03	2.27743E-03	2.05291E-03	1.87572E-03	1.76343E-03	2.21005E-03
1.26748E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= -46.46 cm past the last aluminum slab (0.7 cm past IVFS) is as follows:

1.14357E-03	6.10034E-03	2.30307E-02	6.50328E-02	1.47850E-01	2.72536E-01	3.93438E-01	5.75864E-01	8.39475E-01	3.06589E-01
2.64894E-01	4.87993E-01	1.10612E+00	1.22140E+00	1.30866E+00	1.35644E+00	1.62823E+00	2.14207E+00	1.40600E+00	5.30741E-01
1.66653E+00	2.04730E+00	8.46532E-02	3.04002E-02	6.08385E-02	5.51666E-01	1.73350E+00	1.40506E+00	8.15640E-01	1.70354E+00
9.71948E-01	2.88804E+00	4.20141E-01	6.37640E-01	7.60855E-01	2.24581E-01	2.89401E-01	4.44966E-01	3.35923E-01	1.68784E+00
1.46414E+00	9.27555E-01	6.90335E-01	3.09640E-01	1.80945E-01	1.39995E-01	1.00275E-01	5.91638E-01	8.16376E-01	1.02527E+00
1.13181E+00	1.24829E+00	8.79517E-01	1.77315E+00	1.24419E+00	8.90876E-01	4.39814E-01	1.00895E+00	1.04136E+00	7.26846E-01
3.35688E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the last aluminum slab is as follows:

1.18539E-04	6.05806E-04	2.29558E-03	6.57423E-03	1.46246E-02	2.67068E-02	4.08872E-02	5.94911E-02	7.92436E-02	2.84960E-02
2.76087E-02	5.79550E-02	1.37094E-01	1.49315E-01	1.49922E-01	2.47862E-01	2.27701E-01	2.83643E-01	1.84187E-01	6.85255E-02
2.15556E-01	2.60190E-01	1.04966E-02	3.71809E-03	7.50530E-03	6.75195E-02	2.06323E-01	1.56603E-01	9.24415E-02	1.86327E-01
1.18011E-01	3.13329E-01	4.53971E-02	7.60953E-02	8.94947E-02	2.30599E-02	3.40170E-02	4.78513E-02	3.17313E-02	1.47429E-01
1.10993E-01	5.63361E-02	3.67914E-02	1.53744E-02	8.95283E-03	6.44365E-03	4.26499E-03	1.53676E-02	9.85080E-03	6.90993E-03
4.42838E-03	3.42700E-03	2.56868E-03	3.07817E-03	2.65309E-03	2.37127E-03	2.13885E-03	1.95577E-03	1.84064E-03	2.31100E-03
1.34249E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last aluminum slab is as follows:

6.92901E-05	3.52047E-04	1.32110E-03	3.71118E-03	8.13048E-03	1.47047E-02	2.23074E-02	3.22431E-02	4.27493E-02	1.50312E-02
1.48979E-02	3.09583E-02	7.27638E-02	7.93655E-02	8.03103E-02	1.29329E-01	1.21906E-01	1.48746E-01	9.84270E-02	3.52159E-02
1.12386E-01	1.39645E-01	5.76696E-03	2.04236E-03	4.11642E-03	3.55338E-02	1.07467E-01	8.38250E-02	5.30853E-02	9.44428E-02
6.94352E-02	1.56344E-01	2.36082E-02	4.61303E-02	4.12785E-02	9.42414E-03	1.46851E-02	2.16282E-02	1.58165E-02	7.95701E-02
6.03796E-02	3.12003E-02	1.98796E-02	8.48624E-03	5.01041E-03	3.60917E-03	2.45247E-03	9.08211E-03	6.09567E-03	4.48516E-03
3.00998E-03	2.45986E-03	1.94925E-03	2.46957E-03	2.20236E-03	2.01422E-03	1.85223E-03	1.72240E-03	1.64563E-03	2.09976E-03
1.32168E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last aluminum slab is as follows:

1.70602E-05	8.57062E-05	3.19976E-04	8.71690E-04	1.85104E-03	3.24481E-03	4.74274E-03	6.71138E-03	8.62507E-03	2.97256E-03
2.92863E-03	5.83606E-03	1.34692E-02	1.44130E-02	1.43848E-02	2.15410E-02	2.12101E-02	2.53957E-02	1.68108E-02	5.76325E-03
1.81530E-02	2.39257E-02	1.00536E-03	3.56763E-04	7.19047E-04	5.96008E-03	1.79788E-02	1.42382E-02	9.88528E-03	1.49548E-02
1.32204E-02	2.50315E-02	3.91625E-03	9.81237E-03	6.18827E-03	1.49192E-03	2.15790E-03	4.01022E-03	3.04740E-03	1.49179E-02
1.20630E-02	7.16883E-03	4.90975E-03	2.26609E-03	1.46375E-03	1.19938E-03	8.23413E-04	3.64158E-03	2.99715E-03	2.56959E-03
2.05059E-03	1.87230E-03	1.63669E-03	2.17900E-03	1.95539E-03	1.77974E-03	1.62424E-03	1.49334E-03	1.39681E-03	1.72082E-03
8.31996E-03

Fig. G.33. Computational model used for Configuration III F.3 (Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL slabs; basic configuration, with extended concrete ring and Cd hut). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.33. Detailed description of the calculational model for Configuration IIIF.3 (Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL slabs; basic configuration, with extended concrete ring and Cd hut).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
525.000	537.000	15	0.0	62	----->							157.10
469.710	525.000	29	0.0	62	----->							157.10
433.033	469.710	20	0.0	62	----->							157.10
431.600	433.033	2	0.0	67	----->							157.10
419.600	431.600	7	0.0	62	----->	84.547	67	----->	85.98	62	----->	157.10
394.000	419.600	32	0.0	62	----->	84.547	67	----->	85.98	62	----->	157.10
388.033	394.000	8	0.0	62	----->	84.547	67	----->	85.98	33	----->	157.10
386.600	388.033	2	0.0	62	----->	84.547	67	----->	85.98	33	----->	157.10
384.030	386.600	2	0.0	27	----->			----->	85.98	33	----->	157.10
383.392	384.030	1	0.0	39	----->			----->	85.98	33	----->	157.10
377.770	383.392	12	0.0	38	----->			----->	85.98	33	----->	157.10
377.130	377.770	1	0.0	39	----->			----->	85.98	33	----->	157.10
376.700	377.130	1	0.0	62	----->			----->	85.98	33	----->	157.10
374.020	376.700	4	0.0	40	----->			----->	85.98	33	----->	157.10
343.200	374.020	28	0.0	62	----->			----->	85.98	33	----->	157.10
339.440	343.200	4	0.0	62	----->	58.707	33	----->	89.19	34	----->	157.10
336.900	339.440	2	0.0	27	----->	58.707	33	----->	89.19	34	----->	157.10
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	----->	89.19	34	----->	157.10
329.120	332.580	3	0.0	27	----->	58.707	33	----->	89.19	34	----->	157.10
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	----->	89.19	34	----->	157.10
323.300	325.840	2	0.0	27	----->	58.707	33	----->	89.19	34	----->	157.10
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.33. Results for Config IIIF.3

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.86600E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.09836E+00	5.56285E+00	1.02080E+01	1.32039E+01	9.19878E+00	5.26548E+00	4.43017E-04	4.40573E-04
.00	-46.46	0.00000E+00	2.01334E+01	6.01216E+01	9.39050E+01	9.31382E+01	5.91293E+01	3.41573E+01	3.18808E-02	2.36111E-02
.00	.70	0.00000E+00	9.42650E-01	4.83353E+00	8.98885E+00	1.17832E+01	8.41982E+00	4.92983E+00	4.12770E-04	4.10386E-04
.00	30.00	0.00000E+00	3.63436E-01	1.57472E+00	2.59203E+00	2.53510E+00	1.56378E+00	8.65728E-01	2.33616E-04	2.32145E-04
.00	150.00	0.00000E+00	7.99914E-02	3.80864E-01	4.94103E-01	4.76486E-01	2.96002E-01	1.64842E-01	2.13097E-04	8.07479E-05

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last aluminum slab is as follows:

1.23468E-04	6.30936E-04	2.39046E-03	6.85875E-03	1.52790E-02	2.79418E-02	4.28891E-02	6.25627E-02	8.37669E-02	2.99084E-02
2.92408E-02	6.16687E-02	1.46240E-01	1.59785E-01	1.61470E-01	2.65637E-01	2.49013E-01	3.09082E-01	2.03535E-01	7.50521E-02
2.41211E-01	2.85693E-01	1.17245E-02	4.17279E-03	8.46003E-03	7.59509E-02	2.25277E-01	1.77484E-01	1.09047E-01	2.16489E-01
1.39200E-01	3.55614E-01	4.89650E-02	9.07226E-02	1.05221E-01	2.44542E-02	3.57493E-02	4.99674E-02	3.29410E-02	1.53735E-01
1.16799E-01	5.93337E-02	3.88194E-02	1.61775E-02	9.40097E-03	6.70526E-03	4.46410E-03	1.58452E-02	1.00585E-02	7.00912E-03
4.42527E-03	3.36286E-03	2.51420E-03	2.86341E-03	2.51871E-03	2.29618E-03	2.07369E-03	1.88767E-03	1.73310E-03	1.54678E-03
4.18641E-05									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= -46.46 cm past the last aluminum slab (0.7 cm past IVFS) is as follows:

1.14358E-03	6.10043E-03	2.30310E-02	6.50338E-02	1.47852E-01	2.72541E-01	3.93446E-01	5.75876E-01	8.39492E-01	3.06596E-01
2.64900E-01	4.88007E-01	1.10616E+00	1.22445E+00	1.30872E+00	1.35654E+00	1.62837E+00	2.14228E+00	1.40616E+00	5.30800E-01
1.66676E+00	2.04764E+00	8.46687E-02	3.04057E-02	6.08495E-02	5.51756E-01	1.73378E+00	1.40531E+00	8.15826E-01	1.70387E+00
9.72193E-01	2.88862E+00	4.20215E-01	6.37830E-01	7.60997E-01	2.24616E-01	2.89445E-01	4.45056E-01	3.35988E-01	1.68811E+00
1.46437E+00	9.27685E-01	6.90434E-01	3.09688E-01	1.80975E-01	1.40018E-01	1.00292E-01	5.91711E-01	8.16434E-01	1.02532E+00
1.13185E+00	1.24833E+00	8.79548E-01	1.77320E+00	1.24423E+00	8.90912E-01	4.39846E-01	1.00898E+00	1.04139E+00	7.26877E-01
3.35738E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .70 cm past the last aluminum slab is as follows:

1.18540E-04	6.05815E-04	2.29561E-03	6.57448E-03	1.46262E-02	2.67096E-02	4.08943E-02	5.95080E-02	7.92700E-02	2.85074E-02
2.76266E-02	5.80007E-02	1.37240E-01	1.49522E-01	1.50181E-01	2.48332E-01	2.28285E-01	2.84708E-01	1.85129E-01	6.88989E-02
2.17147E-01	2.61938E-01	1.05748E-02	3.74715E-03	7.56679E-03	6.80214E-02	2.07776E-01	1.57891E-01	9.32649E-02	1.87805E-01
1.19034E-01	3.15720E-01	4.57306E-02	7.67349E-02	9.02304E-02	2.32604E-02	3.42024E-02	4.81540E-02	3.19597E-02	1.48478E-01
1.11811E-01	5.67809E-02	3.70726E-02	1.54872E-02	9.02036E-03	6.49561E-03	4.29775E-03	1.54711E-02	9.89594E-03	6.94508E-03
4.43797E-03	3.40108E-03	2.57394E-03	2.95397E-03	2.61406E-03	2.38791E-03	2.15748E-03	1.96455E-03	1.80349E-03	1.59216E-03
3.97658E-05									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last aluminum slab is as follows:

6.92909E-05	3.52145E-04	1.32194E-03	3.71774E-03	8.14639E-03	1.47324E-02	2.23497E-02	3.23069E-02	4.28407E-02	1.50668E-02
1.49421E-02	3.10598E-02	7.30473E-02	7.97358E-02	8.07465E-02	1.30057E-01	1.22913E-01	1.50509E-01	9.99888E-02	3.58114E-02
1.14785E-01	1.42309E-01	5.89001E-03	2.08807E-03	4.21265E-03	3.62566E-02	1.09576E-01	8.56518E-02	5.43112E-02	9.63554E-02
7.10016E-02	1.59429E-01	2.40780E-02	4.71026E-02	4.21143E-02	9.64846E-03	1.48726E-02	2.20191E-02	1.61504E-02	8.10667E-02
6.15025E-02	3.17948E-02	2.02408E-02	8.63520E-03	5.09997E-03	3.67644E-03	2.49507E-03	9.21648E-03	6.14921E-03	4.52927E-03
3.01682E-03	2.41862E-03	1.95739E-03	2.28884E-03	2.15446E-03	2.04543E-03	1.87998E-03	1.73202E-03	1.58222E-03	1.19609E-03
2.11582E-05									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last aluminum slab is as follows:

1.68936E-05	8.49613E-05	3.17337E-04	8.63332E-04	1.83296E-03	3.21162E-03	4.69245E-03	6.63963E-03	8.53446E-03	2.94077E-03
2.89775E-03	5.77421E-03	1.33281E-02	1.42680E-02	1.42451E-02	2.13247E-02	2.09918E-02	2.50803E-02	1.65924E-02	5.68171E-03
1.79512E-02	2.36513E-02	9.95790E-04	3.53535E-04	7.12718E-04	5.91059E-03	1.78056E-02	1.41336E-02	9.82475E-03	1.48511E-02
1.31268E-02	2.48377E-02	3.87975E-03	9.74844E-03	6.18385E-03	1.49005E-03	2.13582E-03	3.95287E-03	3.00599E-03	1.47729E-02
1.19611E-02	7.14058E-03	4.89252E-03	2.25669E-03	1.46023E-03	1.20213E-03	8.24246E-04	3.64461E-03	2.99973E-03	2.58168E-03
2.06434E-03	1.87271E-03	1.65417E-03	2.15296E-03	1.96107E-03	1.80508E-03	1.64751E-03	1.51014E-03	1.39468E-03	1.46861E-03
5.61218E-05

Fig. G.34. Computational model used for Configuration IIIIF.4 (Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL slabs; basic configuration, with extended concrete ring and Cd plate). Note that the actual calculational model also included everything shown in Fig. G.7b.

Table G.34. Detailed description of the calculational model for Configuration IIIF.4 (Fe/AL/Boral/2m Na/Hom IVFS/Void/SS/B4C/AL slabs; basic configuration, with extended concrete ring and Cd plate).

NUMBER OF FINE MESH IN EACH AXIAL ZONE			RADIAL BOUNDS (R IN CM) FOR EACH MATERIAL (M) IN EACH AXIAL ZONE									
ZMIN	ZMAX	N	R	M	(etc) ...							
525.000	537.000	15	0.0	62	----->							157.100
469.710	525.000	29	0.0	62	----->							157.100
433.033	469.710	20	0.0	62	----->							157.100
431.600	433.033	2	0.0	62	----->						135.400	34 157.100
419.600	431.600	7	0.0	62	----->						135.400	34 157.100
394.000	419.600	32	0.0	62	----->						135.400	34 157.100
388.033	394.000	8	0.0	62	----->						135.400	34 157.100
386.600	388.033	2	0.0	67	----->							157.100
384.030	386.600	2	0.0	27	----->							157.100
383.392	384.030	1	0.0	39	----->							157.100
377.770	383.392	12	0.0	38	----->							157.100
377.130	377.770	1	0.0	39	----->							157.100
376.700	377.130	1	0.0	62	----->							157.100
374.020	376.700	4	0.0	40	----->							157.100
343.200	374.020	28	0.0	62	----->							157.100
339.440	343.200	4	0.0	62	----->							157.100
336.900	339.440	2	0.0	27	----->							157.100
332.580	336.900	12	0.0	52	51.865 53 52.467 54 55.059 55 55.902 27	58.707	33	----->				157.100
329.120	332.580	3	0.0	27	----->							157.100
325.840	329.120	9	0.0	48	51.865 49 52.467 50 55.059 51 55.902 27	58.707	33	----->				157.100
323.300	325.840	2	0.0	27	----->							157.100
89.890	323.300	254	See description of the thick sodium spectral modifier (Table G.7b)									

- 1) For a detailed physical and neutronic description of materials 25 through 67, see Tables M.1 and M.2, respectively. Materials 1 to 24 were not used in any of the JASPER IVFS analyses.
- 2) The 166 radial mesh intervals used in all of the 2-D RZ analytic models are given in Table G.1b.

Table R.34. Results for Config IIIF.4

DORRE options: cod=3.000 (not used), hemisphere=180, rotate=y, x00= 0.00000E+00 y00= 0.00000E+00 z00= 3.86600E+02

R	Z	3 BB(mod)	3 BB	4 BB	5 BB	8 BB	10 BB	12 BB	FC(bare)	FC(Cd)
.00	.00	0.00000E+00	1.11669E+00	5.63567E+00	1.03112E+01	1.32662E+01	9.22585E+00	5.27587E+00	4.47408E-04	4.45880E-04
.00	-46.46	0.00000E+00	2.01363E+01	6.01319E+01	9.39199E+01	9.31481E+01	5.91340E+01	3.41592E+01	3.18845E-02	2.36132E-02
.00	2.13	0.00000E+00	7.46739E-01	3.77344E+00	7.06095E+00	9.44445E+00	6.94800E+00	4.31827E+00	6.58060E-04	4.16075E-04
.00	30.00	0.00000E+00	3.56268E-01	1.54427E+00	2.54346E+00	2.49132E+00	1.53826E+00	8.52487E-01	5.21016E-04	2.50787E-04
.00	150.00	0.00000E+00	7.98323E-02	3.08067E-01	4.94164E-01	4.76342E-01	2.95831E-01	1.64711E-01	2.53614E-04	8.33875E-05

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= .00 cm past the last aluminum slab is as follows:

1.23354E-04	6.30462E-04	2.39071E-03	6.86113E-03	1.52904E-02	2.79736E-02	4.29601E-02	6.26875E-02	8.40247E-02	3.00309E-02
2.93985E-02	6.20739E-02	1.47535E-01	1.61644E-01	1.63761E-01	2.69706E-01	2.53723E-01	3.16720E-01	2.09805E-01	7.74876E-02
2.51286E-01	2.96287E-01	1.22072E-02	4.34785E-03	8.82035E-03	7.88965E-02	2.33913E-01	1.84954E-01	1.13474E-01	2.24798E-01
1.44442E-01	3.68915E-01	5.08354E-02	9.37056E-02	1.09072E-01	2.55299E-02	3.67282E-02	5.17545E-02	3.43601E-02	1.59507E-01
1.20876E-01	6.12311E-02	3.99213E-02	1.65865E-02	9.62478E-03	6.85317E-03	4.55229E-03	1.60009E-02	9.97840E-03	6.89144E-03
4.24985E-03	3.14633E-03	2.35968E-03	2.47985E-03	2.28336E-03	2.15368E-03	1.93474E-03	1.73392E-03	1.52467E-03	8.25302E-04
1.44382E-05									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= -46.46 cm past the last aluminum slab (0.7 cm past IVFS) is as follows:

1.14361E-03	6.10058E-03	2.30316E-02	6.50355E-02	1.47857E-01	2.72550E-01	3.93460E-01	5.75898E-01	8.39525E-01	3.06608E-01
2.64912E-01	4.88034E-01	1.10623E+00	1.22156E+00	1.30885E+00	1.35680E+00	1.62869E+00	2.14279E+00	1.40656E+00	5.30944E-01
1.66731E+00	2.04842E+00	8.47054E-02	3.04188E-02	6.08757E-02	5.51972E-01	1.73443E+00	1.40589E+00	8.16266E-01	1.70466E+00
9.72768E-01	2.88996E+00	4.20382E-01	6.38258E-01	7.61312E-01	2.24690E-01	2.89541E-01	4.45249E-01	3.36127E-01	1.68868E+00
1.46484E+00	9.27931E-01	6.90617E-01	3.09776E-01	1.81027E-01	1.40057E-01	1.00320E-01	5.91825E-01	8.16519E-01	1.02539E+00
1.13191E+00	1.24838E+00	8.79590E-01	1.77326E+00	1.24428E+00	8.90960E-01	4.39887E-01	1.00902E+00	1.04143E+00	7.26919E-01
3.35803E-01									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 2.13 cm past the last aluminum slab is as follows:

1.12691E-04	5.76751E-04	2.18577E-03	6.26875E-03	1.39492E-02	2.54853E-02	3.90557E-02	5.68718E-02	7.58062E-02	2.71786E-02
2.64439E-02	5.55532E-02	1.31706E-01	1.43919E-01	1.45062E-01	2.39103E-01	2.20980E-01	2.74768E-01	1.79295E-01	6.62358E-02
2.11394E-01	2.54689E-01	1.03745E-02	3.67946E-03	7.43315E-03	6.62785E-02	2.01600E-01	1.54725E-01	9.18136E-02	1.82593E-01
1.16793E-01	3.05670E-01	4.42714E-02	7.50383E-02	8.69342E-02	2.21360E-02	3.20266E-02	4.54744E-02	3.07137E-02	1.43536E-01
1.07917E-01	5.48677E-02	3.56513E-02	1.48754E-02	8.68887E-03	6.29908E-03	4.17480E-03	1.49758E-02	9.48271E-03	6.68099E-03
4.23961E-03	3.22419E-03	2.47645E-03	2.83498E-03	2.52433E-03	2.31736E-03	2.09482E-03	1.90676E-03	1.74911E-03	1.83824E-03
1.02589E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 30.00 cm past the last aluminum slab is as follows:

6.86685E-05	3.48709E-04	1.30794E-03	3.67340E-03	8.04420E-03	1.45436E-02	2.20552E-02	3.18735E-02	4.22639E-02	1.48593E-02
1.47322E-02	3.06139E-02	7.20030E-02	7.86071E-02	7.96125E-02	1.28164E-01	1.20820E-01	1.47390E-01	9.75183E-02	3.48674E-02
1.12104E-01	1.38813E-01	5.75118E-03	2.03785E-03	4.10924E-03	3.54595E-02	1.07034E-01	8.39033E-02	5.31101E-02	9.45980E-02
6.92552E-02	1.56329E-01	2.35112E-02	4.59554E-02	4.15109E-02	9.51270E-03	1.46241E-02	2.15475E-02	1.57539E-02	7.91143E-02
6.00239E-02	3.10481E-02	1.97591E-02	8.41454E-03	4.97068E-03	3.59175E-03	2.43642E-03	8.99006E-03	5.99171E-03	4.41100E-03
2.94333E-03	2.38465E-03	1.90865E-03	2.35886E-03	2.13779E-03	1.98206E-03	1.82525E-03	1.69368E-03	1.59918E-03	1.84790E-03
1.14768E-02									

Flux (n/s/cm2/watt) by group (ig=1,61) at R= .00, Z= 150.00 cm past the last aluminum slab is as follows:

1.69203E-05	8.49543E-05	3.17025E-04	8.63179E-04	1.83254E-03	3.21118E-03	4.69240E-03	6.63895E-03	8.53218E-03	2.93991E-03
2.89690E-03	5.77392E-03	1.33307E-02	1.42731E-02	1.42536E-02	2.13587E-02	2.10111E-02	2.51360E-02	1.66329E-02	5.70218E-03
1.80654E-02	2.37322E-02	9.99081E-04	3.54661E-04	7.15050E-04	5.93528E-03	1.78738E-02	1.42122E-02	9.85822E-03	1.49615E-02
1.31591E-02	2.50012E-02	3.89849E-03	9.76101E-03	6.23124E-03	1.50394E-03	2.15622E-03	3.97723E-03	3.01876E-03	1.48174E-02
1.19821E-02	7.13067E-03	4.87868E-03	2.24751E-03	1.45206E-03	1.19197E-03	8.17441E-04	3.60792E-03	2.96229E-03	2.54200E-03
2.02556E-03	1.83943E-03	1.61807E-03	2.11859E-03	1.92181E-03	1.76408E-03	1.61047E-03	1.47803E-03	1.37008E-03	1.53757E-03
7.22715E-03									

4.0 COMPARISONS OF CALCULATED AND MEASURED VALUES

Bonner ball and fission chamber measurements for those JASPER IVFS experiments associated with the US LMR program are scattered throughout ORNL/TM-11989 while all of the corresponding calculated results have been presented in Sect. 3 of this report. In order to facilitate one-on-one cross comparisons between these measured and calculated values, all of the pertinent data from both sources has been extracted and combined here in Tables X.1 through X.15 at the end of Sect. 4. Briefly, each of these tables may be described as follows:

<u>Table</u>	<u>Description</u>
X.1.	Comparison of the measured and calculated neutron flux spectrum in the fast and intermediate energy ranges, 25 cm downstream of the Pb slabs in Config. IA.
X.2.	Comparison of the measured and calculated neutron flux spectrum in the fast and intermediate energy ranges, 179.1 cm downstream of the radial blanket assemblies in Config. IB.
X.3.	Comparison of the measured and calculated neutron flux spectrum in the fast and intermediate energy ranges, 25 cm downstream of the Pb slabs in Config. IC.
X.4.	Measured and calculated Bonner ball responses [(counts/sec)/watt] on the centerline at the NE213 location(s).
X.5.	Measured and calculated Bonner ball responses [(counts/sec)/watt] on the centerline, at 30 cm behind the spectrum modifiers.
X.6.	Measured and calculated Bonner ball responses [(counts/sec)/watt] on the centerline, at 30 cm behind the LMR shield mockups.
X.7.	Measured and calculated Bonner ball responses [(counts/sec)/watt] on the centerline, at 150 cm behind the spectrum modifiers.
X.8.	Measured and calculated Bonner ball responses [(counts/sec)/watt] on the centerline, at 150 cm behind the LMR shield mockups.

- X.9. Measured and calculated 3-inch Bonner ball responses [(counts/sec)/watt] along horizontal traverses at 30 cm behind the LMR shield mockups.
- X.10. Measured and calculated 10-inch Bonner ball responses [(counts/sec)/watt] along horizontal traverses at 30 cm behind the LMR shield mockups.
- X.11. Measured and calculated fission chamber responses [(counts/sec)/watt] for the bare and Cd-covered fission chambers located along the centerline of the system, at 0.7, 30, and 150 cm from the surface of the different spectral modifiers and IVFS shield mockups.
- X.12. Frequency distribution of C/E ratios for all (bare and Cd-covered) fission detectors in all of the IVFS shielding experiments shown in Table X.11.
- X.13. Measured and calculated bare fission chamber responses [(counts/sec)/watt] along horizontal traverses at 30 cm behind the LMR shield mockups.
- X.14. Measured and calculated Cd-covered fission chamber responses [(counts/sec)/watt] along horizontal traverses at 30 cm behind the LMR shield mockups.
- X.15. Measured and calculated bare fission chamber responses [(counts/sec)/watt] along horizontal traverses at 30 cm behind the LMR shield mockups, with a Cd plate over the face of the mockups.

Results in each of these tables will be discussed in the subsequent parts of Sect. 4.

4.1 DISCUSSION OF THE NEUTRON SPECTRUM MEASUREMENTS IN TABLES X.1 TO X.3 (IN LIGHT OF THE BONNER BALL MEASUREMENTS IN TABLE X.4)

Comparisons of the measured and calculated neutron flux spectra in the fast and intermediate energy range are shown in Tables X.1, X.2, and X.3 for the three basic spectral modifiers represented by Configs. IA/PB, IB, and IC/PB, respectively. Note that for Configs. IA/PB and IC/PB, the NE213 measurements ($0.811 \text{ MeV} < E < 15 \text{ MeV}$) and hydrogen spectrometer measurements ($0.05 \text{ MeV} < E < 1.4 \text{ MeV}$) were made 25 cm downstream of the Pb slabs shown in Figs. G.3 and G.11, while for Config. IB, both sets of measurements were made 179.1 cm downstream of the radial blanket assembly mockups.

The NE213 liquid scintillator spectrometer measurements ($E > 0.811 \text{ MeV}$) used pulse-shape discrimination to distinguish neutron pulses from gamma-ray pulses,

and were subsequently unfolded with the FERD code to yield the absolute neutron energy spectra in ORNL/TM-11989, while the pulse height data from the hydrogen-filled proton recoil spectrometers in three overlapping energy ranges between 0.05 MeV and 1.4 MeV were unfolded using the SPEC-4 code to obtain the lower portion of the absolute neutron spectra reported in ORNL/TM-11989. In Tables 14, 21, and 23 of that report, the NE213 data was given in terms of upper and lower estimates for the spectral flux at 55 energy points between 0.811 MeV and 23.5 MeV, while in Tables 15, 22, and 24 of that report, the hydrogen-filled spectrometer data was given in terms of the average spectral flux over each of 26 overlapping energy bands between 0.039 MeV and 1.4 MeV. To facilitate comparisons with the calculated multigroup fluxes, the experimental data was first fitted in a piecewise continuous fashion by a function of the form $y = aE^b$ between each pair of energy points, with minor adjustments at overlapping energy points to insure that this piecewise continuous function could still reproduce all of the integral data originally given in ORNL/TM-11989 to within 1%. Those piecewise-continuous representations of the experimentally measured spectral flux were then integrated analytically so that the measured fluxes in Tables X.1 to X.3 could be expressed in the same multigroup energy structure as the calculated fluxes. [Note that this was the only time anywhere in this report that measured data in ORNL/TM-11989 was massaged for any reason. Everywhere else, the measured data is shown digit-for-digit as it appeared in the original report.]

While the C/E ratios for the integral fast flux above any given energy ($E > E_{min}$) appear quite good for Config. IB (downstream of the radial blanket assemblies) with the calculated values typically within ± 3 to 10% of the measured values over the entire energy range, the corresponding ratios of the integrated fast flux ($E > E_{min}$) for those measurements made downstream of the Pb slabs in Config. IA/PB and IC/PB are not nearly as good. (Moreover, as noted below, the reason for this lack of agreement is not understood.) In Config. IC/PB, for example, the calculated integrals of the fast fluxes above 2 MeV are typically 10 to 12% lower than the measured values whereas if E_{min} is extended down to 0.9 MeV (or any other energy down to 0.05 MeV), the calculated integral for the fast flux above E_{min} is 35 to 40% higher than the measured value. While this might lead one to suspect that this could be due to the overestimate of fast or intermediate energy neutron transmission through some anti-resonance (cross-section) window in the thick sodium tank in the calculation (see group 20, for example), the 3-, 5-, and 10-inch Bonner ball responses behind the Pb slabs (cf. Table X.4) for this configuration do not support that hypothesis. Examination of the C/E ratios for those Bonner balls at this same location behind the Pb slabs in Config. IC/PB shows those C/E ratios to be no lower than 0.973, no higher than 1.029, and certainly nowhere close to 1.40. On the other hand, while the integral of the calculated fast and intermediate flux spectrum yields values that are 35 to 40% higher than the measured values for Config. IC,

these integrals over the calculated flux spectrum are typically 15 to 20% lower than the measured ratios for Config. IA. Why the integral of the fast and intermediate flux would calculate 15 to 20% low for Config. IA/PB, be within ± 3 to 10% of the measured values for Config. IB, and calculate 35 to 40% high for Config. IC/PB, is a mystery — especially when (as noted below) the calculated Bonner ball responses at these same locations are in good agreement with the measured values. [One suggested source of uncertainty lies in the application of the FERD and SPEC-4 unfolding codes originally used to infer the measured spectra from the raw NE213 and hydrogen-filled spectrometer data. There is, however, nothing to support that speculation and, moreover, it would not explain why the data would be low in some cases and high in others.]

Adding to the mystery (or making the measured spectral data further suspect) is the fact that the measured and calculated Bonner ball responses at the NE213 locations tend to agree quite well. As shown in Table X.4 and noted above, the C/E ratios for the 3-, 5-, and 10-inch Bonner balls downstream of Config. IC/PB are all between 0.97 and 1.03. Moreover, for Config. IA, the calculated values downstream of the Pb slabs are also within 10% of the measured values (with C/E ratios between 0.896 and 0.989). Comparisons for Config. IB have to be interpreted with slightly more care, but are still quite good if properly understood. In this case, unlike the others, the spectral measurements and the Bonner ball measurements were made 179.1 cm downstream of the experimental mockup. At this distant location, the effect of background radiation was more significant (18% of the total response for the 3-inch Bonner ball, and 6.5% of the total response for the 10-inch Bonner ball). For calculational run IB.2 which included an artificial concrete ring to simulate background radiation (cf. Sect. 2.6), the C/E ratios were all quite good and varied between 0.93 and 0.99. For calculational run IB.1, which did not have this concrete ring to simulate background radiation, the C/E ratios at first glance would appear to be as low as 0.81. In reality, however, the calculated values for calculational run IB.1 (without background simulation) should be compared against the measured values without background. For the 3-inch Bonner ball, for example, the C/E ratio should be calculated as

$$C/E = 74.14 / (91.8 - 16.2) = 74.14 / 75.6 = 0.981 \quad (\text{rather than } 0.808).$$

Likewise, the C/E ratios for the 5- and 10-inch Bonner balls (for Config. IB.1) would be 0.940 and 0.931 (rather than 0.846 and 0.871) if the measured background radiation were properly taken into account. With that correction, all of the calculated Bonner ball responses at the NE213 location would be within 10% of the corresponding measured values, and most would be within 3, 5, or 7%. While little can be said with certainty, the contrast between the good agreement found here and the poor agreement found in Table X.3 might suggest some inconsistency with the

measured neutron spectrum data or the unfolding codes initially used to interpret that data.

4.2 DISCUSSION OF THE BONNER BALL MEASUREMENTS AT 30 AND 150 CM DOWNSTREAM OF THE SPECTRAL MODIFIERS AND THE LMR SHIELD MOCKUPS, AS PRESENTED IN TABLES X.5 TO X.8

Tables X.5 and X.6 show the measured and calculated Bonner ball responses on the system centerline, 30 cm downstream of the basic spectral modifiers (Table X.5) and the LMR shield mockups involving the IVFS fuel slab and/or the radial blanket assembly (Table X.6), while Tables X.7 and X.8 show the corresponding values 150 cm downstream of the basic spectral modifiers and the LMR shield mockups.

4.2.1 Bonner Ball Results 30 cm Downstream of the Shielding Configurations

Because they are less affected by background radiation, those measured and calculated values 30 cm downstream of the various shielding configurations will provide the best and most meaningful indications of how well the codes and cross-section data can predict the transport of neutrons through the shielding configurations of interest. If one examines Tables X.5 and X.6 and considers all of the C/E ratios except those for Config. IIIE which we will discuss separately below, one will see that, of the 96 comparisons made for the 3, 4, 5, 8, 10, and 12-inch Bonner balls:

55% (53 of the 96) lie between 0.95 and 1.05 (more-or-less evenly distributed);

90% (86 of the 96) lie between 0.90 and 1.10 (with 18 between 0.90 and 0.95, and 15 between 1.05 and 1.10); and

all 96 lie between 0.86 and 1.17 (with 4 between 0.86 and 0.90, and 6 between 1.10 and 1.17).

This agreement is deemed to be exceptionally good and merits very little additional comment. Moreover, the only additional comment worth noting is that for the 3-D XYZ TORT analysis of the heterogeneous IVFS fuel slab (Config. IIIA) with the 6-inch-wide aluminum blocks between the 3 distinct fuel bearing compartments, the C/E ratios for all of the Bonner balls lie between 0.934 and 0.967. This excellent agreement is noteworthy only insofar as there are (to date) only a very limited number of true experimental benchmarks for the TORT code involving actual three-dimensional geometries.

From a designer's viewpoint, the measured (and calculated) data in Table X.6 also confirms several other things that were or should have been obvious *a priori*. [These have nothing to do with the calculations, but may be of interest anyway.]

- 1) The heterogeneous IVFS fuel slab could be modeled as a homogeneous slab, but only if one were willing to accept uncertainties of up to 40%. That is: the homogeneous model would have overpredicted the fast flux measured by the 12-inch Bonner ball downstream of the heterogeneous fuel slab by a factor of 1.22 ($=5.843/4.78$), while the homogeneous model would have underestimated the intermediate flux as measured by the 3-inch Bonner ball downstream of the heterogeneous fuel slab by a factor of 1.41 ($=8.86/6.303$). By using the actual 3-D model, the calculated values would have been within 3.3% to 6.6% of the measured values.
- 2) Placing the B_4C slab downstream of the homogeneous IVFS slab (as in Config. IIID) reduced the flux further downstream by about a factor of 3 ($=19.6/6.43$ for the 5-inch Bonner ball) relative to what it would have been without the B_4C slab (Config. IIIB).
- 3) Placing the B_4C upstream of the homogeneous IVFS fuel slab (as in Config. IIIE) rather than placing it downstream as in Config. IIID was an even more effective shield design, and reduced the flux downstream by an additional order of magnitude ($12.0 = 6.43/0.534$ for the 5-inch Bonner ball). Although the calculational uncertainties in this case (with the B_4C upstream) would have been somewhat higher with C/E ratios up to 1.30 and 1.40, this greater uncertainty would have been more than offset by the significantly lower fluxes actually present with the B_4C slab upstream of the IVFS slab. The reason for this, of course, is that the thermal neutrons that would have previously entered the IVFS slab and caused high energy neutrons to be born there by fissioning within the fuel are now stopped in the B_4C slab so they can never enter the IVFS slab and cause those fissions. With the B_4C downstream as in Config. IIID, these thermal neutrons enter the IVFS slab and create a new source of high energy neutrons against which the B_4C slab downstream is much less effective. [Thus: an ounce of prevention is worth a pound of cure!]

4.2.2 Bonner Ball Results 150 cm Downstream of the Shielding Configurations

Because they are more affected by background radiation, those measured and calculated values 150 cm downstream of the various shielding configurations will provide a useful but slightly less meaningful indication of how well the transport codes and cross-section data can predict the transport of neutrons through the shielding

configurations of interest. If one examines Tables X.7 and X.8 and considers all of the C/E ratios except those for Config. IIIE which we will discuss separately below, one will see that, of the 84 comparisons made for the 3, 4, 5, 8, 10, and 12-inch Bonner balls:

40% (34 of the 84) lie between 0.95 and 1.05 (more-or-less evenly distributed);

70% (59 of the 84) lie between 0.90 and 1.10 (with 7 between 0.90 and 0.95, and 18 between 1.05 and 1.10); and

96% (81 of the 84) lie between 0.79 and 1.20 (with 11 between 0.79 and 0.90, and 11 between 1.10 and 1.20);

with the other three (all for Config. IIID) being 1.249, 1.281, and 1.390. Although not quite as good as the results at 30 cm, these results are still regarded as quite acceptable. Notably missing from Table X.8 are the results for the 3-D XYZ TORT analysis of Config. IIIA (the heterogeneous IVFS fuel slab) — not because we wanted to exclude those results, but because the 3-D TORT results simply were not available. [As noted in Sect. 3.6, the running time and disk space requirements for the 3-D XYZ TORT model would have made it totally impractical to extend a fine mesh model out to a point 150 cm past the IVFS fuel slab. In addition, an auxiliary code to estimate the scalar flux some distance from the external surface by integrating the angular flux distribution over the surface (as DISKTRAN does for a 2-D RZ DORT model) has not yet been written for the 3-D TORT code.] Most of the other comments in Sect. 4.2.1 apply equally well here and will not be repeated. Two other things could be noted briefly, however:

- 1) Many/most of those cases with low C/E ratios are for cases where the measurements show the background radiation to be high but where the calculational model did not include the extended concrete ring to account for background radiation. The results for the 3-inch Bonner ball in calculational run IIIF.1 are typical of such a case. Here, the geometry model in Fig. G.31 has nothing past the B₄C and aluminum slabs to account for background radiation which, according to the measured values in Tables X.8 account for 17% of the 3-inch Bonner ball response. A more appropriate method of calculating the C/E ratio (which has always been used in the past) for such cases is to compare the calculated responses (for models like Config. IIIF.1, with no extended concrete ring) against the difference between the total measured response and the measured background. In that case, one would have:

$$C/E = 0.05737 / (0.0728 - 0.0122) = 0.05737 / 0.0606 = 0.947 \text{ (rather than 0.788).}$$

Moreover, all of the low C/E ratios below 0.9 in Table X.7 and X.8 are for calculational models like this (i.e., with no concrete ring) and would show similar improvements if the C/E ratios for those cases were computed as shown above.

- 2) The high C/E ratios for Config. IIIE (cf. Table X.8) were excluded from the above survey and are discussed separately below. Of the remaining 84 C/E ratios in the above survey, the 4 highest values (1.205 to 1.390) were all associated with Config. IIID. Even the calculated values without the extended concrete ring to account for background radiation (cf. Config. IIID.1) were generally 5 to 10% higher than the measured foreground values (which include background radiation). While the C/E ratios are not bad, they are marginal. The fact that Configs. IIID and IIIE both had relatively high C/E ratios and both used the B₄C slab might make one suspicious of neutron transmission through the B₄C slab if it were not for the fact that calculations for Config. IIIF (which is neutronicallly almost the same as Config. IIID) gave much better results that were generally within 5 to 10% of the measured results once background radiation was properly accounted for (see note above). Moreover, given that the C/E results for Config. IIID at 30 cm (see Table X.6) were all generally between 0.998 and 1.084 (with one exception of 1.140 for the 3-inch Bonner ball), the slightly higher than normal C/E ratios for Config. IIID at 150 cm remain a relatively unimportant curiosity.

4.2.3 Discussion of Results for Config. IIIE with the B₄C Slab Upstream of the Homogeneous IVFS Fuel Slab

The C/E ratios for the Bonner balls even at 30 cm downstream of the IVFS fuel slab in Config. IIIE are not very good and are all unusually high. Whereas most of the calculated Bonner ball responses for most of the configurations have been within 5 to 10% of the measured values, the C/E ratios for Config. IIIE varied (monotonically) from a low of 1.167 or 1.183 for the 12-inch Bonner ball, to a high of 1.389 or 1.442 for the 3-inch Bonner balls, with most of the C/E ratios at 30 cm being between 1.26 and 1.35. Unfortunately, the root cause for this has not been identified, although many proposed explanations have been investigated and ruled out. For reference, Figs. G.27 and G.28 show the shielding configurations in question (IIIE.1 and IIIE.2) while the following list briefly summarizes some of the

proposed explanations that have been investigated and ruled out:

1. Thermal neutron background radiation causing fission in the IVFS
2. Questions about the IVFS fuel slab:
 - a. Representation of fast neutron streaming through the fission gas plenum in the top of the fuel pins
 - b. Orientation of the IVFS fuel slab
 - c. Resonance self-shielding effects
3. Thermal neutron transmission through the B_4C slab
 - a. Spatial mesh not fine enough
 - b. Single thermal neutron group inadequate
 - c. Inaccurate boron cross-section data
 - d. Inappropriately weighted cross sections in the stainless steel casing
 - e. B^{10} density too low in calculation
 - f. B_4C density too low in calculation
4. Experimental uncertainties
 - a. B_4C did not fill slab; compressed near bottom
 - b. Used different B_4C slab by mistake
 - c. Poorly calibrated measurements that day

Simple analytic methods, 1-D scoping calculations, and a few additional 2-D calculations were used to investigate these proposed explanations in July 1992 and, in Sept 1992, this particular experiment was actually repeated at the TSR — all to no avail. The following paragraphs briefly summarize the findings to date (roughly in the order listed above).

Having the B_4C upstream of the IVFS effectively blocks the thermal neutrons that would otherwise enter the IVFS from the sodium tanks (and subsequently create high energy neutrons via fission). With this source of thermal neutrons effectively blocked, the fission source in the IVFS should now be more dependent on those thermal neutrons that backscatter into the IVFS from surrounding structures like the ground or the concrete pad. Unfortunately, if one examines the results for calculational run IIIE.2 (with the artificial concrete ring) and IIIE.1 (without the concrete ring to simulate background radiation) as shown in Table X.6, there is very little difference. Both sets of results are generally 26 to 35% too high.

The SPERT fuel rods in the IVFS fuel slab each have a 9.476 cm fission gas plenum near the top of the pins, as represented in Table G.28 by materials 50 and 54 extending from $R=52.467$ cm to $R=55.059$ cm in the 2-D RZ model. These densities were checked, however, and found to be reasonable. Also, solid angle calculations from the detector (at 30 cm) back to the IVFS slab show the solid angle of this ring to be only about 4% as large as the solid angle subtended by the bulk of the IVFS slab occupied by the active fuel. Moreover, the results from the 2-D RZ calculations show that the flux in front of this ring corresponding to the fission gas plenum is only about half as large as the flux along the centerline at $R=0$. Thus, there simply is no large amount of local flux peaking in this region, and any significant contribution to the flux at the centerline due to streaming through this narrow solid angular ring would be very negligible.

The one section of the homogeneous IVFS slab contains 230 fuel pins while the other section contains 306 fuel pins. As expected, 1-D calculations first performed with the 230 pin section upstream and then repeated with the 306 pin section upstream yielded Bonner ball responses that were within 1% of each other.

Calculated Bonner ball responses downstream of the IVFS (which are basically 30 to 35% too high) could only be lowered if the fission source density in the IVFS fuel slab is lowered. If the cross sections in the fuel had too much resonance self-shielding due to the infinite homogeneous media model that was used (cf. Sect. 2.2), the U-238 parasitic capture cross section would be too low, more epithermal neutrons would escape capture by the large 6.67 eV U-238 resonance, and more would be available at lower energies to cause more fissions. Conversely, if infinitely dilute cross sections were used, the parasitic capture cross section (especially that at 6.67 eV) would increase, thus reducing the thermal neutron population available to cause fissions. With the infinitely dilute cross sections for the fuel nuclides, the fission density in the IVFS slab in a 1-D model of the entire experiment did go down, but only by 16%, which was far short of the 30 to 35% drop that would be needed to obtain good agreement with the experiments. Moreover, the use of the infinitely dilute cross-section data in place of the properly resonance self-shielded data would be wholly unjustified. [To keep this in perspective: The background cross section (σ_o) used for the Bondarenko resonance self-shielding of the U-238 in this homogenized fuel mixture using the infinite homogeneous media model was 25.1 barns. Depending on the effective escape cross section (σ_{esc}) in the 1-D slab (i.e., whether it is based on the combined thickness of both fuel sections in the IVFS slab or just the thickness of the thinner 230-pin section), the effective background cross section (σ_o), including the escape cross section, would then be between 35 and 45 barns. On the other hand, using the infinitely dilute cross section data would be equivalent to having a background cross section in excess of several hundred thousand barns, which would result in a group 57 U-238 resonance self-shielded capture cross sec-

tion of 174 barns in lieu of the more reasonable 8.5 barns obtained using resonance self-shielding based on the infinite homogeneous media model.]

In the 2-D RZ models of Config. IIIE, 12 axial mesh intervals were used in the B_4C portion of the B_4C slab, as was also the case for Config. IIID and Config. IIIF. Because the IVFS fuel slab is now located downstream of the B_4C , however, the attenuation through the B_4C (and especially the ratio of the slowing-down source to the absorption density in the last fraction of a cm in the B_4C slab) was of much greater importance than in the other cases. To model this potentially important edge effect may require additional mesh intervals. Using 1-D models, it was found that having 4 times as many mesh intervals in the B_4C slab (i.e., 48 instead of 12) would increase (not decrease) the fission density in the IVFS fuel slab by 0.75%.

When spectral effects (such as the ratio of the slowing-down density to the absorption density in the last fraction of a cm in the B_4C slab next to the IVFS slab) are important, the use of a single thermal sink group is often inadequate. One-dimensional shielding calculations were therefore performed using the SCALE 27-group library having 13 thermal groups below 3.05 eV, and with a collapsed version of that library having the same number of fast and epithermal groups above 3.05 eV but only one thermal group below 3.05 eV. The fission density in the IVFS fuel slab was found to change by less than 0.05%.

The VELM cross-section library has two different cross-section datasets for B-11. While both were in the original ORNL VITAMIN-E library from which VELM was derived, the newer dataset normally used in the IVFS analyses [VELM/ANISN nuclide ID 67-72, dated 1984] was originally based on the LENDL cross-section library from Lawrence Livermore, while the other (older) dataset [VELM/ANISN nuclide ID 61-66, dated 1980] was originally based on ENDF/B-V data. Using the older B-11 data in the B_4C slab did lower the calculated response of the 5-inch Bonner ball, but only by 0.66%.

The weighting of the cross-section data for the Fe, Cr, Mn, and Ni isotopes in the stainless steel box containing the B_4C was also questioned. As standard practice, we used the material-dependent stainless-steel-weighted datasets for these nuclides in this particular application (cf. VELM/ANISN nuclide ID's 501 to 524). Datasets using a basic $1/(E\Sigma_t)$ weighting are also available in the VELM library, but were normally considered inappropriate for this application. Nevertheless, calculations performed with these alternate cross-section datasets were found to lower the calculated response of the 5-inch Bonner ball, but only by 1.67%.

The B_4C used in the experiments and the original reference analysis was made of natural boron (19.9 at% B-10, 80.1 at% B-11, as shown in Table M.2, Mixture

38) and was reported to have a density of 1.41 g/cc in B₄C slab number 4W. Just for curiosity, we tried increasing the B-10 density by 10% in the 1-D model used for scoping. Accordingly, the fission density in the IVFS slab was reduced by 9.9%. Since thermal neutrons coming directly from the sodium tanks would have been completely absorbed in either case [because the 5.622-cm-thick region of B₄C was the equivalent of about 40 mean free paths for thermal neutrons], this 9.9% drop confirmed the suspicion that the thermal neutrons entering the IVFS fuel slab were controlled by the relative amount of slowing-down vs absorption (of epithermal and thermal neutrons) in the last cm or so of the B₄C slab. [This is also true of epithermal and thermal neutrons entering the B₄C slab from the IVFS slab and then backscattering again toward the IVFS slab.] Moreover, if there were no thermal neutrons left near that interface (as some people suggested), the change in the B-10 density would have had no effect. It did, however, have a marked effect, as noted above.

While adjusting the boron enrichment was academically interesting, it was also rather unrealistic. Two (more reasonable) academic questions then arose: "Could the reported B₄C density be wrong? What B₄C density would be required to bring the C/E ratios into better agreement?" Using 1-D scoping models, and later the full 2-D RZ model of Config. IIIE, it was found that numerically increasing the density of the granulated B₄C powder by a factor of 1.22 (from 1.41 g/cc to 1.72 g/cc) would bring the calculated results for the 4, 5, 8, and 10-inch balls all to within 3% of the measured values. Could this be the explanation? Perhaps. While granulated B₄C powder was used in the B₄C slab, solid B₄C actually has a density of 2.52 g/cc. Could the granulated B₄C powder with an original density of 1.41 g/cc have "settled" inside the 5-ft x 5-ft stainless steel container over a period of several years and become compressed under its own weight? Interestingly, experience with common table salt shows that a 10-inch-high column, gently poured in a large-diameter 12-inch glass and leveled neatly at the top, will settle by about an inch and a half (to a height of about 8.5 inches) with just a modest amount of shaking, thus increasing the effective density of the salt in the bottom portion of the glass by a factor of 1.18. Could that be what happened to the B₄C slab? Acoustic soundings taken from the outside of B₄C slab number 4W suggested not. Procedures for filling the B₄C slab tank and other QA records also suggest that this was not the case. The volume of the B₄C slab was first measured by filling it with water. QA records then showed that the B₄C slab was carefully weighed before and after it was filled with B₄C. (They also show the before and after weight of the original 100-lb drums from which the extremely fine B₄C powder was taken.) Moreover, during filling, the stainless steel slab container (4W) was placed on a vibration table and shaken periodically as the B₄C powder was added in order to ensure that the powder (which finally had a compressed density of 1.41 g/cc) was as compressed as possible before the container was sealed. In addition, at least one experiment for the Japanese

LMR shielding program took neutron flux measurements at 9 locations in a 3 x 3 array distributed over the downstream surface of the B₄C slab in front of the Tower Shielding Reactor and found no appreciable differences that may have indicated any void near the top due to settling. Finally, in late September 1992, the shielding configuration for Config. IIIE was reconstructed and the experiment repeated with freshly calibrated detectors. These results were all within about 5% of the results originally reported.

Thus, the question "Why are the C/E ratios for this one configuration so high while all the others are so good?" remains unresolved.

4.3 HORIZONTAL TRAVERSES WITH THE 3- AND 10-INCH BONNER BALLS 30 CM DOWNSTREAM OF CONFIGS. IIIA AND IIIB, AS SHOWN IN TABLES X.9 AND X.10

Measured and calculated 3-inch Bonner ball responses along horizontal traverses 30 cm downstream of the heterogeneous and homogeneous IVFS fuel slabs are listed in Table X.9, while those for the 10-inch Bonner ball are listed in Table X.10. Within the first 50 or 60 cm on either side of the centerline, the calculated values are all remarkably good — i.e., almost always within 10% of the measured values, and usually within 5% of the measured values. At locations 60 to 100 cm away from the centerline, the calculated results begin to differ substantially from the measured results (and are anywhere from 15 or 20% high, to 25 or 50% low). To appreciate why this is so, one must carefully examine the results in Tables X.9 and X.10 while simultaneously looking at Figs. G.13, G.15, and G.16 which show the geometric models associated with Configs. IIIA.1, IIIB.1, and IIIB.2. (For convenience, these are duplicated here as Figs. 4.1, 4.2, and 4.3.) From Fig. 4.1 and Table G.13, we see that the heterogeneous IVFS fuel slab in Config. IIIA only extends from X=-46.09 cm to X=+46.09 cm. Likewise, while the homogeneous IVFS fuel slab in Config. IIIB actually extended from X=-48.69 cm to X=+48.69 cm, the cylindrical model of the (97.38 cm x 111.19 cm) fuel slab extended out to R=58.707 cm in the final 2-D RZ calculations. Thus, it should not be surprising that the calculated results for Configs. IIIB.1 and IIIB.2 begin to differ with the measured results somewhere between R=50 and 60 cm. Moreover, while the geometry associated with the spectral modifier, the sodium tanks, and the IVFS slab is clearly documented in ORNL/TM-11989, the exact placement of the lithiated paraffin blocks around the IVFS, and the placement of the concrete blocks around the lithiated paraffin near the end of the shielding configuration, is very nebulous and poorly documented in the experimental report (ORNL/TM-11989). Despite the fact that the analytic models of that adjacent concrete illustrated here were developed with careful attention to the published information available (and refined after numerous

Fig. 4.1. Top view of the calculational model used for Configurations IIIA.1b and IIIA.1d featuring the heterogeneous IVFS fuel slab. Note that Fig. 4.1 is identical to Fig. G.13 at the end of Sect 3, but is duplicated here as a convenience. Axially, the model includes the IVFS fuel slab and the last of six sodium tanks, with a 3-D XYZ boundary source located at what would have been the interface between the fifth and sixth sodium tanks. Vertical XY planes represented by views AA and BB are shown in Figs. G.14a and G.14b, respectively.

Fig. 4.2. Computational model used for Configuration IIB.1 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration by itself). Note that Fig. 4.2 is identical to Fig. G.15 at the end of Sect 3, but is duplicated here as a convenience. Also note that the actual computational model also included everything shown in Fig. G.7b.

Fig. 4.3. Calculational model used for Configuration IIIB.2 (Fe/AL/Boral/2m Na/Homog IVFS slab; basic configuration, with extended concrete ring in analytic model to simulate background radiation). Note that Fig. 4.3 is identical to Fig. G.16 at the end of Sect 3 but is duplicated here as a convenience. Also note that the actual calculational model also included everything shown in Fig. G.7b.

conversations with the experimental staff and several visits to the Tower Shielding Reactor), we now believe, in retrospect, that some small inconsistencies probably still exist which would affect the results at points 80, 90, or 100 cm off the centerline. In the analytic model of Config. IIIA, for example, the 3-inch Bonner ball at R=100 cm (Z=30 cm downstream of the IVFS) would have been almost totally shielded from the IVFS by the concrete less than 6.9 cm away, while the 3-inch Bonner ball at R=90 cm would have been partially shielded by the concrete. The unusually low C/E ratio of 0.546 at this location (cf. Table X.9) would therefore suggest that the concrete may not have extended as far out axially as originally thought when the analytic model shown in Figs. G.13 and 4.1 was originally developed. Moreover, the fact that a 10-inch Bonner ball measurement was actually made at X=80 cm, Z=370.19 cm (i.e., 30 cm downstream of the IVFS) confirms that suspicion since the corner of the concrete at X=86.36 cm, Z=363.3 cm would have been only 9.4 cm away from the center of the 10-inch Bonner ball which, in reality, has a radius of 12.52 cm. Given this modeling inconsistency, the C/E ratios for locations 80, 90, and 100 cm off centerline should be discounted heavily. Having said that, it is remarkable that:

- 1) The calculated 10-inch Bonner ball responses for Config. IIIA have been found to be within 13% of the measured responses over the full range of measurements (i.e., up to and including X=80 cm), and generally within 4 to 9% of the measured values for X up to 50 cm off centerline.
- 2) The calculated 3-inch Bonner ball responses for Config. IIIA have been found to be within 13 to 22% of the measured responses for points up to 70 cm off centerline, and generally within 3 to 8% of the measured values for points up to 50 cm off centerline.

Undoubtedly, this excellent agreement is due in large part to the new, recently adopted, methodology for actually calculating the responses of those Bonner balls located some distance off centerline. (This methodology is described in Sects. 2.5.4 and 2.5.6.)

The C/E ratios for the horizontal traverses in front of Config. IIIB are also good to excellent, but not quite as good due to the fact that the 97.38 cm x 111.19 cm homogeneous IVFS slab was approximated within the context of a 2-D RZ model. In particular, it should be noted that:

- 1) Except for the one physically impossible result at R=100 cm (see above discussion), the calculated 10-inch Bonner ball responses for Config. IIIB have been found to be within 20% of the measured values over the full range of measurements (up to R=80 cm off centerline), and generally within 3 to 10%

of the measured values for points up to 50 cm off centerline (i.e., across the full width of the IVFS slab) even though the measured values dropped by almost a factor of 2 over this range.

- 2) For points up to 40 cm off centerline, the calculated 3-inch Bonner ball responses for Config. IIIB are generally within 6 to 15% of the measured responses. Beyond that point, the C/E ratios generally vary between 1.17 and 1.40. Here, however, it must be remembered that the homogeneous IVFS slab which physically extends from $X=-48.69$ cm to $X=+48.69$ cm had to be modeled as a cylinder of radius $R=58.707$ cm while the actual experiment (like a true XYZ model) would have had the lithiated paraffin starting at $X=48.69$ cm. Thus, the measured epithermal flux (to which the 3-inch Bonner ball is sensitive) would understandably be lower than the calculated values at points more than 50 or 60 cm off centerline. [Interestingly, the calculated values for Config. IIIB.1 vs Config. IIIB.2 at $R=100$ cm demonstrate the sensitivity of the 3-inch Bonner ball to epithermal neutron radiation. At this location, the Bonner ball would be partially/largely shielded from neutrons directly from the IVFS by the lithiated paraffin and the concrete actually used in the experiment. Note, however, that Config. IIIB.2 has the artificial extended concrete ring to simulate thermal and epithermal background radiation while Config. IIIB.1 does not. Accordingly, the C/E ratio for the 3-inch Bonner ball response at this location ($R=100$ cm) in Config. IIIB.2 is 1.209, while for Config. IIIB.1 it is 0.771.]

Making the C/E ratios even more impressive than they might otherwise appear is the fact that the actual 2-D RZ model(s) included everything downstream of the boundary source at $Z=89.89$ cm, i.e. the steel, aluminum, and boral slabs, the 205 cm of sodium in the six sodium tanks, and the homogeneous IVFS fuel slab — not just the truncated portion of the configuration illustrated in Figs. 4.2 and 4.3.

4.4 BARE AND CD-COVERED FISSION CHAMBER RESPONSES AT 0.7, 30, AND 150 CM DOWNSTREAM OF THE SPECTRAL MODIFIERS AND ALL THE LMR SHIELD MOCKUPS, AS SUMMARIZED IN TABLES X.11 AND X.12

4.4.1 Overview of Results

Table X.11 lists the measured and calculated responses for both the bare and Cd-covered fission chambers located along the centerline of the system at 0.7, 30, and 150 cm from the surface of the different spectral modifiers (Config. IA, IB, and IC) and the different LMR shield mockups (Configs. IIIA, IIIB, IIIC, IIID, IIIE,

IIIF). Moreover, it shows the measured and calculated values for the basic configurations as well as for calculational variations in which an artificial concrete ring was incorporated in the model to account for thermal and epithermal background radiation (cf. Sect. 2.6.2). Table X.11 also shows the measured and calculated values obtained at 0.7 cm and 30 cm downstream of the shield but inside the cadmium hut, and the measured and calculated values obtained at 30 and 150 cm downstream of the shield when a cadmium plate was placed over the face of the basic shield configuration(s). Because it gathers so much information together in one place, Table X.11 is extremely valuable and useful. Most of the necessary comments that need to be made relative to each case are made in one or more of the 15 footnotes attached to the bottom of that table, and will not be repeated here. Unfortunately, because of its sheer bulk and size, and the number of necessary footnotes that must be remembered when trying to interpret the data, it is difficult to look at Table X.11 directly and formulate an "overall" judgement of how well the calculations predict the measured results. To facilitate the formation of such judgements, Table X.12 shows the frequency distribution of C/E ratios for all (of the bare and Cd-covered) fission chamber detectors in all of the IVFS shielding experiments based on the multitude of results previously shown in Table X.11. Moreover, these results at 0.7, 30, and 150 cm downstream of the configurations have been arranged in increasing order, with footnotes (b) and (c) used to tag those particular values that should not be included in any overall judgements of quality. In the one case (c), the two corresponding C/E ratios for the bare and Cd-covered detectors have a value of 1.0 because, as noted in Sect. 2.4.2, these measured values were used to calibrate (or normalize) the fission chamber response functions used in determining all of the calculated values for all the other cases. Thus, these two values must be excluded when formulating an overall judgement of quality. In the other tagged cases (b), the bare and Cd-covered fission chamber responses (especially the bare fission chamber responses) were known experimentally to be very dependent on thermal neutron background radiation while the corresponding calculational model had no mechanism to account for this. Such comparisons would also be unfair and should be excluded. Examples of this would include fission chamber measurements made directly downstream of a large B_4C slab or other strong thermal neutron absorber. In such cases, for example, virtually all of the measured thermal neutron flux would be due to background radiation. Calculational models that included the artificial concrete ring to partially account for thermal neutron background radiation may certainly (and fairly) be compared against the measured values, but calculated models that are basically truncated at the surface of the B_4C slab or other strong thermal neutron absorber and have no mechanism to account for thermal neutron background radiation are (by definition) poor models whose C/E ratios in this energy range would represent very unfair comparisons. Thus, these particular configurations flagged by a (b) in Table X.12 must be excluded when forming judgements of the overall quality. [The results of these calculations

were originally included in Table X.11 because they represent the basic (unmodified) experimental configurations and because they, taken together with the other results reported there, do provide valuable insights as to the relative importance of background radiation in the various experiments.] Having noted these necessary exclusions in Table X.12, some useful observations may now be made regarding the ability of the calculations to predict the measured values.

Regarding the 29 applicable C/E ratios at 0.7 cm:

45% (13 of the 29) lie between 0.95 and 1.05 (more-or-less uniformly distributed);

76% (22 of the 29) lie between 0.90 and 1.10 (with 4 between 0.90 and 0.95, and 5 between 1.05 and 1.10); and

93% (27 of the 29) lie between 0.85 and 1.15 (with 4 between 0.85 and 0.90, and 1 between 1.10 and 1.15);

with the other two C/E ratios being 0.809 and 1.335.

Regarding the 41 applicable C/E ratios at 30 cm:

27% (11 of the 41) lie between 0.95 and 1.05 (more-or-less uniformly distributed);

49% (20 of the 41) lie between 0.90 and 1.10 (with 5 between 0.90 and 0.95, and 4 between 1.05 and 1.10); and

85% (35 of the 41) lie between 0.75 and 1.25 (with 7 between 0.75 and 0.90, and 8 between 1.10 and 1.20);

with one additional value at 0.712, and five additional values between 1.26 and 1.38.

Regarding the 31 applicable C/E ratios at 150 cm:

35% (11 of the 31) lie between 0.90 and 1.10 (with a few more on the low side of 1.0);

65% (20 of the 31) lie between 0.80 and 1.20 (with 4 between 0.80 and 0.90, and 5 between 1.10 and 1.20); and

all 31 lie between 0.50 and 1.60 (with 7 between 0.50 and 0.80, and 4 between 1.20 and 1.60).

Obviously, as one gets further downstream of the shield, the methodology used here to account for thermal neutron background radiation becomes more approximate and the relatively good agreement seen at 0.7 cm and at 30 cm begins to deteriorate. Up to 30 cm downstream of the configuration, however, the agreement remains relatively good as long as the calculational model makes some attempt to account for thermal neutron background radiation — i.e., as long as the models include the artificial concrete ring described in Sect. 2.6.2. If this is not done, the calculated model may underestimate the measured values by a factor of 2 at 0.7 cm and by a factor of 3 at 30 cm (as indicated by the very low C/E ratios near the top of Table X.12). Focusing on Table X.11, the following subsections provide a few additional insights.

4.4.2 Comments Regarding Config. IIIA

Calculated results at 150 cm downstream of the configuration are not available because the calculational running time and computer storage requirements associated with the large number of 3-D XYZ mesh intervals that would have been required prevented us from modeling anything more than 31.4 cm downstream of the heterogeneous IVFS fuel slab. Without this, thermal neutron background radiation could not be included in the model, thus bringing into question even the values at 0.7 cm and 30 cm that are shown in Table X.11.

In retrospect, the choice of mesh intervals directly downstream of the IVFS fuel slab may have left something to be desired. Moreover, the first mesh downstream of the IVFS slab was 3.01 cm thick in the axial (Z) direction rather than 1.4 cm thick which may have been more desirable. This meant that the fluxes at 0.7 cm (downstream of the IVFS as shown in Tables R.13 and R.14) had to be interpolated by the TORRE code as described in Sect. 2.5.6. Those values led to the C/E ratios shown in Table X.11 (0.640, 0.751, 0.683, and 0.788). Had one used the multigroup fluxes printed by the TORT code at this point 0.7 cm downstream, the resulting C/E ratios would have been 0.759, 0.874, 0.820, and 0.932, respectively. On the surface, those values appear to be in better agreement with the measured values. That observation, however, might easily lead to a false sense of security for two reasons. First, as noted in the last paragraph of Sect. 2.5.6, the direct TORT values would not have been the values at 0.7 cm downstream, but rather the generic values associated with all points in that first mesh interval downstream of the IVFS (from $Z=340.19$ cm to $Z=343.20$ cm), which would actually be more typical of the flux 1.5 cm downstream of the IVFS. Secondly, there is a modest peak in the thermal flux a few cm downstream of the IVFS along the centerline (as evidenced by the higher measured and calculated fission chamber responses at 30 cm). Directly behind the central fuel column, the thermal flux is depressed because of thermal neutron absorption in the fuel itself. As one backs off a few cm and goes further downstream,

one can begin to "see" thermal neutrons that have streamed through the 6-inch-wide aluminum blocks between the fuel columns. Thus, the interpolated TORRE fluxes and the associated C/E ratios at 0.7 cm, while in poor agreement with the measured values, are believed to be more typical of a finer mesh TORT calculation than the generic values printed directly by the code itself in this case. [Note that this was the only case in which the calculated and measured values differed noticeably. For all points 30 cm downstream of the configuration having a single mesh interval going from 29.5 to 30.5 cm downstream, the TORRE and TORT fluxes always agreed to 5 significant digits when the interpolated point of interest was at or near the center of a TORT mesh interval.] While having additional axial mesh intervals directly in front of the IVFS fuel slab would have allowed us to model these gradients more accurately, they would have driven up the already long (13 day) running time and would probably still have been low relative to the measurements since they would still have not been able to account for background radiation.

4.4.3 Comments Regarding Config. IIID (and Config. IIIF)

The last component in Config. IIID is the B_4C slab (see Fig. G.23 or G.24). Not surprisingly, the bare and Cd-covered fission chamber results for this configuration are extraordinarily sensitive to how one approximates thermal neutron background radiation in the calculational model. In Config. IIID.1 (cf. Fig. G.23) without the artificial concrete ring to simulate background radiation, the calculated responses for the bare fission chamber underestimated the measured value by 20% ($C/E=0.809$) whereas with Config. IIID.2 (cf. Fig. G.24), which had the artificial concrete ring, the calculated response for the bare fission chamber overestimated the measured value by 33% ($C/E=1.335$). Further downstream, the effect becomes even more pronounced. At 30 cm, the one model underestimates by 32% ($C/E=0.677$) while the other overestimates by 38% ($C/E=1.382$). At 150 cm, the one model underestimates by 66% ($C/E=0.338$) while the other model overestimates by 61% ($C/E=1.607$). Moreover, most of the very high C/E ratios flagged by a (d) in Table X.12 are directly attributable to the latter calculational model for Config. IIID. Similar but less pronounced observations may also be made regarding Config. IIIF which also has a B_4C slab as one of the last components in the shield. [In cases such as Config. IC which does not have any strong thermal neutron absorber near the end for the shield configuration, the difference in the calculated bare fission chamber responses using and not using the artificial concrete ring to simulate background radiation is very slight because the amount of thermal neutron background radiation is, in fact, relatively small compared to that transmitted through the shield.] The bottom line here is that "in those cases where thermal neutron background radiation is important relative to that transmitted through the shield, the C/E ratios obtained for the bare fission chamber will depend almost entirely on whatever artificial contrivance the analyst uses in the model to simulate thermal background

radiation, and will have very little to do with how well the transport code(s) or the cross-section data can model the transmission and slowing down of neutrons in the shield." Thus, the lower C/E ratios associated with those other cases where the transmitted component of the thermal flux is not so heavily attenuated should be considered a much more accurate measure of the ability of the shielding codes and cross-section data to predict such phenomena.

4.4.4 Note of Caution When Making Inferences About Background Radiation

Looking at the results for the bare fission chamber downstream of the cadmium plate in Config. IC, for example, relative to the results without the cadmium plate, one may at first be inclined to infer that two-thirds of the response is due to background radiation. Looking at the results for the bare fission chamber inside the cadmium hut, however, someone else might at first be inclined to infer that two-thirds of the response is due to thermal neutron radiation transmitted directly through the shielding configuration. The explanation of this apparent contradiction, of course, lies in the fact that the epithermal neutrons are being counted in both cases, and are not affected substantially by the Cd plate or the Cd hut. If one wishes to make estimates of the importance of background radiation based on measured data only, one should not fall into the above trap, but instead apply the logic outlined in Sect. 2.6.1. Alternately, one can look at calculated results for models like Config. IIID.1 vs Config. IIID.2 (see Figs. G.23 and G.24) to gain a better feel for when thermal neutron background radiation is and is not important.

4.5 HORIZONTAL TRAVERSES WITH THE BARE AND CD-COVERED FISSION CHAMBERS 30 CM DOWNSTREAM OF CONFIGS. IIIA AND IIIB, AS SHOWN IN TABLES X.13 THROUGH X.15

4.5.1 General Observations

Measured and calculated results for the bare and Cd-covered fission chambers along horizontal traverses 30 cm downstream of Configs. IIIA and IIIB are shown in Tables X.13 through X.15. Some general observations based on the C/E ratios over the central region ($|X| \leq 30$ or 40 cm) are as follows:

- 1) The calculated bare fission chamber results in this central region for Config. IIIA are generally 10 to 30% lower than the measured results in Table X.13. This was expected a priori and is largely due to the fact that the geo-

metric models used for Config. IIIA in both calculations had no mechanism to account for thermal neutron background radiation.

- 2) The calculated bare fission chamber results in this central region for Config. IIIB are anywhere from 10 or 12% high (for Config. IIIB.2) to 10 or 12% low (for Config. IIIB.1), depending on whether the artificial concrete ring is or is not included in the model to simulate thermal neutron background radiation.
- 3) The calculated Cd-covered fission chamber responses in this central region for Config. IIIA are generally 8 to 25% lower than the measured values in Table X.14. This was also expected *a priori* and is again due to the fact that the geometric model used for Config. IIIA in both calculations had no mechanism to account for thermal or epithermal background radiation.
- 4) The calculated Cd-covered fission chamber responses in this central region for Config. IIIB are from 6 or 7% high (for Config. IIIB.2) to about 2% low (for Config. IIIB.1), depending on whether the artificial concrete ring is or is not included in the model to simulate background radiation. In either case, these results must be regarded as exceptionally good. [Moreover, these excellent results make one wonder why/how the calculated results for Config. IIIA could be 8 to 25% low.]
- 5) The special effects seen in Tables X.13 and X.14 for Config. IIIB (such as the high C/E ratios around $R=50$ or 60 cm, and the curiously high and low C/E ratios for Configs. IIIB.2 and IIIB.1, respectively, around $R=80$ or 100 cm) will be discussed later.
- 6) The fact that the C/E ratios for the bare fission chamber in Config. IIIA (cf. Table X.13) become lower and lower as one moves outward in either direction from $X=\pm 50$ cm is easily understood in terms of the model. Directly in front of the IVFS (i.e., close to the center of the slab), most of the thermal neutrons come through the slab. As one moves off to either side, this direct contribution to the bare fission chamber response naturally decreases so that, physically, the relative importance of thermal neutron background radiation becomes greater and greater. Since the 3-D XYZ calculational model used here does not have the equivalent of an artificial concrete ring to simulate this background radiation, the calculated bare fission chamber response falls off more rapidly, and the C/E ratios become lower and lower, approaching 0.46 at $X=90$ cm from the centerline. [The good news is that these values far away from the centerline which depend more on background radiation are primarily only of academic interest and are not representative of how well the transport code(s) and cross-section data can represent the transport and slowing down of neutrons in the

shield itself. Moreover, those measured and calculated values at points closer to the centerline which are less dependent on background radiation are better measures of the ability of the transport code(s) and cross-section data to represent the transport and slowing down of neutrons in the shield itself, and the C/E ratios at these more central locations are much better.]

4.5.2 Remarks Concerning Config. IIIA

One of the original reasons for including the heterogeneous IVFS fuel slab shown in Fig. G.13 was to measure any three-dimensional effects that might be present downstream of the IVFS fuel slab. On a superficial level, this may appear to have been a failure, while on a more fundamental level, this has indeed been a success.

If one examines the measured bare fission chamber responses for Config. IIIA shown in Table X.13, one would see that the measured response decreases monotonically from a high of 0.0279 cps (at $X=5$ cm on the south side of the centerline) to 0.00463 cps at 90 cm south of the centerline, and that it also decreases monotonically as one proceeds from $X=5$ cm south to $X=78$ cm north. While the source would appear to be just very slightly off center, the monotonic variation of the bare detector response might be more surprising and could easily be misinterpreted as meaning that there are no significant 3-D effects — especially if one was expecting to see large peaks and depressions in the thermal flux along the horizontal traverse downstream of the IVFS fuel slab. In reality, the thermal flux a centimeter or so downstream of the fuel column is fairly depressed, while definite peaks in the thermal flux do exist a centimeter or so downstream of the 6-inch-wide aluminum blocks between the fuel columns. By the time one moves 30 cm downstream of the IVFS, where these horizontal traverses were made, the highly localized 3-D effects are all but “washed out” and can barely be seen. Phantom evidence that 3-D effects were/are present can be seen by comparing the measured bare fission chamber responses for the heterogeneous IVFS slab in Config. IIIA with those for the homogeneous IVFS slab in Config. IIIB. Notably, while the flux shape is more-or-less monotonically decreasing away from the centerline in both cases, the overall magnitude of the flux at 30 cm in Config. IIIA is about 1.9 to 2.0 times higher than the flux at the corresponding point in Config. IIIB with the homogeneous IVFS fuel slab. This high flux level is due to thermal neutrons that streamed through the aluminum blocks between the fuel columns before then fanning out over the whole area. While some pronounced peaks and valleys in the thermal flux may exist a centimeter or so downstream of the IVFS, faint traces of this can still be seen in the analytical results at 30 cm for calculational run IIIA.1b. There, the bare fission chamber response has a local minimum at $X=0$ where the calculated response was 0.0200 cps. It then rises to a local maxima of 0.0239 at $X=5$ and then decreases to

a local minimum of 0.0192 at $X=15$ cm. After this, it then rises to a smaller peak value of 0.0212 cps at $X=20$ cm before beginning its monotonic decrease at greater distances. Thus, while the larger peaks and valleys one might have expected are all but washed out here at 30 cm downstream of the IVFS, these faint traces are still visible if one looks closely at the flux at individual points in space. Note, however, that the distances between the peaks and valleys are typically just 5 to 10 cm. By way of comparison, the face of the fission chamber detector (i.e., the circular end of the canister facing the shield) is just 3.0 inches ($=7.62$ cm) in diameter, while the fission plate inside the detector is 2.625 inches ($=6.67$ cm) in diameter. Thus, wherever the fission chamber is located along the horizontal traverse, part of its sensitive surface is always close to a small flux peak while part of its sensitive surface is always close to a small flux depression. The net experimentally measured result is the smoothed-out monotonic behavior that one sees for Config. IIIA in Tables X.13 and X.14. The fact that the overall thermal fluxes are 1.9 to 2.0 times higher for Config. IIIA than for Config. IIIB is, in the end, the only demonstrable evidence that 3-D effects were, in fact, present.

4.5.3 Remarks Concerning Config. IIIB

First, the fact that the calculated bare and Cd-covered responses which had been within 2 to 12% of the measured values across the first 30 or 40 cm of the IVFS slab suddenly increase to the point where they are 10 to 60% above the measured values at $R=50$ to 60 cm off centerline certainly deserves some explanation. In reality, the explanation first given in Sect. 4.3 still applies and is quite simple. Physically, the homogeneous IVFS fuel slab measures 97.38 cm horizontally (in the X direction) and 111.19 cm vertically (in the Y direction), and extends from $X=-48.69$ cm to $X=+48.69$ cm. By the time the detectors used in the experiment are 50 or 60 cm to either side of the centerline, they are really located in front of (i.e., downstream of) the lithiated paraffin blocks surrounding the IVFS fuel slab. The measured bare and Cd-covered fission chamber responses are therefore quite depressed. By way of contrast, consider the 2-D RZ calculational model. There, the 97.38 cm x 111.19 cm IVFS fuel slab had to be modeled as a cylinder whose outer radius extended out to $R=58.707$ cm. A point 50 or 60 cm off centerline in the 2-D RZ calculational model, therefore, is still in front of (or very close to) the fissionable material in the IVFS fuel slab, whereas the corresponding points 50 or 60 cm off centerline in the real experiment were located in front of (i.e., downstream of) the lithiated paraffin where the thermal flux was very depressed, thus causing the C/E ratios in this localized region to become unusually large. Moreover, it is this necessary limitation in the 2-D RZ model (rather than any inherent defect in the DORT code or the VELM cross-section data) that is responsible for these high C/E ratios in this one localized area.

Secondly, the fact that the C/E ratio for the bare fission chamber in Config. IIIB.2 rises to 1.843 at $R=100$ cm off centerline while that for Config. IIIB.1 drops to 0.645 at this same location certainly deserves some explanation. Moreover, that seemingly divergent behavior can also be understood quite easily once one reviews the actual calculational models illustrated in Figs. G.16 and G.15, respectively. In the real (physical) experiment, the contribution to the detector response due to direct transmission through the shield decreases as one moves further and further away from the centerline so that the relative contribution due to thermal and epithermal background radiation becomes more important. Since Config. IIIB.1 (cf. Fig. G.15) does not have the artificial concrete ring to simulate background radiation, the calculated value decreases faster than the measured value, and the C/E ratio goes down as one moves further out from the centerline (i.e., past $Z=80, 90$, or 100 cm). Config. IIIB.2 (shown in Fig. G.16) on the other hand, does have the extended concrete ring which was designed to simulate the effect of background radiation along the centerline, close to the surface of the shield. Moreover, it performs that function quite nicely. Unfortunately, as one moves further out radially (see Fig. G.16), the reflected thermal and epithermal flux due to this artificial concrete ring will get larger and larger as one gets closer and closer to the artificial concrete ring. As a result, the C/E ratio for the bare and Cd-covered fission chamber in Config. IIIB.2 will naturally increase at locations far from the centerline which are close to this artificial ring (which starts at $R=135.4$ cm). Thus, the seemingly divergent results associated with Config. IIIB.1 and Config. IIIB.2 are wholly consistent with the two respective geometric models. All that can be said about the results at 80 to 100 cm away from the centerline is that the two models bracket reality, but that neither one accurately represents the effect of background radiation very well in this particular region. Moreover, as previously pointed out, the important thing is how well the calculated values predict the measured values closer to the centerline where the effect of thermal and epithermal background radiation is much less important or can be modeled more correctly. There, the calculated bare fission chamber responses are generally within 12% on either side of the measured responses for Config. IIIB, while the calculated responses for the Cd-covered fission chamber are generally within 6 to 7% of the measured responses for Config. IIIB.

Table X.1. Comparison of the measured and calculated neutron flux spectrum in the fast and intermediate energy ranges, 25 cm downstream of the Pb slabs in Config 1A. C/E ratios are shown for the flux in each energy group as well as for the integral of the flux over all higher energies. Fluxes are in units of (n/s/cm²/watt).

GRP NO.	Energy Range (eV)		Measured Fluxes		Calculated Fluxes (1A/PB.1)				Calculated Fluxes (1A/PB.15)			
	E _{min}	E _{max}	by grp	E>E _{min}	by grp	C/E	E>E _{min}	C/E	by grp	C/E	E>E _{min}	C/E
1	1.221e+7	1.492e+7	4.020e-1	4.020e-1	2.155e-1	0.536	2.155e-1	0.536	2.155e-1	0.536	2.155e-1	0.536
2	1.000e+7	1.221e+7	1.470e+0	1.872e+0	9.893e-1	0.673	1.205e+0	0.644	9.893e-1	0.673	1.205e+0	0.644
3	8.187e+6	1.000e+7	3.991e+0	5.862e+0	3.302e+0	0.828	4.507e+0	0.769	3.302e+0	0.828	4.507e+0	0.769
4	6.703e+6	8.187e+6	8.718e+0	1.458e+1	7.738e+0	0.888	1.225e+1	0.840	7.738e+0	0.888	1.224e+1	0.840
5	5.488e+6	6.703e+6	1.601e+1	3.059e+1	1.447e+1	0.904	2.671e+1	0.873	1.446e+1	0.903	2.671e+1	0.873
6	4.493e+6	5.488e+6	2.642e+1	5.701e+1	2.140e+1	0.810	4.811e+1	0.844	2.142e+1	0.811	4.813e+1	0.844
7	3.679e+6	4.493e+6	3.877e+1	9.578e+1	2.665e+1	0.687	7.475e+1	0.780	2.672e+1	0.689	7.486e+1	0.782
8	3.012e+6	3.679e+6	5.713e+1	1.529e+2	4.130e+1	0.723	1.161e+2	0.759	4.148e+1	0.726	1.163e+2	0.761
9	2.466e+6	3.012e+6	8.847e+1	2.414e+2	6.857e+1	0.775	1.846e+2	0.765	6.922e+1	0.782	1.856e+2	0.769
10	2.346e+6	2.466e+6	2.903e+1	2.704e+2	2.821e+1	0.972	2.128e+2	0.787	2.841e+1	0.979	2.140e+2	0.791
11	2.231e+6	2.346e+6	3.256e+1	3.030e+2	2.859e+1	0.878	2.414e+2	0.797	2.880e+1	0.884	2.428e+2	0.801
12	2.019e+6	2.231e+6	7.643e+1	3.794e+2	6.071e+1	0.794	3.021e+2	0.796	6.114e+1	0.800	3.039e+2	0.801
13	1.653e+6	2.019e+6	1.952e+2	5.746e+2	1.605e+2	0.822	4.627e+2	0.805	1.618e+2	0.829	4.657e+2	0.810
14	1.353e+6	1.653e+6	2.437e+2	8.183e+2	1.955e+2	0.802	6.581e+2	0.804	1.976e+2	0.811	6.633e+2	0.811
15	1.108e+6	1.353e+6	3.057e+2	1.124e+3	2.176e+2	0.712	8.758e+2	0.779	2.204e+2	0.721	8.837e+2	0.786
16	9.072e+5	1.108e+6	3.740e+2	1.498e+3	3.623e+2	0.969	1.238e+3	0.826	3.653e+2	0.977	1.249e+3	0.834
17	7.427e+5	9.072e+5	3.469e+2	1.845e+3	2.819e+2	0.813	1.520e+3	0.824	2.920e+2	0.842	1.541e+3	0.835
18	6.081e+5	7.427e+5	4.116e+2	2.256e+3	4.085e+2	0.993	1.928e+3	0.855	4.149e+2	1.008	1.956e+3	0.867
19	5.234e+5	6.081e+5	3.461e+2	2.603e+3	2.576e+2	0.744	2.186e+3	0.840	2.629e+2	0.760	2.219e+3	0.853
20	4.979e+5	5.234e+5	1.143e+2	2.717e+3	1.417e+2	1.240	2.328e+3	0.857	1.434e+2	1.255	2.362e+3	0.870
21	3.877e+5	4.979e+5	5.333e+2	3.250e+3	4.297e+2	0.806	2.757e+3	0.848	4.360e+2	0.818	2.798e+3	0.861
22	3.020e+5	3.877e+5	5.249e+2	3.775e+3	4.511e+2	0.859	3.208e+3	0.850	4.638e+2	0.884	3.262e+3	0.864
23	2.985e+5	3.020e+5	2.543e+1	3.800e+3	1.937e+1	0.762	3.228e+3	0.849	2.001e+1	0.787	3.282e+3	0.864
24	2.972e+5	2.985e+5	9.437e+0	3.810e+3	7.156e+0	0.758	3.235e+3	0.849	7.394e+0	0.783	3.289e+3	0.863
25	2.945e+5	2.972e+5	2.000e+1	3.830e+3	1.471e+1	0.736	3.250e+3	0.849	1.519e+1	0.760	3.305e+3	0.863
26	2.732e+5	2.945e+5	1.638e+2	3.994e+3	1.151e+2	0.703	3.365e+3	0.843	1.190e+2	0.726	3.424e+3	0.857
27	2.237e+5	2.732e+5	4.039e+2	4.397e+3	3.455e+2	0.856	3.710e+3	0.844	3.560e+2	0.881	3.780e+3	0.860
28	1.832e+5	2.237e+5	2.966e+2	4.694e+3	3.092e+2	1.042	4.020e+3	0.856	3.192e+2	1.076	4.099e+3	0.873
29	1.500e+5	1.832e+5	2.473e+2	4.941e+3	1.681e+2	0.680	4.188e+3	0.847	1.774e+2	0.717	4.276e+3	0.865
30	1.228e+5	1.500e+5	2.768e+2	5.218e+3	3.077e+2	1.112	4.495e+3	0.861	3.166e+2	1.144	4.593e+3	0.880
31	8.652e+4	1.228e+5	3.645e+2	5.583e+3	2.140e+2	0.587	4.709e+3	0.844	2.271e+2	0.623	4.820e+3	0.863
32	5.656e+4	8.652e+4	5.174e+2	6.100e+3	5.009e+2	0.968	5.210e+3	0.854	5.155e+2	0.996	5.336e+3	0.875
33	5.248e+4	5.656e+4	7.541e+1	6.176e+3	9.118e+1	1.209	5.301e+3	0.858	9.380e+1	1.244	5.429e+3	0.879

Measured values for E > 0.811 MeV are based on NE213 measurements reported in Table 14 of ORNL/TM-11989, while measured values for E < 1.4 MeV are based on hydrogen counter measurements reported in Table 15 of that report.

Table X.2. Comparison of the measured and calculated neutron flux spectrum in the fast and intermediate energy ranges, 179.1 cm downstream of the radial blanket assemblies in Config IB. C/E ratios are shown for the flux in each energy group as well as for the integral of the flux over all higher energies. Fluxes are in units of (n/s/cm²/watt).

GRP NO.	Energy Range (eV)		Measured Fluxes		Calculated Fluxes (IB.1)				Calculated Fluxes (IB.2)			
	E _{min}	E _{max}	by grp	E>E _{min}	by grp	C/E	E>E _{min}	C/E	by grp	C/E	E>E _{min}	C/E
1	1.221e+7	1.492e+7	1.153e-2	1.153e-2	9.197e-3	0.797	9.197e-3	0.797	9.214e-3	0.799	9.214e-3	0.799
2	1.000e+7	1.221e+7	4.646e-2	5.800e-2	3.894e-2	0.838	4.814e-2	0.830	3.908e-2	0.841	4.830e-2	0.833
3	8.187e+6	1.000e+7	1.410e-1	1.990e-1	1.293e-1	0.917	1.774e-1	0.892	1.300e-1	0.922	1.783e-1	0.896
4	6.703e+6	8.187e+6	3.136e-1	5.126e-1	3.149e-1	1.004	4.924e-1	0.961	3.172e-1	1.011	4.955e-1	0.967
5	5.488e+6	6.703e+6	5.917e-1	1.104e+0	6.324e-1	1.069	1.125e+0	1.019	6.388e-1	1.080	1.134e+0	1.027
6	4.493e+6	5.488e+6	8.962e-1	2.000e+0	9.963e-1	1.112	2.121e+0	1.060	1.010e+0	1.127	2.144e+0	1.072
7	3.679e+6	4.493e+6	1.118e+0	3.119e+0	1.032e+0	0.923	3.154e+0	1.011	1.054e+0	0.942	3.198e+0	1.025
8	3.012e+6	3.679e+6	1.356e+0	4.475e+0	1.418e+0	1.046	4.572e+0	1.022	1.453e+0	1.071	4.651e+0	1.039
9	2.466e+6	3.012e+6	2.271e+0	6.746e+0	2.450e+0	1.079	7.022e+0	1.041	2.515e+0	1.107	7.166e+0	1.062
10	2.346e+6	2.466e+6	6.993e-1	7.446e+0	1.038e+0	1.484	8.060e+0	1.082	1.059e+0	1.515	8.225e+0	1.105
11	2.231e+6	2.346e+6	7.365e-1	8.182e+0	9.424e-1	1.279	9.002e+0	1.100	9.661e-1	1.312	9.191e+0	1.123
12	2.019e+6	2.231e+6	1.530e+0	9.712e+0	1.366e+0	0.893	1.037e+1	1.068	1.408e+0	0.920	1.060e+1	1.091
13	1.653e+6	2.019e+6	3.048e+0	1.276e+1	2.981e+0	0.978	1.335e+1	1.046	3.082e+0	1.011	1.368e+1	1.072
14	1.353e+6	1.653e+6	3.289e+0	1.605e+1	3.249e+0	0.988	1.660e+1	1.034	3.377e+0	1.027	1.706e+1	1.063
15	1.108e+6	1.353e+6	3.387e+0	1.944e+1	3.511e+0	1.037	2.011e+1	1.035	3.663e+0	1.082	2.072e+1	1.066
16	9.072e+5	1.108e+6	3.528e+0	2.296e+1	2.629e+0	0.745	2.274e+1	0.990	2.753e+0	0.780	2.347e+1	1.022
17	7.427e+5	9.072e+5	4.959e+0	2.792e+1	6.030e+0	1.216	2.877e+1	1.030	6.283e+0	1.267	2.976e+1	1.066
18	6.081e+5	7.427e+5	8.599e+0	3.652e+1	9.273e+0	1.078	3.804e+1	1.042	9.624e+0	1.119	3.938e+1	1.078
19	5.234e+5	6.081e+5	7.123e+0	4.364e+1	7.874e+0	1.105	4.592e+1	1.052	8.242e+0	1.157	4.762e+1	1.091
20	4.979e+5	5.234e+5	2.033e+0	4.568e+1	2.673e+0	1.315	4.859e+1	1.064	2.791e+0	1.373	5.041e+1	1.104
21	3.877e+5	4.979e+5	8.699e+0	5.438e+1	5.514e+0	0.634	5.410e+1	0.995	5.952e+0	0.684	5.637e+1	1.037
22	3.020e+5	3.877e+5	1.167e+1	6.605e+1	1.015e+1	0.870	6.426e+1	0.973	1.084e+1	0.929	6.720e+1	1.018
23	2.985e+5	3.020e+5	6.464e-1	6.669e+1	4.695e-1	0.726	6.472e+1	0.970	5.061e-1	0.783	6.771e+1	1.015
24	2.972e+5	2.985e+5	2.419e-1	6.694e+1	1.914e-1	0.791	6.492e+1	0.970	2.048e-1	0.847	6.792e+1	1.015
25	2.945e+5	2.972e+5	5.147e-1	6.745e+1	4.288e-1	0.833	6.534e+1	0.969	4.561e-1	0.886	6.837e+1	1.014
26	2.732e+5	2.945e+5	4.186e+0	7.164e+1	3.481e+0	0.832	6.883e+1	0.961	3.719e+0	0.888	7.209e+1	1.006
27	2.237e+5	2.732e+5	1.051e+1	8.215e+1	9.795e+0	0.932	7.862e+1	0.957	1.049e+1	0.998	8.258e+1	1.005
28	1.832e+5	2.237e+5	1.098e+1	9.312e+1	9.864e+0	0.899	8.849e+1	0.950	1.058e+1	0.964	9.316e+1	1.000
29	1.500e+5	1.832e+5	1.145e+1	1.046e+2	9.121e+0	0.797	9.761e+1	0.933	9.848e+0	0.860	1.030e+2	0.985
30	1.228e+5	1.500e+5	1.277e+1	1.173e+2	1.122e+1	0.878	1.088e+2	0.927	1.199e+1	0.939	1.150e+2	0.980
31	8.652e+4	1.228e+5	1.864e+1	1.360e+2	1.396e+1	0.749	1.228e+2	0.903	1.519e+1	0.815	1.302e+2	0.957
32	5.656e+4	8.652e+4	2.385e+1	1.598e+2	2.424e+1	1.016	1.470e+2	0.920	2.584e+1	1.083	1.560e+2	0.976
33	5.248e+4	5.656e+4	3.532e+0	1.634e+2	2.878e+0	0.815	1.499e+2	0.918	3.164e+0	0.896	1.592e+2	0.974

Measured values for E > 0.811 MeV are based on NE213 measurements reported in Table 21 of ORNL/TM-11989, while measured values for E < 1.4 MeV are based on hydrogen counter measurements reported in Table 22 of that report.

Table X.3. Comparison of the measured and calculated neutron flux spectrum in the fast and intermediate energy ranges, 25 cm downstream of the Pb slabs in Config 1C. C/E ratios are shown for the flux in each energy group as well as for the integral of the flux over all higher energies. Fluxes are in units of (n/s/cm²/watt).

GRP NO.	Energy Range (eV)		Measured Fluxes		Calculated Fluxes (IC/PB.1)				Calculated Fluxes (IC/PB.9)			
	E _{min}	E _{max}	by grp	E>E _{min}	by grp	C/E	E>E _{min}	C/E	by grp	C/E	E>E _{min}	C/E
1	1.221e+7	1.492e+7	9.173e-5	9.173e-5	5.624e-5	0.613	5.624e-5	0.613	5.624e-5	0.613	5.624e-5	0.613
2	1.000e+7	1.221e+7	3.803e-4	4.720e-4	2.055e-4	0.540	2.617e-4	0.555	2.055e-4	0.540	2.617e-4	0.555
3	8.187e+6	1.000e+7	9.215e-4	1.393e-3	6.747e-4	0.732	9.364e-4	0.672	6.747e-4	0.732	9.364e-4	0.672
4	6.703e+6	8.187e+6	1.413e-3	2.806e-3	1.315e-3	0.931	2.252e-3	0.802	1.315e-3	0.931	2.252e-3	0.802
5	5.488e+6	6.703e+6	1.932e-3	4.738e-3	2.080e-3	1.077	4.332e-3	0.914	2.080e-3	1.077	4.332e-3	0.914
6	4.493e+6	5.488e+6	3.212e-3	7.950e-3	3.070e-3	0.956	7.402e-3	0.931	3.072e-3	0.956	7.404e-3	0.931
7	3.679e+6	4.493e+6	4.304e-3	1.225e-2	3.456e-3	0.803	1.086e-2	0.886	3.460e-3	0.804	1.086e-2	0.887
8	3.012e+6	3.679e+6	6.114e-3	1.837e-2	5.169e-3	0.845	1.603e-2	0.873	5.181e-3	0.847	1.604e-2	0.873
9	2.466e+6	3.012e+6	8.128e-3	2.650e-2	7.512e-3	0.924	2.354e-2	0.888	7.555e-3	0.930	2.360e-2	0.891
10	2.346e+6	2.466e+6	2.416e-3	2.891e-2	2.209e-3	0.914	2.575e-2	0.891	2.225e-3	0.921	2.582e-2	0.893
11	2.231e+6	2.346e+6	2.642e-3	3.155e-2	2.547e-3	0.964	2.829e-2	0.897	2.563e-3	0.970	2.839e-2	0.900
12	2.019e+6	2.231e+6	6.219e-3	3.777e-2	4.878e-3	0.784	3.317e-2	0.878	4.912e-3	0.790	3.330e-2	0.882
13	1.653e+6	2.019e+6	1.675e-2	5.453e-2	2.148e-2	1.282	5.466e-2	1.002	2.157e-2	1.287	5.487e-2	1.006
14	1.353e+6	1.653e+6	2.192e-2	7.644e-2	3.373e-2	1.539	8.838e-2	1.156	3.389e-2	1.546	8.875e-2	1.161
15	1.108e+6	1.353e+6	2.299e-2	9.944e-2	3.439e-2	1.496	1.228e-1	1.235	3.465e-2	1.507	1.234e-1	1.241
16	9.072e+5	1.108e+6	2.133e-2	1.208e-1	3.270e-2	1.533	1.555e-1	1.287	3.300e-2	1.547	1.564e-1	1.295
17	7.427e+5	9.072e+5	1.771e-2	1.385e-1	3.035e-2	1.714	1.858e-1	1.342	3.096e-2	1.748	1.874e-1	1.353
18	6.081e+5	7.427e+5	2.002e-2	1.585e-1	2.573e-2	1.285	2.116e-1	1.335	2.616e-2	1.307	2.135e-1	1.347
19	5.234e+5	6.081e+5	2.565e-2	1.841e-1	2.827e-2	1.102	2.398e-1	1.302	2.864e-2	1.117	2.422e-1	1.315
20	4.979e+5	5.234e+5	1.042e-2	1.946e-1	3.088e-2	2.962	2.707e-1	1.391	3.102e-2	2.976	2.732e-1	1.404
21	3.877e+5	4.979e+5	5.370e-2	2.483e-1	8.210e-2	1.529	3.528e-1	1.421	8.260e-2	1.538	3.558e-1	1.433
22	3.020e+5	3.877e+5	7.019e-2	3.185e-1	9.038e-2	1.288	4.432e-1	1.392	9.148e-2	1.303	4.473e-1	1.404
23	2.985e+5	3.020e+5	4.277e-3	3.227e-1	3.553e-3	0.831	4.467e-1	1.384	3.611e-3	0.844	4.509e-1	1.397
24	2.972e+5	2.985e+5	1.615e-3	3.244e-1	1.714e-3	1.061	4.485e-1	1.383	1.736e-3	1.075	4.526e-1	1.395
25	2.945e+5	2.972e+5	3.472e-3	3.278e-1	6.790e-3	1.955	4.552e-1	1.389	6.837e-3	1.969	4.594e-1	1.402
26	2.732e+5	2.945e+5	2.829e-2	3.561e-1	4.688e-2	1.657	5.021e-1	1.410	4.728e-2	1.671	5.067e-1	1.423
27	2.237e+5	2.732e+5	6.969e-2	4.258e-1	9.500e-2	1.363	5.971e-1	1.402	9.619e-2	1.380	6.029e-1	1.416
28	1.832e+5	2.237e+5	6.224e-2	4.881e-1	8.057e-2	1.294	6.777e-1	1.389	8.179e-2	1.314	6.847e-1	1.403
29	1.500e+5	1.832e+5	7.205e-2	5.601e-1	9.153e-2	1.270	7.692e-1	1.373	9.272e-2	1.287	7.774e-1	1.388
30	1.228e+5	1.500e+5	8.279e-2	6.429e-1	1.213e-1	1.466	8.906e-1	1.385	1.227e-1	1.482	9.001e-1	1.400
31	8.652e+4	1.228e+5	1.578e-1	8.007e-1	1.968e-1	1.247	1.087e+0	1.358	1.991e-1	1.262	1.099e+0	1.373
32	5.656e+4	8.652e+4	2.292e-1	1.030e+0	2.983e-1	1.301	1.386e+0	1.345	3.013e-1	1.315	1.401e+0	1.360
33	5.248e+4	5.656e+4	3.710e-2	1.067e+0	3.950e-2	1.065	1.425e+0	1.336	4.003e-2	1.079	1.441e+0	1.350

Measured values for E > 0.811 MeV are based on NE213 measurements reported in Table 23 of ORNL/TM-11989, while measured values for E < 1.4 MeV are based on hydrogen counter measurements reported in Table 24 of that report.

Table X.4. Measured and calculated Bonner ball responses [(counts/sec)/watt] on centerline at NE 213 location

Config(a)	Detector Location	3-inch BB		5-inch BB		10-inch BB	
		Foregnd(c)	Backgnd(d)	Foregnd(c)	Backgnd(d)	Foregnd(c)	Backgnd(d)
IA.exp	25 cm behind lead(b)	1.66E+03		9.72E+03		4.99E+03	
IA.run-15a (C/E):	(e)	1.641E+03 0.989		9.376E+03 0.965		4.583E+03 0.918	
IA.run-1a (C/E):	(f)	1.488E+03 0.896		8.995E+03 0.925		4.488E+03 0.899	
<hr/>							
IB.exp	179.1 cm behind mockup	9.18E+01	1.62E+01	4.11E+02	4.09E+01	1.47E+02	9.53E+00
IB.run-2c (C/E):	(e)	9.127E+01 0.994		3.889E+02 0.946		1.368E+02 0.931	
IB.run-1a (C/E):	(f)	7.414E+01 0.808		3.478E+02 0.846		1.280E+02 0.871	
	(g)	0.981		0.940		0.931	
<hr/>							
IC.exp	25 cm behind lead(b)	2.10E+01		3.32E+01		4.82E+00	
IC.run-9a (C/E):	(e)	2.160E+01 1.029		3.269E+01 0.985		4.739E+00 0.983	
IC.run-1a (C/E):	(f)	2.128E+01 1.013		3.232E+01 0.973		4.690E+00 0.973	

- (a) Experimentally measured data taken from Table 16 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
- (b) Lead slab between configuration and detector (see schematics).
- (c) Count rate without shadow shield between detector and configuration.
- (d) Count rate with shadow shield between detector and configuration.
- (e) With extended concrete ring in calculation to simulate background radiation.
- (f) Without extended concrete ring in calculation to simulate background radiation.
- (g) Recommended C/E ratio for this Config = Calculated/(Foreground-Background); see Sect 4.1.

Table X.5. Measured and calculated Bonner ball responses [(counts/sec)/watt] on the centerline, at 30 cm behind the spectrum modifiers

Config	Note	3-inch BB	4-inch BB	5-inch BB	8-inch BB	10-inch BB	12-inch BB
IA.exp	(a)	2.65E+03	9.98E+03	1.59E+04	1.41E+04	7.79E+03	4.19E+03
IA.run-14c (C/E):	(b)	2.561E+03 0.966	9.691E+03 0.971	1.493E+04 0.939	1.306E+04 0.926	7.652E+03 0.982	4.057E+03 0.968
IA.run-2a (C/E):	(c)	2.395E+03 0.904	9.304E+03 0.932	1.445E+04 0.909	1.280E+04 0.908	7.534E+03 0.967	4.008E+03 0.957

IB.exp	(a)	6.78E+02	2.40E+03	3.44E+03	2.36E+03	1.25E+03	5.70E+02
IB.run-2c (C/E):	(b)	6.856E+02 1.011	2.230E+03 0.929	3.107E+03 0.903	2.158E+03 0.914	1.101E+03 0.881	5.202E+02 0.913
IB.run-1a (C/E):	(c)	6.456E+02 0.952	2.148E+03 0.895	3.015E+03 0.876	2.114E+03 0.896	1.082E+03 0.866	5.126E+02 0.899

IC.exp	(a)	3.31E+01	5.65E+01	5.46E+01	2.04E+01	8.07E+00	3.23E+00
IC.run-6a (C/E):	(b)	3.576E+01 1.080	5.723E+01 1.013	5.621E+01 1.029	2.094E+01 1.026	8.293E+00 1.028	3.176E+00 0.983
IC.run-2a (C/E):	(c)	3.549E+01 1.072	5.688E+01 1.007	5.589E+01 1.024	2.083E+01 1.021	8.252E+00 1.023	3.160E+00 0.978

- (a) Experimentally measured data taken from Table 17 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
(b) With extended concrete ring in calculation to simulate background radiation.
(c) Without extended concrete ring in calculation to simulate background radiation.

Table X.6. Measured and calculated Bonner ball responses [(counts/sec)/watt]
on centerline, at 30 cm behind the LMR shield mockups

Config	Note	3-inch BB	4-inch BB	5-inch BB	8-inch BB	10-inch BB	12-inch BB
IIIA.exp	(a)	8.86E+00	1.89E+01	2.28E+01	1.52E+01	8.71E+00	4.78E+00
IIIA.run-1b (C/E):	(b,e)	8.365E+00 .944	1.761E+01 .932	2.177E+01 .955	1.470E+01 .967	8.324E+00 .956	4.486E+00 .938
IIIA.run-1d (C/E):	(c,e)	8.478E+00 .957	1.782E+01 .943	2.191E+01 .961	1.460E+01 .961	8.264E+00 .949	4.464E+00 .934

IIIB.exp	(a)	5.72E+00	1.44E+01	1.96E+01	1.59E+01	9.83E+00	5.54E+00
IIIB.run-2a (C/E):	(d)	6.479E+00 1.133	1.557E+01 1.081	2.095E+01 1.069	1.698E+01 1.068	1.036E+01 1.054	5.843E+00 1.055
IIIB.run-1d (C/E):	(e)	6.303E+00 1.102	1.521E+01 1.056	2.052E+01 1.047	1.673E+01 1.052	1.023E+01 1.041	5.784E+00 1.044

IIIC.exp	(a)	7.12E+00	1.40E+01	1.60E+01	9.81E+00	5.54E+00	2.96E+00
IIIC.run-2b (C/E):	(d)	8.312E+00 1.167	1.554E+01 1.110	1.785E+01 1.116	1.067E+01 1.088	5.784E+00 1.044	3.030E+00 1.024
IIIC.run-1a (C/E):	(e)	8.108E+00 1.139	1.519E+01 1.085	1.748E+01 1.092	1.049E+01 1.069	5.703E+00 1.029	2.993E+00 1.011

IIID.exp	(a)	8.18E-01	3.80E+00	6.43E+00	6.58E+00	4.29E+00	2.50E+00
IIID.run-2a (C/E):	(d)	9.327E-01 1.140	4.121E+00 1.084	6.863E+00 1.067	6.938E+00 1.054	4.407E+00 1.027	2.518E+00 1.007
IIID.run-1a (C/E):	(e)	8.755E-01 1.070	3.985E+00 1.049	6.692E+00 1.041	6.836E+00 1.039	4.358E+00 1.016	2.496E+00 .998

IIIE.exp	(a)	1.28E-01	3.94E-01	5.34E-01	3.59E-01	1.88E-01	9.94E-02
IIIE.run-2a (C/E):	(d)	1.846E-01 1.442	5.332E-01 1.353	7.084E-01 1.327	4.684E-01 1.305	2.411E-01 1.282	1.176E-01 1.183
IIIE.run-1a (C/E):	(e)	1.778E-01 1.389	5.197E-01 1.319	6.931E-01 1.298	4.608E-01 1.284	2.376E-01 1.264	1.160E-01 1.167

IIIF.exp	(a)	3.46E-01	1.53E+00	2.59E+00	2.52E+00	1.55E+00	8.87E-01
IIIF.run-2a (C/E):	(d)	3.583E-01 1.036	1.552E+00 1.014	2.557E+00 .987	2.508E+00 .995	1.550E+00 1.000	8.596E-01 .969
IIIF.run-1c (C/E):	(e)	3.243E-01 .937	1.472E+00 .962	2.456E+00 .948	2.449E+00 .972	1.522E+00 .982	8.473E-01 .955

- (a) Experimentally measured data taken from Table 49 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
 (b) 3-D TORT analysis performed using the (faster) theta-weighted difference technique.
 (c) 3-D TORT analysis performed using the (slower, but hopefully more accurate) nodal method.
 (d) With extended concrete ring in calculation to simulate background radiation.
 (e) Without extended concrete ring in calculation to simulate background radiation.

Table X.7. Measured and calculated Bonner ball responses [(counts/sec)/watt] on centerline, at 150 cm behind the spectrum modifiers

Config	Note	3-inch BB		4-inch BB		5-inch BB		8-inch BB		10-inch BB		12-inch BB	
		Foregnd(b)	Backgnd(c)	Foregnd	Backgnd	Foregnd	Backgnd	Foregnd	Backgnd	Foregnd	Backgnd	Foregnd	Backgnd
IA.exp	(a)	4.90E+02	7.88E+01	1.71E+03	1.81E+02	2.58E+03	2.18E+02	2.15E+03	1.25E+02	1.22E+03	6.47E+01	6.79E+02	3.00E+01
IA.run-14c (C/E):	(d)	5.178E+02 1.057		1.771E+03 1.036		2.636E+03 1.022		2.203E+03 1.025		1.268E+03 1.039		6.639E+02 0.978	
IA.run-2a (C/E):	(e)	3.927E+02 0.801		1.476E+03 0.863		2.270E+03 0.880		1.985E+03 0.923		1.164E+03 0.954		6.194E+02 0.912	

IB.exp		1.22E+02	1.91E+01	3.99E+02	4.13E+01	5.64E+02	4.64E+01	3.81E+02	2.13E+01	1.98E+02	1.01E+01	9.39E+01	4.50E+00
IB.run-2c (C/E):	(d)	1.318E+02 1.080		3.957E+02 0.992		5.403E+02 0.958		3.701E+02 0.971		1.884E+02 0.952		8.857E+01 0.943	
IB.run-1a (C/E):	(e)	1.020E+02 0.836		3.316E+02 0.831		4.655E+02 0.825		3.323E+02 0.872		1.724E+02 0.871		8.231E+01 0.877	

IC.exp		7.18E+00	7.16E-01	1.20E+01	1.09E+00	1.14E+01	1.02E+00	4.34E+00	3.52E-01	1.70E+00	1.42E-01	6.55E-01	5.66E-02
IC.run-6a (C/E):	(d)	8.011E+00 1.116		1.252E+01 1.043		1.222E+01 1.072		4.491E+00 1.035		1.765E+00 1.038		6.722E-01 1.026	
IC.run-2a (C/E):	(e)	7.471E+00 1.041		1.176E+01 0.980		1.151E+01 1.010		4.259E+00 0.981		1.680E+00 0.988		6.426E-01 0.981	

- (a) Experimentally measured data taken from Table 18 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
 (b) Count rate without shadow shield between detector and configuration.
 (c) Count rate with shadow shield between detector and configuration.
 (d) With extended concrete ring in calculation to simulate background radiation.
 (e) Without extended concrete ring in calculation to simulate background radiation.

Table X.8. Measured and calculated Bonner ball responses [(counts/sec)/watt] on the centerline, at 150 cm behind the LMR shield mockups

Config	Note	3-inch BB		4-inch BB		5-inch BB		8-inch BB		10-inch BB		12-inch BB	
		Foregnd(c)	Backgnd(d)	Foregnd	Backgnd	Foregnd	Backgnd	Foregnd	Backgnd	Foregnd	Backgnd	Foregnd	Backgnd
IIIA.exp	(a,b)	1.47E+00	9.68E-02	3.01E+00	1.79E-01	3.44E+00	1.97E-01	2.16E+00	1.06E-01	1.19E+00	5.61E-02	6.24E-01	2.93E-02
IIIB.exp	(b)	9.91E-01	5.59E-02	2.23E+00	1.11E-01	2.87E+00	1.34E-01	2.20E+00	7.49E-01	1.32E+00	4.38E-02	7.30E-01	2.40E-02
IIIB.run-2a (C/E):	(e)	1.088E+00 1.098		2.575E+00 1.155		3.417E+00 1.191		2.621E+00 1.191		1.537E+00 1.164		8.345E-01 1.143	
IIIB.run-1d (C/E):	(f)	9.462E-01 0.955		2.288E+00 1.026		3.075E+00 1.071		2.423E+00 1.101		1.440E+00 1.091		7.895E-01 1.082	
IIIC.exp	(b)	1.43E+00	1.04E-01	2.74E+00	1.81E-01	2.98E+00	1.90E-01	1.73E+00	9.09E-02	9.44E-01	4.43E-02	4.89E-01	2.23E-02
IIIC.run-2b (C/E):	(e)	1.576E+00 1.102		2.887E+00 1.054		3.274E+00 1.099		1.857E+00 1.073		9.702E-01 1.028		4.919E-01 1.006	
IIIC.run-1a (C/E):	(f)	1.400E+00 0.979		2.586E+00 0.944		2.949E+00 0.990		1.697E+00 0.981		8.954E-01 0.949		4.584E-01 0.937	
IIID.exp	(b)	1.25E-01	1.49E-02	5.58E-01	3.38E-02	9.36E-01	4.36E-02	9.56E-01	2.98E-02	6.13E-01	1.74E-02	3.61E-01	9.53E-03
IIID.run-2a (C/E):	(e)	1.737E-01 1.390		7.148E-01 1.281		1.169E+00 1.249		1.152E+00 1.205		7.230E-01 1.179		4.078E-01 1.130	
IIID.run-1a (C/E):	(f)	1.321E-01 1.057		6.093E-01 1.092		1.030E+00 1.100		1.058E+00 1.107		6.745E-01 1.100		3.855E-01 1.068	
IIIE.exp	(b)	2.41E-02	2.94E-03	6.89E-02	5.99E-03	8.72E-02	6.67E-03	5.73E-02	3.20E-03	3.03E-02	1.57E-03	1.57E-02	7.64E-04
IIIE.run-2a (C/E):	(e)	3.019E-02 1.253		8.857E-02 1.285		1.176E-01 1.349		7.583E-02 1.323		3.844E-02 1.269		1.864E-02 1.187	
IIIE.run-1a (C/E):	(f)	2.463E-02 1.022		7.719E-02 1.120		1.046E-01 1.200		6.927E-02 1.209		3.557E-02 1.174		1.746E-02 1.112	
IIIF.exp	(b)	7.28E-02	1.22E-02	2.94E-01	3.04E-02	4.69E-01	3.79E-02	4.58E-01	2.49E-02	2.82E-01	1.50E-02	1.60E-01	7.84E-03
IIIF.run-2a (C/E):	(e)	8.052E-02 1.106		3.103E-01 1.055		4.978E-01 1.061		4.804E-01 1.049		2.986E-01 1.059		1.663E-01 1.039	
IIIF.run-1c (C/E):	(f)	5.737E-02 0.788		2.533E-01 0.862		4.241E-01 0.904		4.319E-01 0.943		2.743E-01 0.973		1.554E-01 0.971	

(a) Because of running time considerations, the 3-D TORT model only went 30 cm past the IVFS slab. Thus, calculated results at 150 cm are unavailable.

(b) Experimentally measured data taken from Table 50 of ORNL/TM-11989. That document is also the primary reference regarding the exp shielding configs.

(c) Count rate without shadow shield between detector and configuration.

(d) Count rate with shadow shield between detector and configuration.

(e) With extended concrete ring in calculation to simulate background radiation.

(f) Without extended concrete ring in calculation to simulate background radiation.

Table X.9. Measured and calculated 3-inch Bonner ball responses [(counts/sec)/watt]
along horizontal traverses at 30 cm behind the LMR shield mockups

Dist from centerline (cm)	IIIA.exp	IIIA.run-1b(b,d)		IIIA.run-1d(c,d)		IIIB.exp	IIIB.run-2a (e)		IIIB.run-1d (f)	
	(a)	Response	C/E	Response	C/E	(a)	Response	C/E	Response	C/E
100 S		2.538E-1	---	2.137E-1	---	6.11E-1	7.390E-1	1.209	4.710E-1	0.771
90	8.79E-1	4.798E-1	0.546	4.657E-1	0.530		9.378E-1	---	7.001E-1	---
80		9.638E-1	---	9.429E-1	---	1.11E+0	1.334E+0	1.202	1.113E+0	1.003
70	1.71E+0	1.330E+0	0.778	1.343E+0	0.785		2.045E+0	---	1.837E+0	---
60		1.997E+0	---	1.977E+0	---	2.39E+0	3.194E+0	1.336	2.991E+0	1.251
50	4.23E+0	4.096E+0	0.968	4.430E+0	1.047	3.57E+0	4.394E+0	1.231	4.198E+0	1.176
40	5.83E+0	5.402E+0	0.927	5.532E+0	0.949	4.36E+0	4.902E+0	1.124	4.715E+0	1.081
30	7.14E+0	6.495E+0	0.910	6.571E+0	0.920	4.92E+0	5.487E+0	1.115	5.309E+0	1.079
20	8.19E+0	7.823E+0	0.955	7.850E+0	0.958	5.46E+0	5.953E+0	1.090	5.774E+0	1.058
15	8.55E+0	7.966E+0	0.932	8.251E+0	0.965		6.143E+0	---	5.963E+0	---
10	8.77E+0	8.893E+0	1.014	8.673E+0	0.989	5.74E+0	6.280E+0	1.094	6.102E+0	1.063
5	8.86E+0	8.871E+0	1.001	8.993E+0	1.015		6.408E+0	---	6.231E+0	---
0	8.84E+0	8.365E+0	0.946	8.478E+0	0.959	5.80E+0	6.479E+0	1.117	6.303E+0	1.087
5	8.84E+0	8.871E+0	1.004	8.993E+0	1.017		6.408E+0	---	6.231E+0	---
10	8.67E+0	8.893E+0	1.026	8.673E+0	1.000	5.68E+0	6.280E+0	1.106	6.102E+0	1.074
15	8.38E+0	7.966E+0	0.951	8.251E+0	0.985		6.143E+0	---	5.963E+0	---
20	7.95E+0	7.823E+0	0.984	7.850E+0	0.987	5.36E+0	5.953E+0	1.111	5.774E+0	1.077
30	6.77E+0	6.495E+0	0.959	6.571E+0	0.971	4.88E+0	5.487E+0	1.124	5.309E+0	1.088
40	5.52E+0	5.402E+0	0.979	5.532E+0	1.002	4.26E+0	4.902E+0	1.151	4.715E+0	1.107
50	3.90E+0	4.096E+0	1.050	4.430E+0	1.136	3.43E+0	4.394E+0	1.281	4.198E+0	1.224
60		1.997E+0	---	1.977E+0	---	2.28E+0	3.194E+0	1.401	2.991E+0	1.312
70	1.54E+0	1.330E+0	0.864	1.343E+0	0.872	1.54E+0	2.045E+0	1.328	1.837E+0	1.193
88 N	8.65E-1	5.537E-1	0.640	5.472E-1	0.633		9.932E-1	---	7.592E-1	---

- (a) Experimentally measured data taken from Table 51 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
 (b) 3-D XYZ TORT analysis performed using the (faster) theta-weighted difference technique.
 (c) 3-D XYZ TORT analysis performed using the (slower, but hopefully more accurate) nodal method.
 (d) 3-D XYZ TORT analysis, without extended concrete ring in calculation to simulate background radiation.
 (e) 2-D RZ DORT analysis, with extended concrete ring in calculation to simulate background radiation.
 (f) 2-D RZ DORT analysis, without extended concrete ring in calculation to simulate background radiation.

Table X.10. Measured and calculated 10-inch Bonner ball responses [(counts/sec)/watt]
along horizontal traverses at 30 cm behind the LMR shield mockups

Dist from centerline (cm)	IIIA.exp	IIIA.run-1b(b,d)		IIIA.run-1d(c,d)		IIIB.exp	IIIB.run-2a (e)		IIIB.run-1d (f)	
	(a)	Response	C/E	Response	C/E	(a)	Response	C/E	Response	C/E
100 S		4.615E-1	---	4.443E-1	---	1.82E+0	9.890E-1	0.543	8.328E-1	0.458
80		1.216E+0	---	1.171E+0	---	1.79E+0	2.023E+0	1.130	1.877E+0	1.049
79.5	1.36E+0	1.235E+0	0.908	1.194E+0	0.878		2.061E+0	---	1.916E+0	---
70	1.95E+0	1.722E+0	0.883	1.716E+0	0.880		3.056E+0	---	2.914E+0	---
60		2.725E+0	---	2.764E+0	---	3.96E+0	4.379E+0	1.106	4.241E+0	1.071
50	4.21E+0	3.952E+0	0.939	3.965E+0	0.942	5.52E+0	5.841E+0	1.058	5.704E+0	1.033
40	5.55E+0	5.378E+0	0.969	5.379E+0	0.969	6.99E+0	7.253E+0	1.038	7.117E+0	1.018
30	6.87E+0	6.562E+0	0.955	6.521E+0	0.949	8.24E+0	8.496E+0	1.031	8.362E+0	1.015
20	7.89E+0	7.525E+0	0.954	7.493E+0	0.950	9.22E+0	9.461E+0	1.026	9.331E+0	1.012
15	8.31E+0	7.888E+0	0.949	7.865E+0	0.946		9.828E+0	---	9.701E+0	---
10	8.53E+0	8.163E+0	0.957	8.128E+0	0.953	9.81E+0	1.011E+1	1.031	9.985E+0	1.018
5	8.78E+0	8.297E+0	0.945	8.260E+0	0.941		1.029E+1	---	1.017E+1	---
0	8.72E+0	8.324E+0	0.955	8.264E+0	0.948	9.93E+0	1.036E+1	1.043	1.023E+1	1.030
5	8.76E+0	8.297E+0	0.947	8.260E+0	0.943		1.029E+1	---	1.017E+1	---
10	8.59E+0	8.163E+0	0.950	8.128E+0	0.946	9.67E+0	1.011E+1	1.046	9.985E+0	1.033
15	8.35E+0	7.888E+0	0.945	7.865E+0	0.942		9.828E+0	---	9.701E+0	---
20	7.93E+0	7.525E+0	0.949	7.493E+0	0.945	9.03E+0	9.461E+0	1.048	9.331E+0	1.033
30	6.97E+0	6.562E+0	0.941	6.521E+0	0.936	8.00E+0	8.496E+0	1.062	8.362E+0	1.045
40	5.74E+0	5.378E+0	0.937	5.379E+0	0.937	6.65E+0	7.253E+0	1.091	7.117E+0	1.070
50	4.30E+0	3.952E+0	0.919	3.965E+0	0.922	5.18E+0	5.841E+0	1.128	5.704E+0	1.101
60		2.725E+0	---	2.764E+0	---	3.71E+0	4.379E+0	1.180	4.241E+0	1.143
70	1.97E+0	1.722E+0	0.874	1.716E+0	0.871	2.55E+0	3.056E+0	1.198	2.914E+0	1.143
80 N	1.33E+0	1.216E+0	0.914	1.171E+0	0.880		2.023E+0	---	1.877E+0	---

- (a) Experimentally measured data taken from Table 52 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
 (b) 3-D XYZ TORT analysis performed using the (faster) theta-weighted difference technique.
 (c) 3-D XYZ TORT analysis performed using the (slower, but hopefully more accurate) nodal method.
 (d) 3-D XYZ TORT analysis, without extended concrete ring in calculation to simulate background radiation.
 (e) 2-D RZ DORT analysis, with extended concrete ring in calculation to simulate background radiation.
 (f) 2-D RZ DORT analysis, without extended concrete ring in calculation to simulate background radiation.

Table X.11. Measured and calculated fission chamber responses [(counts/sec)/watt] for the bare and Cd-covered fission chambers located along the centerline of the system, at 0.7, 30, and 150 cm from the surface of the different spectral modifiers and IVFS shield mockups.

Config	Notes	0.7 cm from face of shield			30 cm from face of shield				150 cm from face of shield		
		FC(bare)	FC(Cd-cov)	FC(bare) in large Cd hut	FC(bare)	FC(Cd-cov)	FC(bare) in large Cd hut	FC(bare) with Cd plate over face of mockup	FC(bare)	FC(Cd-cov)	FC(bare) with Cd plate over face of mockup
IA.exp	(a,m)	-----	-----	-----	3.35E+00	2.37E+00	-----	-----	1.36E+00	5.13E-01	-----
IA.run-14c	(c)	-----	-----	-----	3.329E+00	1.836E+00	-----	-----	1.326E+00	4.922E-01	-----
(C/E):		-----	-----	-----	0.994	0.775	-----	-----	0.975	0.959	-----
IA.exp	(a,m)	-----	-----	-----	3.35E+00	2.37E+00	-----	-----	1.36E+00	5.13E-01	-----
IA.run-2a	(d)	-----	-----	-----	1.513E+00	1.503E+00	-----	-----	2.934E-01	2.737E-01	-----
(C/E):		-----	-----	-----	0.452	0.634	-----	-----	0.216	0.534	-----
IA.exp	(a,n)	-----	-----	-----	-----	-----	-----	-----	1.00E+00	1.59E-01	-----
IA.run-xx	(o)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
(C/E):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
IB.exp	(a,m)	-----	-----	-----	7.39E-01	5.43E-01	-----	-----	2.79E-01	1.14E-01	-----
IB.run-2c	(c)	-----	-----	-----	8.783E-01	4.928E-01	-----	-----	3.684E-01	1.312E-01	-----
(C/E):		-----	-----	-----	1.188	0.908	-----	-----	1.320	1.151	-----
IB.exp	(a,m)	-----	-----	-----	7.39E-01	5.43E-01	-----	-----	2.79E-01	1.14E-01	-----
IB.run-1a	(d)	-----	-----	-----	4.675E-01	4.070E-01	-----	-----	1.038E-01	7.515E-02	-----
(C/E):		-----	-----	-----	0.633	0.750	-----	-----	0.372	0.659	-----
IB.exp	(a,n)	-----	-----	-----	-----	-----	-----	-----	1.98E-01	3.17E-02	-----
IB.run-xx	(o)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
(C/E):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
IC.exp	(a,m)	2.06E-01	1.23E-01	-----	1.42E-01	7.43E-02	-----	-----	3.95E-02	1.69E-02	-----
IC.run-6a	(b,c)	2.060E-01	1.230E-01	-----	1.352E-01	7.234E-02	-----	-----	4.266E-02	1.704E-02	-----
(C/E):		1.000	1.000	-----	0.952	0.974	-----	-----	1.080	1.008	-----
IC.exp	(a,m)	2.06E-01	1.23E-01	-----	1.42E-01	7.43E-02	-----	-----	3.95E-02	1.69E-02	-----
IC.run-2a	(d)	1.909E-01	1.204E-01	-----	1.250E-01	7.103E-02	-----	-----	3.301E-02	1.533E-02	-----
(C/E):		0.927	0.979	-----	0.880	0.956	-----	-----	0.836	0.907	-----
IC.exp	(a,e)	-----	-----	1.76E-01	-----	-----	1.17E-01	-----	-----	-----	-----
IC.run-7a	(c,e)	-----	-----	1.677E-01	-----	-----	1.081E-01	-----	-----	-----	-----
(C/E):	Cd hut	-----	-----	0.953	-----	-----	0.924	-----	-----	-----	-----
IC.exp	(a,f,m)	-----	-----	-----	-----	-----	-----	9.05E-02	-----	-----	2.51E-02
IC.run-8a	(c,f)	-----	-----	-----	-----	-----	-----	8.155E-02	-----	-----	2.595E-02
(C/E):	Cd plate	-----	-----	-----	-----	-----	-----	0.901	-----	-----	1.034

Table X.11 (cont)

Config	Notes	0.7 cm from face of shield			30 cm from face of shield				150 cm from face of shield		
		FC(bare)	FC(Cd-cov)	FC(bare) in large Cd hut	FC(bare)	FC(Cd-cov)	FC(bare) in large Cd hut	FC(bare) with Cd plate over face of mockup	FC(bare)	FC(Cd-cov)	FC(bare) with Cd plate over face of mockup
IIIA.exp	(a)	1.50E-02	1.10E-02	-----	2.81E-02	1.69E-02	-----	-----	6.53E-03	3.06E-03	-----
IIIA.run-1b	(g,i,k)	9.604E-03	8.256E-03	-----	2.000E-02	1.321E-02	-----	-----	-----	-----	-----
(C/E):		0.640	0.751	-----	0.712	0.782	-----	-----	-----	-----	-----
IIIA.exp	(a)	1.50E-02	1.10E-02	-----	2.81E-02	1.69E-02	-----	-----	6.53E-03	3.06E-03	-----
IIIA.run-1d	(h,i,k)	1.024E-02	8.671E-03	-----	1.982E-02	1.285E-02	-----	-----	-----	-----	-----
(C/E):		0.683	0.788	-----	0.705	0.760	-----	-----	-----	-----	-----
IIIA.exp	(a,e)	-----	-----	1.38E-02	-----	-----	2.59E-02	-----	-----	-----	-----
IIIA.run-xx	(j,e)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
(C/E):	Cd hut	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
IIIA.exp	(a,f)	-----	-----	-----	-----	-----	-----	1.81E-02	-----	-----	4.18E-03
IIIA.run-xx	(j,f)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
(C/E):	Cd plate	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
IIIB.exp	(a)	1.71E-02	1.42E-02	-----	1.39E-02	8.92E-03	-----	-----	3.79E-03	1.75E-03	-----
IIIB.run-2a	(c)	1.819E-02	1.458E-02	-----	1.759E-02	9.555E-03	-----	-----	3.379E-03	1.718E-03	-----
(C/E):		1.064	1.027	-----	1.265	1.071	-----	-----	0.892	0.982	-----
IIIB.exp	(a)	1.71E-02	1.42E-02	-----	1.39E-02	8.92E-03	-----	-----	3.79E-03	1.75E-03	-----
IIIB.run-1d	(d)	1.584E-02	1.409E-02	-----	1.505E-02	9.097E-03	-----	-----	1.664E-03	1.392E-03	-----
(C/E):		0.926	0.992	-----	1.083	1.020	-----	-----	0.439	0.795	-----
IIIB.exp	(a,e)	-----	-----	1.69E-02	-----	-----	1.30E-02	-----	-----	-----	-----
IIIB.run-3a	(c,e)	-----	-----	1.511E-02	-----	-----	1.440E-02	-----	-----	-----	-----
(C/E):	Cd hut	-----	-----	0.894	-----	-----	1.108	-----	-----	-----	-----
IIIB.exp	(a,f)	-----	-----	-----	-----	-----	-----	9.78E-03	-----	-----	2.57E-03
IIIB.run-4a	(c,f)	-----	-----	-----	-----	-----	-----	1.144E-02	-----	-----	3.044E-03
(C/E):	Cd plate	-----	-----	-----	-----	-----	-----	1.170	-----	-----	1.184

Table X.11 (cont)

Config	Notes	0.7 cm from face of shield			30 cm from face of shield				150 cm from face of shield		
		FC(bare)	FC(Cd-cov)	FC(bare) in large Cd hut	FC(bare)	FC(Cd-cov)	FC(bare) in large Cd hut	FC(bare) with Cd plate over face of mockup	FC(bare)	FC(Cd-cov)	FC(bare) with Cd plate over face of mockup
IIIC.exp	(a)	3.24E-02	2.21E-02	-----	2.21E-02	1.44E-02	-----	-----	5.53E-03	2.99E-03	-----
IIIC.run-2b	(c)	3.548E-02	2.329E-02	-----	2.592E-02	1.538E-02	-----	-----	6.669E-03	2.950E-03	-----
(C/E):		1.095	1.054	-----	1.173	1.068	-----	-----	1.206	0.987	-----
IIIC.exp	(a)	3.24E-02	2.21E-02	-----	2.21E-02	1.44E-02	-----	-----	5.53E-03	2.99E-03	-----
IIIC.run-1a	(d)	3.163E-02	2.256E-02	-----	2.192E-02	1.472E-02	-----	-----	4.011E-03	2.463E-03	-----
(C/E):		0.976	1.021	-----	0.992	1.022	-----	-----	0.725	0.824	-----
IIIC.exp	(a,e)	-----	-----	3.01E-02	-----	-----	1.95E-02	-----	-----	-----	-----
IIIC.run-3a	(c,e)	-----	-----	2.763E-02	-----	-----	1.813E-02	-----	-----	-----	-----
(C/E):	Cd hut	-----	-----	0.918	-----	-----	0.930	-----	-----	-----	-----
IIIC.exp	(a,f)	-----	-----	-----	-----	-----	-----	1.60E-02	-----	-----	4.16E-03
IIIC.run-4a	(c,f)	-----	-----	-----	-----	-----	-----	1.765E-02	-----	-----	4.627E-03
(C/E):	Cd plate	-----	-----	-----	-----	-----	-----	1.103	-----	-----	1.112
IIID.exp	(a)	1.23E-03	1.08E-03	-----	7.80E-04	5.98E-04	-----	-----	2.73E-04	1.08E-04	-----
IIID.run-2a	(c)	1.642E-03	1.137E-03	-----	1.078E-03	6.210E-04	-----	-----	4.388E-04	1.548E-04	-----
(C/E):		1.335	1.053	-----	1.382	1.038	-----	-----	1.607	1.433	-----
IIID.exp	(a)	1.23E-03	1.08E-03	-----	7.80E-04	5.98E-04	-----	-----	2.73E-04	1.08E-04	-----
IIID.run-1a	(d)	9.954E-04	9.938E-04	-----	5.277E-04	5.075E-04	-----	-----	9.235E-05	8.255E-05	-----
(C/E):		0.809	0.920	-----	0.677	0.849	-----	-----	0.338	0.764	-----
IIID.exp	(a,e)	-----	-----	1.15E-03	-----	-----	6.08E-04	-----	-----	-----	-----
IIID.run-3a	(c,e)	-----	-----	1.102E-03	-----	-----	5.882E-04	-----	-----	-----	-----
(C/E):	Cd hut	-----	-----	0.958	-----	-----	0.967	-----	-----	-----	-----
IIID.exp	(a,f)	-----	-----	-----	-----	-----	-----	7.35E-04	-----	-----	2.61E-04
IIID.run-4a	(c,f)	-----	-----	-----	-----	-----	-----	1.016E-03	-----	-----	4.199E-04
(C/E):	Cd plate	-----	-----	-----	-----	-----	-----	1.382	-----	-----	1.609

Table X.11 (cont)

Config	Notes	0.7 cm from face of shield			30 cm from face of shield				150 cm from face of shield		
		FC(bare)	FC(Cd-cov)	FC(bare) in large Cd hut	FC(bare)	FC(Cd-cov)	FC(bare) in large Cd hut	FC(bare) with Cd plate over face of mockup	FC(bare)	FC(Cd-cov)	FC(bare) with Cd plate over face of mockup
IIIE.exp	(a)	2.45E-04	1.63E-04	-----	2.67E-04	1.19E-04	-----	-----	1.40E-04	2.82E-05	-----
IIIE.run-2a	(c)	2.592E-04	1.879E-04	-----	3.152E-04	1.583E-04	-----	-----	7.004E-05	2.624E-05	-----
(C/E):		1.058	1.153	-----	1.181	1.330	-----	-----	0.500	0.930	-----
IIIE.exp	(a)	2.45E-04	1.63E-04	-----	2.67E-04	1.19E-04	-----	-----	1.40E-04	2.82E-05	-----
IIIE.run-1a	(d)	1.691E-04	1.672E-04	-----	2.392E-04	1.427E-04	-----	-----	1.818E-05	1.545E-05	-----
(C/E):		0.690	1.026	-----	0.896	1.199	-----	-----	0.130	0.548	-----
IIIE.exp	(a,e)	-----	-----	1.83E-04	-----	-----	1.92E-04	-----	-----	-----	-----
IIIE.run-4a	(c,e)	-----	-----	1.838E-04	-----	-----	2.439E-04	-----	-----	-----	-----
(C/E):	Cd hut	-----	-----	1.004	-----	-----	1.270	-----	-----	-----	-----
IIIE.exp	(a,f)	-----	-----	-----	-----	-----	-----	1.83E-04	-----	-----	1.16E-04
IIIE.run-5a	(c,f)	-----	-----	-----	-----	-----	-----	2.059E-04	-----	-----	6.811E-05
(C/E):	Cd plate	-----	-----	-----	-----	-----	-----	1.125	-----	-----	0.587
IIIF.exp	(a)	7.44E-04	4.34E-04	-----	5.61E-04	2.66E-04	-----	-----	3.05E-04	7.21E-05	-----
IIIF.run-2a	(c)	7.518E-04	4.354E-04	-----	5.679E-04	2.568E-04	-----	-----	2.826E-04	8.672E-05	-----
(C/E):		1.010	1.003	-----	1.012	0.965	-----	-----	0.927	1.203	-----
IIIF.exp	(a)	7.44E-04	4.34E-04	-----	5.61E-04	2.66E-04	-----	-----	3.05E-04	7.21E-05	-----
IIIF.run-1c	(d)	3.519E-04	3.513E-04	-----	1.995E-04	1.873E-04	-----	-----	6.875E-05	4.367E-05	-----
(C/E):		0.473	0.809	-----	0.356	0.704	-----	-----	0.225	0.606	-----
IIIF.exp	(a,e)	-----	-----	4.75E-04	-----	-----	3.08E-04	-----	-----	-----	-----
IIIF.run-3a	(c,e)	-----	-----	4.128E-04	-----	-----	2.336E-04	-----	-----	-----	-----
(C/E):	Cd hut	-----	-----	0.869	-----	-----	0.758	-----	-----	-----	-----
IIIF.exp	(a,f)	-----	-----	-----	-----	-----	-----	4.49E-04	-----	-----	2.67E-04
IIIF.run-4a	(c,f)	-----	-----	-----	-----	-----	-----	5.210E-04	-----	-----	2.536E-04
(C/E):	Cd plate	-----	-----	-----	-----	-----	-----	1.160	-----	-----	0.950
IIIF.exp	(a)	3.68E-02	2.25E-02	-----	-----	-----	-----	-----	-----	-----	-----
IIIF.run-2a	(c,l)	3.188E-02	2.361E-02	-----	-----	-----	-----	-----	-----	-----	-----
(C/E):	by IVFS	0.866	1.049	-----	-----	-----	-----	-----	-----	-----	-----
IIIF.exp	(a)	3.68E-02	2.25E-02	-----	-----	-----	-----	-----	-----	-----	-----
IIIF.run-1c	(d,l)	3.187E-02	2.361E-02	-----	-----	-----	-----	-----	-----	-----	-----
(C/E):	by IVFS	0.866	1.049	-----	-----	-----	-----	-----	-----	-----	-----

Table X.11 (cont)

Notes:

- (a) Basic configuration. Experimentally measured results reported here were taken from Tables 19, 20, 25, 48, 56, and 57 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
- (b) This particular calculation was used to normalize the spectral response of the bare and Cd-covered fission chambers.
- (c) This 2-D RZ DORT analysis was performed with an extended concrete ring in calculation to artificially simulate background radiation.
- (d) This 2-D RZ DORT analysis was performed without an extended concrete ring in calculation to artificially simulate background radiation. Because background radiation is significant relative to the direct radiation in many cases, and because much of this is comprised of thermal neutrons to which the fission chambers (especially the bare fission chambers) are extremely sensitive, calculations which do not have this concrete ring to simulate background and which do not employ the cadmium hut to shield out background radiation can be expected to give fairly poor results for the bare fission chamber responses.
- (e) Variation of the basic configuration, where the bare fission chamber was located inside a large 5 ft x 5 ft cadmium hut whose one large open side faced the experimental mockup. Hopefully, with this, the bare fission chamber would see only thermal neutrons coming directly through the shield configuration.
- (f) Variation of the basic configuration, in which a Cd sheet was placed over the face of the mockup so that the bare fission chamber would see primarily background thermal neutron radiation.
- (g) This 3-D XYZ TORT analysis performed using the (faster) theta-weighted difference technique.
- (h) This 3-D XYZ TORT analysis performed using the (slower, but hopefully more accurate) nodal method. This was run primarily to verify that the mesh used in the other TORT calculation was sufficiently fine.
- (i) Because of running time considerations, the 3-D TORT model only went 30 cm past the IVFS slab. Thus, calculated results at 150 cm are unavailable.
- (j) Because of running time considerations, calculational variations of the 3-D TORT model including the cadmium hut and/or the Cd plate over the face of the shield configuration were not investigated. (Note that the two TORT cases that were analyzed took 2.5 cpu weeks each on an IBM RS/6000, Model 530.)
- (k) 3-D XYZ TORT analysis performed without extended concrete ring (or open ended concrete box) in calculation to simulate background radiation. Without this, unfortunately, one can generally expect to underpredict the response of the bare fission chamber.
- (l) These particular results (both calculated and measured) correspond to a point 0.7 cm downstream of the IVFS slab itself. Note that for Config IIIF, there is a stainless steel slab, a B4C slab, and an aluminum slab even further downstream.
- (m) These measurements at 150 cm are denoted in Table 20 of ORNL/TM-11989 as foreground measurements, with nothing between the surface of the shield configuration and the detector.
- (n) These measurements at 150 cm behind the respective spectral modifiers are denoted in Table 20 of ORNL/TM-11989 as "background" measurements. They were made by placing with a thick lithiated paraffin "shadow shield" somewhere between the detector and the spectral modifier so that the detector's direct line-of-sight view of the spectral modifier slabs would be obstructed while the detector's view of everything else (the surrounding lithiated paraffin blocks and the concrete) would not be obstructed. These measured results are provided here for information only.
- (o) Due to the relatively ill-defined description of the shadow shield used in these background measurements (see note n, above), detailed calculational analyses corresponding to these two configurations were not performed.

Table X.12. Frequency distribution of C/E ratios for all (bare and Cd-covered) fission detectors in all of the IVFS shielding experiments shown in Table X.11a.

Results at 0.7 cm:	Results at 30 cm:	Results at 150 cm:
0.473 (b)	0.356 (b)	0.130 (b)
0.640 (b,a)	0.452 (b)	0.216 (b)
0.683 (b,a)	0.633 (b)	0.225 (b)
0.690 (b)	0.634 (b)	0.338 (b)
0.751 (b,a)	0.677 (b)	0.372 (b)
0.788 (b,a)	0.704 (b)	0.439 (b)
0.809 (b)	0.705 (b)	0.500
0.809	0.712	0.534
-----	-----	0.548
0.866	0.750	0.587
0.866	0.758	0.606
0.869	0.760	0.659
0.894	0.775	0.725 (b)
-----	0.782	0.764
0.918	0.849	-----
0.920	0.880	0.795
0.926	-----	0.824
0.927	0.896	0.836
-----	0.901	0.892
0.953	0.908	-----
0.958	0.924	0.907
0.976	0.930	0.927
0.979	-----	0.930
0.992	0.952	0.950
1.000 (c)	0.956	0.959
1.000 (c)	0.965	0.975
1.003	0.967	0.982
1.004	0.974	0.987
1.010	0.992	1.008
1.021	0.994	1.034
1.026	1.012	1.080
1.027	1.020	-----
1.049	1.022	1.112
1.049	1.038	1.151
-----	-----	1.184
1.053	1.068	1.203
1.054	1.071	1.206
1.058	1.083	-----
1.064	1.103	1.320
1.095	-----	1.433 (d)
-----	1.108	1.607 (d)
1.153	1.125	1.609 (d)
-----	1.160	
1.335 (d)	1.170	
	1.173	
	1.181	
	1.188	
	1.199	

	1.265	
	1.270	
	1.330	
	1.382 (d)	
	1.382 (d)	

(a) See discussion of these results for Config IIIA in the main text.

(b) These particular values should not be included in any overall judgements of quality for the reasons described in the text. Generally these models were not applicable since they had no mechanism for accounting for thermal and epithermal neutron background radiation to which the detectors are sensitive.

(c) Likewise, these two values for Config IC.6 should not be included since the measured values at this point in this configuration were used to normalize the fission detector response functions, as described in Sect 2.4.2.

(d) See discussion of these results for Config IIID in the main text.

Table X.13. Measured and calculated bare fission chamber responses [(counts/sec)/watt] along horizontal traverses at 30 cm behind the LMR shield mockups

Dist from centerline (cm)	IIIA.exp	IIIA.run-1b(b,d)		IIIA.run-1d(c,d)		IIIB.exp	IIIB.run-2a (e)		IIIB.run-1d (f)	
	(a)	Response	C/E	Response	C/E	(a)	Response	C/E	Response	C/E
100 S		1.679E-3	---	1.619E-3	---	3.47E-3	6.395E-3	1.843	2.237E-3	0.645
90	4.63E-3	2.158E-3	0.466	2.144E-3	0.463		6.289E-3	---	2.674E-3	---
80		3.100E-3	---	3.156E-3	---	5.30E-3	6.820E-3	1.287	3.489E-3	0.658
70	6.78E-3	3.936E-3	0.580	4.112E-3	0.606		8.090E-3	---	4.998E-3	---
60		5.545E-3	---	5.705E-3	---	7.82E-3	1.169E-2	1.495	8.737E-3	1.117
50	1.44E-2	1.230E-2	0.854	1.379E-2	0.958	1.14E-2	1.541E-2	1.352	1.260E-2	1.105
40	2.02E-2	1.323E-2	0.655	1.409E-2	0.698	1.30E-2	1.399E-2	1.076	1.134E-2	0.872
30	2.37E-2	1.652E-2	0.697	1.638E-2	0.691	1.40E-2	1.436E-2	1.026	1.180E-2	0.843
20	2.66E-2	2.123E-2	0.798	2.170E-2	0.816	1.44E-2	1.496E-2	1.039	1.239E-2	0.860
15	2.71E-2	1.924E-2	0.710	2.113E-2	0.780		1.533E-2	---	1.276E-2	---
10	2.75E-2	2.363E-2	0.859	2.362E-2	0.859	1.46E-2	1.617E-2	1.108	1.358E-2	0.930
5	2.79E-2	2.387E-2	0.855	2.470E-2	0.885		1.744E-2	---	1.488E-2	---
0	2.77E-2	2.000E-2	0.722	1.982E-2	0.716	1.46E-2	1.759E-2	1.205	1.505E-2	1.031
5	2.76E-2	2.387E-2	0.865	2.470E-2	0.895		1.744E-2	---	1.488E-2	---
10	2.74E-2	2.363E-2	0.862	2.362E-2	0.862	1.46E-2	1.617E-2	1.108	1.358E-2	0.930
15	2.71E-2	1.924E-2	0.710	2.113E-2	0.780		1.533E-2	---	1.276E-2	---
20	2.60E-2	2.123E-2	0.817	2.170E-2	0.835	1.42E-2	1.496E-2	1.054	1.239E-2	0.873
30	2.33E-2	1.652E-2	0.709	1.638E-2	0.703	1.37E-2	1.436E-2	1.048	1.180E-2	0.861
40	1.96E-2	1.323E-2	0.675	1.409E-2	0.719	1.28E-2	1.399E-2	1.093	1.134E-2	0.886
50	1.45E-2	1.230E-2	0.848	1.379E-2	0.951	1.07E-2	1.541E-2	1.440	1.260E-2	1.177
60		5.545E-3	---	5.705E-3	---	7.45E-3	1.169E-2	1.569	8.737E-3	1.173
70	6.77E-3	3.936E-3	0.581	4.112E-3	0.607		8.090E-3	---	4.998E-3	---
78 N	5.66E-3	3.381E-3	0.597	3.419E-3	0.604		6.878E-3	---	3.597E-3	---

- (a) Experimentally measured data taken from Table 53 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
- (b) 3-D XYZ TORT analysis performed using the (faster) theta-weighted difference technique.
- (c) 3-D XYZ TORT analysis performed using the (slower, but hopefully more accurate) nodal method.
- (d) 3-D XYZ TORT analysis, without extended concrete ring in calculation to simulate background radiation.
- (e) 2-D RZ DORT analysis, with the extended concrete ring in the calculation to simulate background radiation near the centerline. At radial positions much past the IVFS slab and in front of the lithiated paraffin blocks ($R > 45$ or 50 cm), these calculated thermal fluxes and fission chamber responses naturally become higher than the measured values as one moves closer and closer to this artificial concrete ring which was not really present in the actual experiment.
- (f) 2-D RZ DORT analysis, without extended concrete ring in calculation to simulate background radiation.

Table X.14. Measured and calculated Cd-covered fission chamber responses [(counts/sec)/watt] along horizontal traverses at 30 cm behind the LMR shield mockups

Dist from centerline (cm)	IIIA.exp	IIIA.run-1b(b,d)		IIIA.run-1d(c,d)		IIIB.exp	IIIB.run-2a (e)		IIIB.run-1d (f)	
	(a)	Response	C/E	Response	C/E	(a)	Response	C/E	Response	C/E
100 S		4.832E-4	---	4.107E-4	---	9.30E-4	1.510E-3	1.623	7.865E-4	0.846
90	1.42E-3	7.922E-4	0.558	7.539E-4	0.531		1.755E-3	---	1.120E-3	---
80		1.564E-3	---	1.559E-3	---	1.77E-3	2.355E-3	1.331	1.769E-3	0.999
70	2.76E-3	2.196E-3	0.796	2.228E-3	0.807		3.423E-3	---	2.876E-3	---
60		3.251E-3	---	3.230E-3	---	3.81E-3	5.800E-3	1.522	5.271E-3	1.383
50	7.52E-3	7.513E-3	0.999	8.176E-3	1.087	5.91E-3	7.714E-3	1.305	7.209E-3	1.220
40	1.08E-2	8.471E-3	0.784	8.473E-3	0.785	7.07E-3	7.602E-3	1.075	7.124E-3	1.008
30	1.34E-2	1.063E-2	0.793	1.038E-2	0.775	8.02E-3	8.339E-3	1.040	7.877E-3	0.982
20	1.55E-2	1.379E-2	0.890	1.362E-2	0.879	8.69E-3	8.961E-3	1.031	8.494E-3	0.977
15	1.63E-2	1.255E-2	0.770	1.363E-2	0.836		9.268E-3	---	8.802E-3	---
10	1.67E-2	1.548E-2	0.927	1.493E-2	0.894	9.05E-3	9.513E-3	1.051	9.039E-3	0.999
5	1.68E-2	1.543E-2	0.918	1.588E-2	0.945		9.609E-3	---	9.146E-3	---
0	1.68E-2	1.321E-2	0.786	1.285E-2	0.765	9.17E-3	9.555E-3	1.042	9.097E-3	0.992
5	1.69E-2	1.543E-2	0.913	1.588E-2	0.940		9.609E-3	---	9.146E-3	---
10	1.65E-2	1.548E-2	0.938	1.493E-2	0.905	9.01E-3	9.513E-3	1.056	9.039E-3	1.003
15	1.61E-2	1.255E-2	0.780	1.363E-2	0.846		9.268E-3	---	8.802E-3	---
20	1.52E-2	1.379E-2	0.907	1.362E-2	0.896	8.59E-3	8.961E-3	1.043	8.494E-3	0.989
30	1.30E-2	1.063E-2	0.818	1.038E-2	0.799	7.87E-3	8.339E-3	1.060	7.877E-3	1.001
40	1.06E-2	8.471E-3	0.799	8.473E-3	0.799	6.98E-3	7.602E-3	1.089	7.124E-3	1.021
50	7.39E-3	7.513E-3	1.017	8.176E-3	1.106	5.68E-3	7.714E-3	1.358	7.209E-3	1.269
60		3.251E-3	---	3.230E-3	---	3.64E-3	5.800E-3	1.593	5.271E-3	1.448
70	2.64E-3	2.196E-3	0.832	2.228E-3	0.844		3.423E-3	---	2.876E-3	---
78 N	2.02E-3	1.772E-3	0.877	1.752E-3	0.868		2.448E-3	---	1.871E-3	---

- (a) Experimentally measured data taken from Table 54 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
- (b) 3-D XYZ TORT analysis performed using the (faster) theta-weighted difference technique.
- (c) 3-D XYZ TORT analysis performed using the (slower, but hopefully more accurate) nodal method.
- (d) 3-D XYZ TORT analysis, without extended concrete ring in calculation to simulate background radiation.
- (e) 2-D RZ DORT analysis, with the extended concrete ring in the calculation to simulate background radiation near the centerline. At radial positions much past the IVFS slab and in front of the lithiated paraffin blocks ($R > 45$ or 50 cm), these calculated thermal fluxes and fission chamber responses naturally become higher than the measured values as one moves closer and closer to this artificial concrete ring which was not really present in the actual experiment.
- (f) 2-D RZ DORT analysis, without extended concrete ring in calculation to simulate background radiation.

Table X.15. Measured and calculated bare fission chamber responses [(counts/sec)/watt] along horizontal traverses at 30 cm behind the LMR shield mockups, with a Cd plate over the face of the mockups

Dist from centerline (cm)	IIIA.exp (a,b)	IIIB.exp (a)	IIIB.run-4a (c)	
			Response	C/E
100 S		2.62E-3	5.672E-3	2.165
90	3.09E-3		5.615E-3	---
80		3.64E-3	6.014E-3	1.652
70	4.02E-3		6.620E-3	---
60		5.08E-3	8.509E-3	1.675
50	8.54E-3	7.00E-3	1.001E-2	1.430
40	1.17E-2	8.23E-3	9.822E-3	1.193
30	1.43E-2	8.94E-3	1.040E-2	1.163
20	1.66E-2	9.65E-3	1.108E-2	1.148
15	1.73E-2		1.134E-2	---
10	1.78E-2	1.01E-2	1.142E-2	1.131
5	1.80E-2		1.144E-2	---
0	1.78E-2	1.01E-2	1.144E-2	1.133
5	1.80E-2		1.144E-2	---
10	1.77E-2	9.98E-3	1.142E-2	1.144
15	1.73E-2		1.134E-2	---
20	1.67E-2	9.54E-3	1.108E-2	1.162
30	1.42E-2	8.88E-3	1.040E-2	1.171
40	1.19E-2	7.92E-3	9.822E-3	1.240
50	8.78E-3	6.84E-3	1.001E-2	1.463
60		4.90E-3	8.509E-3	1.736
70	4.22E-3		6.620E-3	---
78 N	3.61E-3		6.050E-3	---

- (a) Experimentally measured data taken from Table 55 of ORNL/TM-11989. That document is also the primary reference regarding the experimental shielding configurations.
- (b) These experimentally measured values for the heterogeneous IVFS slab (IIIA) are shown for completeness, and for comparison against the measured values for the homogeneous IVFS slab (IIIB). No 3-D TORT analyses were performed for this configuration with the Cd plate over the face of the heterogeneous mockup since (1) the primary source of thermal neutrons beyond the Cd plate would have been due to background radiation, and (2) the cost associated with the extra mesh intervals needed to model the extended concrete ring normally used to simulate the effect of this background radiation would have been prohibitively expensive in the 3-D XYZ model.
- (c) 2-D RZ DORT analysis, with the Cd plate over the face of the mockup and the extended concrete ring in the calculational model to simulate background radiation near the centerline. At radial positions much past the IVFS slab and in front of the lithiated paraffin blocks ($R > 45$ or 50 cm), these calculated thermal fluxes and fission chamber responses naturally become higher than the measured values as one moves closer and closer to this artificial concrete ring which was not really present in the actual experiment.

5.0 SUMMARY

5.1 OVERVIEW OF THE BASIC RESULTS

Spectral measurements made by unfolding the responses of the NE213 and hydrogen-filled spectrometers would imply that the calculated fluxes for fast and intermediate energy neutrons ($E > 0.05$ MeV) may be anywhere from 15 to 20% low for Config. IA/PB (with the iron, aluminum, boral and Pb slabs), to within ± 3 to 10% of the measured values for Config. IB with the radial blanket assembly, to almost 35 to 40% high for Config. IC/PB with the Pb slabs downstream of the six sodium tanks. More reliable Bonner ball measurements, however, would suggest that the agreement between the calculated and measured values may be much better and more consistent.

The most reliable measurements of the fast, intermediate, and epithermal neutron fluxes were made with the 12, 10, 8, 5, 4, and 3-inch Bonner balls located along the centerline of the system, 30 cm downstream of Configs. IA, IB, IC, IIIA, IIIB, IIIC, IIID, IIIE, and IIIF. These results (not including those for Config. IIIE) show that 55% (i.e., 53) of the 96 measurements made were within 5% of the calculated values, while 90% (i.e., 86) of the 96 were within 10% of the calculated values, and the remaining values were all within 14 to 17% of the calculated values. Given that most of the shield configurations consisted of relatively homogeneous materials, this agreement (which is considered excellent) should not be considered too surprising. It does, however, tend to confirm the adequacy of the zone-weighted cross-section data for the sodium and steel found in the VELM cross-section library for LMR shielding analyses. [Slightly less reliable Bonner ball measurements along the centerline at 150 cm downstream of the various shield configurations still showed that 40% of the calculated values were within 5% of the corresponding measured values, that 70% of the the calculated values were within 10%, and that 96% of the calculated values were within 20% of the corresponding measured values.]

While horizontal traverses 30 cm downstream of the heterogeneous IVFS fuel slab in Config. IIIA (with its three distinct compartments of SPERT fuel rods separated by 6-inch wide blocks of aluminum) did not show any corresponding peaks or depressions in the flux, three-dimensional effects were still present as evidenced by the fact that the 12-inch Bonner ball response at the centerline was 16% lower than that for the homogeneous IVFS fuel slab ($1.16 = 5.54/4.78$), while the 3-inch Bonner ball response there was 55% higher than that for the homogenized IVFS fuel slab ($1.55 = 8.86/5.72$), and the thermal flux as measured by the bare fission chamber 30 cm downstream of the IVFS fuel slab was 2.0 times higher than that for the homogeneous IVFS fuel slab ($2.0 = 2.81/1.39$).

Bare and cadmium-covered fission chambers were used to measure the thermal and epithermal flux at 0.7, 30, and 150 cm downstream of the various configurations mentioned above. Thermal and epithermal background radiation was a severe problem — both experimentally and calculationally. When care was taken to artificially simulate this background radiation in the calculational models, then the most reliable measurements at 0.7 cm downstream of the shield showed that 45% of the calculated values were within 5% of the corresponding measured values, that 76% of the calculated values were within 10% of the measured values, and that 93% of the calculated values were within 15% of the corresponding measured values along the centerline. At 30 cm from the surface, where background radiation becomes more important, the measurements showed that only 27% of the calculated values were within 5% of the corresponding measured values, that 49% of the calculated values were within 10% of the measured values, and that 85% of the calculated values were within 25% of the corresponding measured values. Results at 150 cm from the shield showed that only 65% of the calculated results were within 20% of the corresponding measured values. All this assumes, however, that one can develop (and is willing to use) an artificial extension to the calculational model that can partially simulate the effect of thermal neutron background radiation. Without this artificial extension (which was necessary here to simulate the effect of backscatter from the concrete pad on the ground in front of the Tower Shielding Reactor), the calculated bare and Cd-covered fission chamber responses sometimes underpredicted the measured responses by as much as a factor of 2 or 3. Fortunately, for those few cases where thermal neutron background radiation appeared to be relatively negligible (such as those measurements made 0.7 cm downstream of the shield but inside the cadmium hut, and those measurements made for Config. IIIF in the large void region between the IVFS and the B₄C slab), the calculated values generally appeared to be within 5 to 15% of the measured values. With respect to all the fission chamber measurements made, these must be regarded as the most reliable and the most straightforward to model. Fortunately, they also had the best C/E ratios.

Unsaid above is the fact that the C/E ratios for Config. IIIE were all relatively poor for some yet unexplained reason. Whereas 90% of all the calculated Bonner ball responses for all the other configurations were within 10% of the corresponding measured values, and none of the calculated values at 30 cm along the centerline deviated from the measured values by more than 17%, the C/E ratios for the 3- to 12-inch Bonner balls at 30 cm downstream of Config. IIIE ranged from 1.167 for the 12-inch Bonner ball to 1.442 for the 3-inch Bonner ball, with most of the C/E ratios being between 1.30 and 1.35. The possible explanations reviewed and rejected to date are summarized in Sect. 4.2.3. With the B₄C slab located upstream of the IVFS fuel slab, this configuration is still (by an order of magnitude) the most effective shield design experimentally mocked up, and is still highly recommended

for that reason, even if one must make allowances for the higher uncertainties still associated with this configuration.

5.2 OTHER NOTEWORTHY OBSERVATIONS

5.2.1 Lessons With Respect to Shield Effectiveness

The shielding experiments showed that placing the B_4C slab downstream of the homogeneous IVFS fuel slab as in Config. IIID reduced the fast and intermediate flux (as measured by the 5-inch Bonner ball) by a factor of 3 ($=19.6/6.43$) relative to what it would have been without the B_4C slab (Config. IIIB). While no doubt obvious a priori, the shielding experiments also demonstrated that placing the B_4C slab upstream of the IVFS slab as in Config. IIIE (rather than downstream as in Config. IIID) would be even more effective, and that this would reduce the fast and intermediate flux (as measured by the 5-inch Bonner ball) by an additional order of magnitude ($12.0=6.43/0.534$). Although the calculational uncertainty in this case (with the B_4C slab upstream) is somewhat higher with C/E ratios up to 1.30 and 1.40, this greater uncertainty is more than offset by the significantly lower fluxes actually present with the B_4C slab upstream of the IVFS fuel slab.

5.2.2 Lessons for Shielding Design Analysts and Experimental Analysts

Properly accounting for resonance self-shielding in the IVFS fuel slab (and the radial blanket assembly mockup) is extremely important. If one simply uses the infinitely dilute U-238 cross-section data in the VELM/ANISN library or other shielding cross-section libraries, the calculated Bonner ball responses for Config. IIIF, for example, will be 1.86 to 1.92 times too low relative to the measured responses. Once the resonance self-shielded data (based on Bondarenko self-shielding using a simple infinite homogeneous media approximation) was used in the 2-D RZ DORT analysis of Config. IIIF, the calculated Bonner ball responses were all found to be within 5 to 7% of the measured responses. This same lesson should certainly be applied in day-to-day LMR shielding design analyses as well.

5.2.3 Lessons Primarily for Experimental Analysts

Care should be taken in the calculation of Bonner ball responses, especially when the Bonner balls are located some distance away from the centerline of the system. While the old technique of folding the fluxes at the center-of-detection with the multigroup response function(s) to get the calculated response may suffice

for detectors located some distance from the source along the centerline of the system, this approximate technique breaks down when the Bonner balls are located closer to a large distributed source and/or when the Bonner balls are located some distance away from the centerline of the system. Instead, it is now recommended that one first take the integral average of the multigroup fluxes over the forward hemisphere of the Bonner ball, where the forward hemisphere is defined as that hemisphere which faces the midpoint of the exposed surface of the shield. For a 10-inch Bonner ball 30 cm downstream of Config. IIIA but 80 cm away from the centerline, averaging the flux over the properly oriented hemisphere (as opposed to the -Z hemisphere frequently used) increased the C/E ratio for the 10-inch Bonner ball from 0.633 (using the -Z hemisphere) to 0.914 when the sensitive hemisphere used in the folding was properly reoriented as described above. Moreover, the calculational procedures used to obtain the calculated Bonner ball responses from the calculated flux field will probably have to be reviewed and improved if one ever desires to routinely obtain C/E ratios much below the 5, 10, or 20% uncertainties typical of the values in this report. It is this analyst's opinion that the uncertainties stemming from questions on "how to calculate the actual response" are probably as great or greater than the uncertainties stemming from the DORT or TORT shielding codes and the cross-section data in use today — at least when applied to simple, more-or-less homogeneous slabs of shielding materials like those found here which do not include any obvious streaming paths or channels.

Lastly, as reiterated several times above, it should be noted that there are always large uncertainties due to thermal neutron background radiation whenever one is trying to calculate (or measure) the thermal and epithermal neutron flux using bare and cadmium-covered fission chambers. In situations where that thermal neutron background radiation is negligible, one can probably expect to obtain calculated results that are accurate to within 10 or 20%. In most situations, however, when thermal neutron background radiation is not negligible, one can expect to obtain this type of agreement only if one is somewhat creative and clever enough to simulate that background radiation in some way — as we have done using the artificial extended concrete ring described in Sect. 2.6 and illustrated in many of the figures in Sect. 3. In any event, one can certainly argue that such artificial "fixes" violate the purity of the comparisons that are to be made. [That is why we performed the calculations both ways (with and without this artificial concrete ring to simulate background radiation) and why we presented both sets of results.] This dilemma will not go away, however, and will have to be addressed somehow by anyone interested in comparing calculated and measured thermal fluxes at the Tower Shielding Reactor or in any other similar experimental facility or setup. Not to account for thermal neutron background radiation in any fashion may easily cause one to underestimate the thermal flux by a factor of 2 or 3 in many situations. Fortunately, this is only a problem for experimenters and experimental analysts, and

is not a problem for shielding design engineers and analysts who seldom (if ever) have to worry about thermal neutron background radiation.

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