Prismatic VHTR Benchmark Problems

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ABSTRACT

This paper aims to fill an apparent scarcity of benchmarks based on high temperature gas-cooled reactors. Within is a description of a whole prismatic VHTR core in its full heterogeneity and modeling using continuous energy nuclear data at a representative hot operating temperature. Also included is a core which has been simplified for ease in modeling while attempting to preserve as faithfully as possible the neutron physics of the core. Fuel and absorber pins have been homogenized from the particle level, however, the blocks which construct the core remain strongly heterogeneous. A six group multigroup (discrete energy) cross section set has been developed via Monte Carlo using the original heterogeneous core as a basis.

Several configurations of the core have been solved using these two cross section sets; eigenvalue results, block-averaged power results, and some selected pin fission density results are presented in this paper, along with the six-group cross section data, so that methods developers may use these problems as a standard reference point.

Key Words: Neutronics, HTTR, hexagonal geometry, numerical benchmark, whole-core transport, heterogeneous core.

1. INTRODUCTION

The Very High Temperature Reactor (VHTR) is one of the Generation IV concepts under investigation internationally. It is a thermal reactor with a graphite core which uses helium for coolant, and boasts high outlet heat and passive safety features. It is, however, expected to present a challenge to many neutronic modeling and simulation tools, due to its complex geometry, its heterogeneity, and its relatively large active core. Of importance in the development and licensing of new reactor concepts and core designs is having valid tools and methods with which to model these cores, and to have benchmark models with which to test their validity. There is, at present, a dearth of benchmarks which model the prismatic VHTR at a level of complexity necessary to judge transport-based methods which are at the same time simpler than a whole-core fully heterogeneous Monte Carlo model. This paper provides several benchmarks based on the VHTR which, it is hoped, will be of value to the community of methods developers with their eyes on this particular core.

Contained in this paper is a description of a VHTR core in full fidelity (heterogeneous to the fuel particles), followed by a summary of how the core problem in this paper has been simplified from the actual fully heterogeneous core, a discussion of the validity of the simplifications, a complete description of the stylized VHTR core, and an explanation of the method of generating the multigroup material data. Section 4 contains the eigenvalue results for the configurations investigated, as well as a fission density map at the block level for the whole core and at the pin level for selected blocks. A brief summary and some concluding remarks are presented in Section 5.

2. DETAILED HETEROGENEOUS BENCHMARK DESCRIPTION

This section details the VHTR active core in full fidelity. The benchmark was designed by compiling information about the prismatic VHTR design from several sources, including earlier benchmark specifications (MacDonald et al., 2003; Gougar et al., 2010), conceptual design reports (Williams et al., 1989), and material data documents (McConn et al., 2011).

2.1. Core Geometry and Specifications

The core is composed of 14 levels of regular hexagonal prismatic graphite blocks. Each level is made up of seven rings of whole blocks around a center column, and a ring of partial graphite blocks around the core periphery. A depiction of the basic core configuration is given by Fig. 1, in which fuel blocks are colored in yellow, standard graphite reflector blocks are in gray, and structural graphite blocks around the periphery are shaded a darker gray. The green colored regions represent the location of control channels. Note that the channels through the fuel blocks are not actually used for control rods, but as a channel for reserve shutdown material; they are modeled as empty channels containing only helium for all configurations in this benchmark.

While an attempt was made to model the core as faithfully as possible to the specifications included in design documents, some deviations included changing the shape of the core barrel from cylindrical to hexagonal prismatic, and changing the location of some control rods so that

the whole core would have one-twelfth symmetry. The eigenvalue of the symmetric core was not found to be significantly different from the original asymmetric core for the purpose of the development of a benchmark for numerical methods development. These changes were made in order to simplify the modeling while preserving the neutron physics within the active core as accurately as possible.

Above the top and below the bottom of the core, as well as on the outside edge, a boundary condition is given as vacuum (no reentrant flux). Where sections of the core have been modeled along the lines of symmetry, a specular reflective boundary condition has been simulated.

Figure 1. Whole core configuration

Table 1. Geometry parameters

Number of fuel columns	66
Number of control rod columns	30
Number of standard reflector columns	73
Number of structural reflector columns	42 sides + 6 corners
Number of axial layers (in 3D problem)	14
Number of layers in active core (3D problem)	10
Flat-to-flat core width	519.6 cm
Flat-to-flat block width	36 cm
Block height (in 3D problem)	79.3 cm

Number of fuel pins in standard block	210
Number of fuel pins in reserve shutdown block	186
Fuel pin hole diameter	1.27 cm
Number of absorber pins in fuel block	6
Absorber pin hole diameter	1.27 cm
Number of large coolant channels in standard block	102
Number of large coolant channels in reserve shutdown block	88
Number of small coolant channels in standard block	6
Number of small coolant channels in reserve shutdown block	7
Large coolant channel diameter	1.588 cm
Small coolant channel diameter	1.27 cm
Pin cell pitch in fuel block	1.8796 cm
Coolant channel pitch in cooled reflector block	3.2556 cm
Reserve shutdown channel diameter	9.525 cm
Control channel diameter / outer control rod diameter	9.525 cm
Inner control rod diameter	5.28 cm
Distance from control rod center to block center	9.756 cm

Each block within the core (but not in the peripheral graphite ring) has the same dimensions of 36 cm from flat edge to flat edge. Additional geometry information is provided in Table 1. A thorough description of each block's composition follows.

2.2. Block Geometry and Specifications

Each block in the active core region has a flat-to-flat width of 36 cm, and a height of 79.3 cm. The fundamental block geometry of each type of block is shown in Figures 2-4, in which the graphite structure is represented by gray, the fuel pin regions are shown in pale yellow, burnable absorber pin regions are shaded green, and the control rod areas are colored deep red. The white spaces in the figures represent helium coolant. Fuel pin, absorber pin, and control rod regions are heterogeneous and more description follows for each.

Figure 2. Standard fuel block, fuel block with reserve shutdown channel.

Figure 3. Standard reflector block, control block with control rod absent, control block.

Figure 4. Standard cooled reflector block, cooled reflector with reserve shutdown channel.

Fuel blocks contain 210 holes of radius 0.635 cm for fuel compacts, 102 holes of radius 0.794 cm for coolant to flow through, and 6 smaller coolant holes of 0.635 cm radius. In addition, six holes for burnable absorbers are at the corners of the fuel blocks, and are of the same radius as the fuel pins. The holes are arranged to have a pitch of 1.8796 cm.

Fuel blocks for which a reserve shutdown channel has been drilled are similar to standard fuel blocks, but they have a hole of 9.525 cm diameter located 9.756 cm from the center of the block. Furthermore, these blocks have only 186 fuel holes, 88 larger coolant holes, and 7 smaller coolant holes of the same dimensions as those in the standard fuel block. The burnable absorber pins remain the same.

In the fuel pins, uranium oxycarbide ($\text{UO}_{1.5}\text{C}_{0.5}$, with uranium enriched to 15.5% in ^{235}U by weight) fuel spheres of radius 0.02125 cm are enveloped in four layers of material: a carbon buffer 0.01 cm thick, a pyrolytic carbon layer 0.0035 cm thick, 0.0035 cm of silicon carbide, and an outer layer of thickness 0.004 cm consisting of pyrolytic carbon. These are placed in a graphite matrix with a packing fraction of 35%, and are arranged in a cubic lattice for ease of modeling, as shown in Figure 5. The side length of the cubic lattice elements is 0.09664222 cm. A similar approach is taken for the burnable absorber pins, where boron carbide reactivity control spheres of radius 0.01 cm are encased in carbon layers of 0.0018 cm and 0.0023 cm thickness. These, too, are modeled in a cubic lattice (of side length 0.04758168 cm) in this benchmark specification rather than their realistically more random distribution. Although the reference suggests varying concentrations of absorbing material distributed in the core as a reactivity control, no more detail is given. For the sake of this benchmark, the burnable absorber material is uniform wherever it appears. Fuel and poison pins are both placed in holes in the graphite block, with a 0.0125 cm gap surrounding the fuel compacts making up the pin, and a 0.0635 cm gap around the poison compacts. Graphite plugs are inserted into the holes to keep the compacts in place. The graphite plugs in fuel cells are each 2.69 cm long, of the same diameter as the fuel hole, and placed at the top and bottom of each block. The remaining 73.92 cm of the fuel pin region (between the plugs) is the heterogeneous fuel compact. The burn pins are structured similarly, but the graphite plugs at the top and bottom of the absorber holes are each 3.558 cm in height.

Figure 5. Cut-through, fuel pin cell and burnable absorber pin cell.

Reflector blocks are composed of the same graphite as the fuel blocks. They may have control channels within. Above and below the active core, reflector blocks contain the same coolant channels as those which run through the standard fuel blocks. Control rods and holes are of the same dimensions as the reserve shutdown holes found in fuel blocks.

Table 2: Materials used in benchmark

Material	Isotopic Composition		Density (g/cm ³)
Fuel kernel	²³⁵ U	0.0522	10.5
	²³⁸ U	0.2811	
	C-nat	0.1667	
	¹⁶ O	0.5000	
Carbon buffer (in fuel particle)	C-nat(*)	1.0	1.0
Pyrolytic carbon (in fuel particle)	C-nat(*)	1.0	1.9
Silicon carbide	C-nat	0.5	3.2
	²⁸ Si	0.5	
Matrix graphite	C-nat(*)	1.0	0.94
Graphite plugs	C-nat(*)	1.0	1.74
Poison kernel	¹⁰ B	0.3146	2.47
	¹¹ B	0.0318	
	C-nat	0.6536	
Pyrolytic carbon (in poison particle)	C-nat(*)	1.0	1.87

Control rod	¹⁰ B	0.3146	1.23573
	¹¹ B	0.0318	
	C-nat(*)	0.6536	
Incoloy-800	C-nat	0.002984	7.94
	²⁷ Al	0.007663	
	²⁸ Si	0.012760	
	³² S	0.000172	
	⁴⁸ Ti	0.004319	
	⁵² Cr	0.222681	
	⁵⁵ Mn	0.009785	
	⁵⁶ Fe	0.430100	
	⁵⁸ Ni	0.305302	
	⁶³ Cu	0.004234	
Block graphite	C-nat(*)	0.9999998	1.74
	¹⁰ B	0.0000002	
Outer (structural) reflector	C-nat(*)	0.9999998	1.78
	¹⁰ B	0.0000002	
Helium coolant	⁴ He	1.0	0.0001786

*Natural carbon is in the form of graphite in these materials; S(α,β) data should be used.

The control rod regions' outer diameter is 9.525 cm, thus leaving no gap in the model between the control material and the graphite. They have an inner diameter of 5.28 cm surrounding a region of vacuum through which, for the sake of the model, helium coolant flows. The control rods themselves are of boron carbide and structural carbon, and are annular with the inner diameter of 5.28 cm and the outer diameter 8.26 cm. The outer annular structure for the control rod composes the balance of the control region (8.26 cm inner diameter; 9.525 cm outer diameter) and is constructed of Incoloy-800.

A listing of all materials used for the benchmark description is presented in Table 2.

3. STYLIZED BENCHMARK DESCRIPTION

In this section, a description is given of the benchmark problem, explaining how it differs from the fully heterogeneous VHTR design and giving rationale for these simplifications. The development of the problem is detailed, including an explanation and justification of the cross section generation method. A complete specification is then given of the new benchmark problem.

3.1. Stylized Core Model Development

The purpose of this work has been to reduce the complexity of the problem specification while retaining as many details as possible to produce a valid representation of the overall core neutronic behavior. As this benchmark is intended to serve as a reference to developers of

methods which model block-level heterogeneity, the aim has been to create an accessible benchmark with enough detail to present a challenging test to a new method, but simplified enough so as to be useful; for instance, very few methods, at present, resolve pin-level heterogeneity in their full-core calculations, and a problem which maintains such minute detail is unlikely to serve much immediate purpose to the community. A similar approach was taken with a benchmark in the style of Japan's High Temperature Test Reactor (Zhang et al., 2011), which has been a valuable model for methods testing (Yang and Satvat, 2012).

The core model neutronic behavior was simulated using the stochastic neutron transport method MCNP5 (X-5 Monte Carlo Team, 2005). The ENDF/B-VII continuous energy library at 900K was selected for the model as a typical hot operating temperature. For the graphite throughout the core and for the uranium and oxygen in the fuel, $S(\alpha,\beta)$ data was used at 800K, as this was the closest temperature available to the hot operating temperature chosen. A set of regions within the core was defined for multigroup macroscopic cross section generation using MoCS-Gen, a Monte Carlo-based multigroup macroscopic cross section utility (Ilas, 2002; Pounders et al., 2007; Pounders et al., 2014) which generates flux-weighted homogenized cross sections. A 6-group library including a P_1 scattering kernel, whose energy bounds may be found in Table 3, was created for the core. The bounds were chosen as they have appeared previously in the analysis of prismatic high temperature reactors (Murata et al. 1994; Zhang et al., 2011). While cross section libraries with a greater number of energy groups are commonly used, the inclusion of the corresponding cross section data would be too cumbersome to include in this paper due to size limitations. Additional discussion of the method of cross section generation is beyond the scope of this paper.

Table 3. 6 group energy structure

Group	Upper energy (MeV)
1	20
2	0.183
3	9.61×10^{-4}
4	2.38×10^{-6}
5	6.5×10^{-7}
6	1.05×10^{-7}

From two core configurations, a total of fourteen unique materials were defined within the core. The first configuration was a one twenty-fourth symmetric core (one twelfth radial symmetry and one half axial symmetry) with control material absent. From this configuration, three fuel material zones were established, five graphite material zones, one for burnable absorber pins, and one for helium coolant. Figure 6 depicts an axial cross-section of the core with different material regions indicated. The second configuration was the core with some rods in. From the one twenty-fourth symmetric core, control rods were placed in the three axial regions closest to the central line of symmetry. Although this is not a realistic depiction of the insertion of control

material, it was considered a reasonable model for generating cross sections. This model yielded an additional fuel material specification, two more graphite regions, and a definition for control material. Figure 7 illustrates an axial slice of the second configuration simulated.

All of the materials present were homogenized from their original heterogeneity to become uniform regions. Fuel regions were homogenized from their initial specification, which included uranium oxycarbide fuel at 15.5% weight enrichment encapsulated in pyrolytic carbon and silicon carbide layers embedded in a graphite matrix, graphite plugs at the top and bottom of fuel compact stacks, and a gap surrounding the compacts. Burnable absorber regions were similarly homogenized from gap, plug, and absorber compacts. Graphite regions and helium coolant regions were already homogeneous from a material specification perspective, but both were given a uniform cross-section throughout at least individual blocks. Control material was defined as the homogenization of boron carbide control material clad by Incoloy-800.

In Figure 6, the pale yellow color denotes inner fuel blocks. The inner fuel and inner graphite composition were determined by homogenizing all of the fuel regions and all of the graphite regions, respectively, in these regions using MoCS-Gen. The same procedure was used for the middle fuel and graphite regions, which were those in the light blue blocks, and the outer fuel and graphite regions, which were those in those blocks colored in light green. All of the burnable absorber pins in the core were homogenized into a single region for cross section generation, and the same was done for all of the helium coolant present within the core. Graphite cross sections were also tabulated for the three different graphite regions illustrated in Figure 6, although upon testing, the central reflector regions and outer reflector regions, indicated by the pale and medium shades of gray, were found to be interchangeable, and only the graphite cross section determined by the homogenization of the medium gray blocks is kept for this benchmark. Finally, a material region was defined for the core periphery, which represents the structural permanent graphite blocks along the edge of the core. This region is colored in the darker shade of gray.

Figure 6. 1/12 of core with all rods out, cross section regions indicated in text

Figure 7. 1/12 of core with rods in, cross section generation regions indicated in text

The second core model used for cross section generation is illustrated in Figure 7. Only the regions of interest are colored in this figure. Material cross section data was determined for the fuel and graphite in those blocks adjacent to the inserted control rods, which are colored in lavender. A final graphite set was found for the graphite in control blocks, which are shown in gray. The control rods are shown in brown, and represent the homogenization of the control material and cladding; they remain annular in the benchmark specification. The blocks without shading were not of interest for development of homogeneous material regions.

3.2. Geometry specification

The core and block specification is exactly the same in the stylized core as that described for the fully heterogeneous core. The only difference in the active core region is that fuel and poison pin regions have been homogenized so that everything inside of the fuel pin hole defined in Table 1 is homogenized fuel material, and everything within the burnable absorber hole is homogenized burnable absorber. The only other difference is that Incoloy-800 and control material have been homogenized to form a single annular control material region of the inner and outer diameter given by Table 1.

4. RESULTS

This section includes results from the continuous energy heterogeneous core, the stylized 3-D core, and a stylized 2-D version of the core. All results are from core models utilizing core symmetry; that is, they model a 1/12 radial section and, for the 3-D configurations, a 1/2 axial section. Eigenvalue results are given for all core configurations with their corresponding uncertainty. Fission density results are also presented. Because of the large number of pins in the core, it would be impractical to list values for all individual pins; therefore, block-level fission density results are given for all blocks in each core. Data is presented in tables using the block numbering scheme presented in Figure 8.

Figure 8. Block numbering scheme

Fission density values have been normalized such that a value of 1 corresponds to the core average block power.

4.1. Continuous energy heterogeneous core

The full fidelity continuous energy core was modeled with all rods out and all rods in using 1/24 symmetry, as the cores are axially symmetric as modeled. MCNP5 was used for the calculations, in which 125,000 particles were simulated per cycle, and 4,000 active cycles were simulated after an initial 200 inactive cycles. A full core calculation was done to produce converged fission source data, and another full core calculation was done to tally fission density information. The core calculation for tallying block-level fission density data in the core with all rods out required just over 2 days on 40 processors, or 136440 cpu minutes; that for all rods in required 136640 cpu minutes, which represents 2.3 days on 40 processors.

Eigenvalue results for all cores are given in Table 4, along with their corresponding uncertainty values, in pcm, as determined by MCNP.

Table 4. Eigenvalue results for all cores: k_{eff} (σ in pcm)

	Heterogeneous, CE	3D Stylized, 6g	2D Stylized, 6g
All Rods Out (ARO)	1.06611 ($\pm$ 4 pcm)	1.09201 ($\pm$ 3 pcm)	1.09844 ($\pm$ 2 pcm)
Some Rods In (SRI)	n/a	1.00769 ($\pm$ 3 pcm)	1.04655 ($\pm$ 2 pcm)
All Rods In (ARI)	0.91538 ($\pm$ 4 pcm)	0.94894 ($\pm$ 3 pcm)	0.95442 ($\pm$ 2 pcm)

Table 5 contains the block-averaged fission density values for all of the blocks in the heterogeneous core. These values have been normalized such that the average block in the core has a fission density value of 1. For the case with all rods out, the uncertainty in the fission density values ranged from 0.03% to 0.06%. With all rods in, the fission density uncertainty

values ranged from 0.03% to 0.07%. Pin fission density results for the fully heterogeneous continuous energy cores are not included, as the reader may calculate these based on the specification detailed in the previous section. In the following section, fission density values are provided at the pin level for the stylized multigroup cores, as these are expected to be useful for benchmarking multigroup transport methods.

Table 5. Block-averaged fission density values, continuous energy heterogeneous core

Block	1	2	3	4	5	6	7
All Rods Out							
1, 10	0.6643	0.6922	0.5961	0.6210	0.6312	0.5300	0.5539
2, 9	0.9369	0.9779	0.8437	0.8760	0.8892	0.7537	0.7860
3, 8	1.1563	1.2062	1.0429	1.0819	1.0983	0.9332	0.9712
4, 7	1.3127	1.3698	1.1825	1.2277	1.2461	1.0578	1.1017
5, 6	1.3938	1.4550	1.2551	1.3039	1.3245	1.1240	1.1703
All Rods In							
1, 10	0.5752	0.6158	0.5471	0.5893	0.6116	0.3953	0.4482
2, 9	0.9020	0.9680	0.8576	0.9224	0.9560	0.6216	0.7030
3, 8	1.1651	1.2504	1.1070	1.1922	1.2358	0.8030	0.9091
4, 7	1.3521	1.4506	1.2860	1.3828	1.4340	0.9324	1.0553
5, 6	1.4484	1.5531	1.3765	1.4806	1.5358	0.9976	1.1302

4.2. Stylized cores, 6 group library

Solutions were found for the stylized six group core in three configurations. MCNP was used to construct the solution, using the 6-group discrete energy macroscopic cross section library in Appendix A. The first configuration, all rods out (ARO), was first solved, as with the heterogeneous configuration, to generate a converged fission source. The same parameters of 125,000 particles per cycle and 200 inactive cycles followed by 4,000 active cycles were used for all of the six group calculations. As with the fully heterogeneous continuous energy case, the stylized 6 group cores utilized 1/24 symmetry: 1/12 rotational symmetry, and 1/2 axial symmetry.

It may be noted from the eigenvalue results presented in Table 4 that the k_{eff} values determined using the multigroup cross section library differ from those of the continuous energy problem by approximately 2500 pcm (2.5%). This was considered acceptable for the sake of this paper, in that its purpose is to provide numerical benchmarks for developers of transport methods, and is not intended to be a study in cross section generation. However, it is worth stating that the means of homogenizing fuel particles and pins and generating a few group macroscopic cross section set used in the compilation of these benchmark problems has preserved the physics of the actual core far more closely than a volume homogenization approach; simple volume homogenization methods may lead to eigenvalue errors of approximately 10%. Additional discussion of methods for the generation of multigroup homogenized cross sections in highly heterogeneous cores is beyond the scope of this paper.

The layout of the ARO core is illustrated in Fig. 9, in which the yellow assemblies represent those for which the “inner fuel block” fuel and graphite composition was used, the pale aqua blocks signify “middle fuel block” fuel and graphite compositions, and the green blocks represent those for which “outer fuel block” fuel and graphite should be used. All of the reflector blocks use the same graphite composition except the ring of permanent structural blocks at the edge which are depicted in darker gray; these were modeled in the “permanent reflector” graphite composition. The ARO core features 5 levels of blocks arranged just as shown by Fig. 9, with two layers above where the fuel blocks are replaced with cooled reflector blocks; the cooled reflector blocks are composed of the same graphite as the standard reflector blocks. Below the modeled active core is a specular reflective boundary condition. The ARO core calculation completed after 22337 cpu minutes.

Figure 9. All rods out block diagram

The configuration with some rods in (SRI) is described here to be a numerical benchmark which challenges solution methods and does not strive for realism. The control rods are present in the middle of the active core, but not the top and bottom, thus creating a model which has the flux peaked at the top and bottom of the core, depressed flux in the center of the reactor, and a non-physical state of control existing. The three axial layers at the center of the core are identical to the standard ARI configuration as illustrated by Figure 10. The axial layer of the active core at the very top and bottom has all rods out, as illustrated by Figure 9. The two axial levels of reflector also have no control material present. The region of the active core which is either second or ninth from the top (or bottom, since axial reflection exists at the center) of the active core is as shown in Figure 11. In Figures 10 and 11, the same color scheme is followed as for Figure 9, but with the following additions: lavender blocks represent fuel blocks with “control block adjacent” fuel and graphite compositions, the rust-colored circles represent control rods, and blocks where control rods are present should use “control block graphite” instead of the standard graphite reflector block cross section set. The SRI core required 23985 minutes of computing time to reach its solution.

The third core configuration has all rods in (ARI). In this configuration, all layers of the axial core are illustrated as in Figure 10. The two layers above the active core have control rods and blocks in the same place as in the active core, but cooled reflector blocks are used in place of fuel blocks. Even for cooled reflector blocks positioned next to control rods, the standard “reflector block graphite” cross section set is used rather than the “control adjacent” set in order to keep a single composition for all cooled reflector blocks; as these are outside of the active core, the effect on reactivity is expected to be negligible for the purposes of presenting a numerical benchmarking description. The ARI core calculation required 19879 cpu minutes.

Figure 10. All rods in block diagram

Figure 11. Block diagram for some rods in, 3-D core, axial layers 2, 9

The block-averaged fission density values for all three stylized cores are presented in Table 6. For both the ARI and ARO cores, the uncertainty in the fission density values ranged from

0.02% to 0.04%. In the more sharply-peaked SRI core, the uncertainty ranged from 0.01% at the high-flux regions to 0.07% in some of the blocks in the heavily-controlled part of the core. Values are normalized such that the average block fission density in the core is 1.0.

Table 6. Block-averaged fission density values, 3-D stylized cores

Block	1	2	3	4	5	6	7
All Rods Out							
1, 10	0.6898	0.8057	0.5861	0.5631	0.5718	0.6457	0.6147
2, 9	0.9032	1.0662	0.7697	0.7294	0.7396	0.8696	0.8174
3, 8	1.1183	1.3209	0.9527	0.9030	0.9163	1.0775	1.0130
4, 7	1.2699	1.4998	1.0821	1.0253	1.0408	1.2242	1.1507
5, 6	1.3470	1.5912	1.1483	1.0886	1.1040	1.2996	1.2214
Some Rods In							
1, 10	2.4737	2.8796	1.9932	1.9847	2.0311	1.9818	1.9598
2, 9	1.8576	2.2310	1.3863	1.4286	1.4795	1.0823	1.1500
3, 8	0.8107	1.0622	0.7415	0.7595	0.7936	0.5661	0.6114
4, 7	0.3810	0.4933	0.3684	0.3726	0.3883	0.2850	0.3072
5, 6	0.2277	0.2934	0.2220	0.2238	0.2329	0.1722	0.1856
All Rods In							
1, 10	0.5698	0.7089	0.5623	0.5690	0.5915	0.4309	0.4674
2, 9	0.8461	1.0646	0.8378	0.8412	0.8733	0.6498	0.6994
3, 8	1.1015	1.3856	1.0894	1.0947	1.1363	0.8451	0.9103
4, 7	1.2804	1.6105	1.2677	1.2725	1.3205	0.9821	1.0573
5, 6	1.3711	1.7243	1.3575	1.3625	1.4142	1.0526	1.1327

In Tables B1 through B3, found in Appendix B, pin fission density results are presented for the three 3-D core configurations. As a listing of all pins in the core would be exhaustive, both in computational time requirements and space, the only results given are for the axial layer of the core containing the highest flux and power. Calculated uncertainty in these results ranges from 0.10% to 0.17% in the ARO core, 0.05% to 0.10% in the SRI core, and 0.10% to 0.18% in the ARI core. The pin numbering scheme is illustrated by Figure 13. Results in these tables for pin fission density figures are normalized such that the average fuel pin within each individual block is 1.0. Pin fission density values normalized over all pins in the core may be found by multiplying the pin fission density value by the block-averaged fission density value in Table 6. Note that those pins along the line of symmetry are correctly normalized.

Finally, a 2-D stylized core was created based on the 3-D stylized core. It represents, essentially, a slice of the core which extends infinitely in the axial direction. The fuel regions are identical in composition and placement to those in the 3-D core. Three configurations were solved using MCNP and using the 6-group macroscopic cross sections from Appendix A: an all-rods-out configuration, and all-rods-in core, and one with only the center rods in. The ARO and ARI

configurations are exactly as illustrated in Figures 9 and 10. For the SRI configuration, only the center rods are inserted into the core, as shown in Figure 12.

Figure 12. Block diagram for 2-D core with some rods inserted

Table 7. Block-averaged fission density values, 2-D stylized cores

Block	1	2	3	4	5	6	7
ARO	1.0650	1.2600	0.9058	0.8584	0.8705	1.0269	0.9638
SRI	0.8010	0.9360	0.9990	0.8830	0.8843	1.2100	1.1217
ARI	1.0437	1.2926	1.0134	1.0178	1.0572	0.8023	0.8636

All three configurations yielded a pin fission density profile with uncertainty averaging 0.025% for individual pin tallies, and maximum uncertainty in the pin-level data of 0.04%. The eigenvalue uncertainty was found to be 2 pcm. To achieve this level of precision, 250,000 particles were simulated for 500 inactive cycles followed by 6,000 active cycles, for a total of 1.5 billion active particle histories. The block fission density results are presented in Table 7. Pin fission density figures for all three cases are provided in Tables B4-B6. A pin numbering diagram is provided in Figure 13, as 210 fuel pins are present in a standard fuel block and all are listed in each of Tables B4-B6. The numbers in the top row refer to the block, and the numbers in the left column list the pin numbers. All pin fission density figures are normalized such that the average pin in the core has a value of 1.0.

Figure 13. Pin numbering diagram for pin fission density data

It should be noted that in block 2, where there is a reserve shutdown channel, several pins are not present in the fuel block; those are blanked in the table. The same is done for pins in blocks 1, 3, and 5; where due to the core symmetry, only those pins which are within the boundaries of the slice of the core solved are provided. In block 5, where the lines of symmetry run through pins 101-110, the values given are correctly normalized to the whole block.

5. SUMMARY AND CONCLUSIONS

A set of benchmark problems has been presented. Two unique core configurations (all rods out and all rods in) were described for a fully heterogeneous core in continuous energy. Three configurations (all rods out, some rods in, and all rods in) were given for a 3-D multigroup stylization of the core, in which fuel and absorber pins are treated as homogeneous (flux-

averaged), but the blocks composing the core remain highly heterogeneous. Additionally, three 2-D configurations (all rods out, center rods in, and all rods in) were presented.

It is anticipated that these benchmark problems will be used by methods developers, as the prismatic VHTR is a challenging core to model, and whole core models are currently not widely available. Potential applications for this work include use as a standard numerical verification resource for reactor core solution methods and also for cross section generation methods. A variety of issues related to cross section generation can be investigated using this benchmark, such as group structure, the number of groups necessary for a solution of desired accuracy, the necessary order to which to expand the scattering kernel, and homogenization of highly heterogeneous pins and associated complicated reactor geometry.

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APPENDIX A: CROSS SECTION DATA

Cross section data is given for all materials in units of cm^{-1} . Data is presented as group number followed by the macroscopic cross section, or, in the case of the fission spectrum, as the quantity of fission neutrons per group per fission neutron. The scattering matrix is also presented for P0 and P1 scattering.

The colors used to illustrate the material or block in the various figures presented in the paper is given in parentheses for clarification.

Inner fuel (fuel in yellow blocks)

CAPTURE CROSS SECTION

1	1.29633E-04
2	7.84585E-04
3	1.22677E-02
4	1.98430E-03
5	5.80629E-03
6	1.08130E-02

FISSION CROSS SECTION

1	3.30605E-04
2	4.94507E-04
3	4.18507E-03
4	6.24056E-03
5	2.48268E-02
6	5.39230E-02

NU-FISSION CROSS SECTION

1	8.75978E-04
2	1.20327E-03
3	1.01927E-02
4	1.52064E-02
5	6.04956E-02
6	1.31394E-01

FISSION SPECTRUM

1	0.969367608193630
2	3.061677199212420E-002
3	1.561981424628129E-005

4 0.000000000000000E+000
 5 0.000000000000000E+000
 6 0.000000000000000E+000

P0 SCATTERING:

1.60326E-01	1.16923E-02	2.21020E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.62149E-01	7.94082E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.75777E-01	5.94908E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	5.84465E-04	2.37923E-01	3.58179E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	9.27362E-04	2.45405E-01	3.15433E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	7.87841E-02	2.11178E-01

P1 SCATTERING:

2.10489E-02	-3.24888E-03	7.66141E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	1.85639E-02	-2.34063E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.66272E-02	-1.68169E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.93229E-04	1.13352E-02	-8.93634E-03	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-7.72176E-05	-2.96860E-02	-7.58348E-03
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-1.87819E-02	-4.98282E-02

Middle fuel (fuel in aqua blocks)

CAPTURE CROSS SECTION

1 1.28030E-04
 2 7.95885E-04
 3 1.21940E-02
 4 1.98214E-03
 5 5.57356E-03
 6 1.05602E-02

FISSION CROSS SECTION

1 3.23025E-04
 2 4.99872E-04
 3 4.17914E-03
 4 6.21066E-03
 5 2.38835E-02
 6 5.26801E-02

NU-FISSION CROSS SECTION

1 8.54463E-04
 2 1.21631E-03
 3 1.01782E-02
 4 1.51335E-02
 5 5.81968E-02
 6 1.28366E-01

FISSION SPECTRUM

1 0.969314801101188
 2 3.067047740275138E-002
 3 1.469671239748238E-005
 4 0.000000000000000E+000
 5 2.478366340216252E-008
 6 0.000000000000000E+000

P0 SCATTERING:

1.61605E-01	1.17793E-02	5.60222E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.62338E-01	7.94475E-03	0.00000E+00	0.00000E+00	0.00000E+00

0.00000E+00	0.00000E+00	2.75875E-01	5.95029E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	5.88892E-04	2.37946E-01	3.58974E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	9.26591E-04	2.45647E-01	3.15620E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	7.91191E-02	2.12103E-01

P1 SCATTERING:

2.12413E-02	-3.26818E-03	3.25127E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	1.86016E-02	-2.34678E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.66653E-02	-1.67778E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.96356E-04	1.13536E-02	-8.91061E-03	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-7.72556E-05	-2.97309E-02	-7.60206E-03
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-1.88686E-02	-5.00512E-02

Outer fuel (fuel in green blocks)

CAPTURE CROSS SECTION

1	1.28370E-04
2	7.78002E-04
3	1.21394E-02
4	1.98183E-03
5	5.83706E-03
6	1.08275E-02

FISSION CROSS SECTION

1	3.32508E-04
2	4.92273E-04
3	4.18350E-03
4	6.25056E-03
5	2.49620E-02
6	5.39956E-02

NU-FISSION CROSS SECTION

1	8.81339E-04
2	1.19783E-03
3	1.01889E-02
4	1.52307E-02
5	6.08248E-02
6	1.31571E-01

FISSION SPECTRUM

1	0.969360837387438
2	3.062414611195433E-002
3	1.501650060802793E-005
4	0.000000000000000E+000
5	0.000000000000000E+000
6	0.000000000000000E+000

P0 SCATTERING:

1.59884E-01	1.16471E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.61990E-01	7.93533E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.75812E-01	5.94570E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	5.85318E-04	2.37895E-01	3.59055E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	9.32976E-04	2.45296E-01	3.15157E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	7.87611E-02	2.11125E-01

P1 SCATTERING:

2.09414E-02	-3.23034E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
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0.00000E+00	1.85611E-02	-2.34093E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.66766E-02	-1.67325E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.97655E-04	1.14205E-02	-8.94440E-03	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-7.81716E-05	-2.96594E-02	-7.58906E-03
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-1.88138E-02	-4.97992E-02

Burnable absorber/poison pins (dark green material in all fuel blocks)

CAPTURE CROSS SECTION

1	3.93318E-04
2	4.01561E-03
3	6.06652E-02
4	2.95121E-01
5	5.61362E-01
6	8.46069E-01

P0 SCATTERING:

1.22600E-01	8.94531E-03	3.49147E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.07325E-01	6.27909E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.16128E-01	4.66294E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.87089E-04	1.93308E-01	2.91572E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	7.66395E-04	2.02635E-01	2.60543E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	6.61547E-02	1.77300E-01

P1 SCATTERING:

1.60769E-02	-2.47491E-03	5.04902E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	1.47206E-02	-1.85069E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.30263E-02	-1.31769E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.63363E-04	9.17567E-03	-7.24006E-03	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-6.43132E-05	-2.44902E-02	-6.27652E-03
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-1.57961E-02	-4.17978E-02

Inner fuel block graphite (graphite in yellow blocks)

CAPTURE CROSS SECTION

1	2.56623E-05
2	6.20603E-07
3	1.07303E-05
4	5.51553E-05
5	1.28799E-04
6	2.63572E-04

P0 SCATTERING:

2.28798E-01	1.66939E-02	6.51582E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	3.90649E-01	1.18313E-02	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.04628E-01	8.72981E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	9.04253E-04	3.58866E-01	5.41286E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	1.39103E-03	3.67789E-01	4.72892E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.17813E-01	3.15748E-01

P1 SCATTERING:

3.00030E-02	-4.61872E-03	9.42255E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.77371E-02	-3.48715E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.43875E-02	-2.46694E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	3.03275E-04	1.70341E-02	-1.34408E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-1.16730E-04	-4.44505E-02	-1.13921E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-2.81308E-02	-7.44364E-02

Middle fuel block graphite (graphite in aqua blocks)

CAPTURE CROSS SECTION

1 2.42457E-05
2 6.31940E-07
3 1.05893E-05
4 5.50766E-05
5 1.24333E-04
6 2.60005E-04

P0 SCATTERING:

2.30275E-01	1.68016E-02	6.55788E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	3.90891E-01	1.18386E-02	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.04628E-01	8.72981E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	9.04251E-04	3.58865E-01	5.41284E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	1.39020E-03	3.67569E-01	4.72609E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.17772E-01	3.15640E-01

P1 SCATTERING:

3.01967E-02	-4.64853E-03	9.48336E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.77542E-02	-3.48931E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.43875E-02	-2.46694E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	3.03274E-04	1.70340E-02	-1.34407E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-1.16661E-04	-4.44239E-02	-1.13852E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-2.81212E-02	-7.44108E-02

Outer fuel block graphite (graphite in green blocks)

CAPTURE CROSS SECTION

1 2.64202E-05
2 6.17122E-07
3 1.06817E-05
4 5.51786E-05
5 1.29187E-04
6 2.63445E-04

P0 SCATTERING:

2.28373E-01	1.66629E-02	6.50372E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	3.90572E-01	1.18290E-02	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.04627E-01	8.72981E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	9.04253E-04	3.58866E-01	5.41286E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	1.39110E-03	3.67807E-01	4.72917E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.17820E-01	3.15766E-01

P1 SCATTERING

2.99473E-02	-4.61016E-03	9.40505E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.77315E-02	-3.48645E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.43875E-02	-2.46693E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	3.03274E-04	1.70341E-02	-1.34408E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-1.16736E-04	-4.44527E-02	-1.13926E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-2.81324E-02	-7.44406E-02

Reflector blocks (light gray blocks)

CAPTURE CROSS SECTION

1 2.00647E-05
 2 6.84947E-07
 3 1.26059E-05
 4 5.58632E-05
 5 1.39415E-04
 6 2.73960E-04

P0 SCATTERING

2.35193E-01	1.71605E-02	6.69795E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	3.91881E-01	1.18686E-02	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.04632E-01	8.72991E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	9.04278E-04	3.58876E-01	5.41301E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	1.39306E-03	3.68327E-01	4.73585E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.17997E-01	3.16241E-01

P1 SCATTERING

3.08417E-02	-4.74784E-03	9.68593E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.78245E-02	-3.49813E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.43878E-02	-2.46696E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	3.03283E-04	1.70345E-02	-1.34412E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-1.16901E-04	-4.45155E-02	-1.14087E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-2.81747E-02	-7.45524E-02

Hhelium coolant (white)

CAPTURE CROSS SECTION

1 0.00000E+00
 2 0.00000E+00
 3 0.00000E+00
 4 0.00000E+00
 5 0.00000E+00
 6 0.00000E+00

P0 SCATTERING

8.28116E-05	6.04221E-06	2.35835E-11	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	1.98704E-05	6.01801E-07	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.99748E-05	4.30954E-07	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.46919E-08	1.77366E-05	2.67526E-06	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	6.92142E-08	1.83003E-05	2.35300E-06
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	5.93951E-06	1.59184E-05

P1 SCATTERING

1.08594E-05	-1.67171E-06	3.41041E-12	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	1.41085E-06	-1.77374E-07	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.20391E-06	-1.21782E-07	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.49891E-08	8.41894E-07	-6.64300E-07	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-5.80821E-09	-2.21175E-06	-5.66841E-07
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-1.41821E-06	-3.75269E-06

Control rod material (rust-colored circles)

CAPTURE CROSS SECTION

1 8.93894E-03
 2 6.55804E-02
 3 3.37974E-01
 4 5.04857E-01
 5 5.62358E-01

6 6.49513E-01

P0 SCATTERING

2.10887E-01	1.53620E-02	1.59075E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	4.26659E-01	1.28697E-02	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	9.12941E-01	1.96927E-02	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.46992E-03	9.87545E-01	1.49592E-01	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	3.57363E-03	1.02555E+00	1.33564E-01
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	3.18910E-01	8.56222E-01

P1 SCATTERING

2.76837E-02	-4.25631E-03	5.65739E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	3.02101E-02	-3.79549E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	5.50224E-02	-5.56723E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	8.19000E-04	4.71136E-02	-3.71382E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-3.07292E-04	-1.24835E-01	-3.21426E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-7.60590E-02	-2.02085E-01

Ccontrol block graphite (gray, but in blocks with rust-colored circle)

CAPTURE CROSS SECTION

1	1.92080E-05
2	6.62029E-07
3	1.20627E-05
4	5.56348E-05
5	1.37995E-04
6	2.73371E-04

P0 SCATTERING

2.36710E-01	1.72430E-02	1.78553E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	3.91605E-01	1.18124E-02	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.04632E-01	8.72812E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	8.97079E-04	3.58678E-01	5.43320E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	1.28170E-03	3.67818E-01	4.79032E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.17823E-01	3.16336E-01

P1 SCATTERING

3.10735E-02	-4.77748E-03	6.35012E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.77280E-02	-3.48366E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.43869E-02	-2.46749E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.97462E-04	1.71117E-02	-1.34886E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-1.10212E-04	-4.47726E-02	-1.15281E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-2.81004E-02	-7.46612E-02

Fuel in blocks adjacent to control rods (lavender blocks)

CAPTURE CROSS SECTION

1	1.28170E-04
2	7.82934E-04
3	1.22034E-02
4	1.96719E-03
5	5.65078E-03
6	1.06514E-02

FISSION CROSS SECTION

1	3.25320E-04
2	4.93965E-04

3 4.15630E-03
 4 6.18107E-03
 5 2.41905E-02
 6 5.31184E-02

NU-FISSION CROSS SECTION

1 8.61425E-04
 2 1.20194E-03
 3 1.01226E-02
 4 1.50614E-02
 5 5.89450E-02
 6 1.29434E-01

FISSION SPECTRUM

1 0.969394207687676
 2 3.059078289228168E-002
 3 1.500942004253539E-005
 4 0.000000000000000E+000
 5 0.000000000000000E+000
 6 0.000000000000000E+000

P0 SCATTERING

1.61333E-01	1.17633E-02	2.43156E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.63137E-01	7.93873E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.76756E-01	5.96534E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	5.91983E-04	2.38495E-01	3.61417E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	8.57488E-04	2.45929E-01	3.19836E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	7.91005E-02	2.12477E-01

P1 SCATTERING

2.11391E-02	-3.26180E-03	1.41419E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	1.85920E-02	-2.33974E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.66799E-02	-1.68066E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	1.97098E-04	1.14028E-02	-8.99168E-03	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-7.25913E-05	-2.99652E-02	-7.69676E-03
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-1.88585E-02	-5.01497E-02

Graphite in fuel blocks adjacent to control rods (lavender blocks)

CAPTURE CROSS SECTION

1 2.46618E-05
 2 6.25329E-07
 3 1.06807E-05
 4 5.51186E-05
 5 1.26165E-04
 6 2.61207E-04

P0 SCATTERING

2.29282E-01	1.67020E-02	1.72950E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	3.90790E-01	1.17878E-02	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.04629E-01	8.72808E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	8.97061E-04	3.58670E-01	5.43309E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	1.27961E-03	3.67219E-01	4.78252E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.17622E-01	3.15795E-01

P1 SCATTERING

3.00985E-02	-4.62757E-03	6.15086E-09	0.00000E+00	0.00000E+00	0.00000E+00
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0.00000E+00	2.76703E-02	-3.47641E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.43867E-02	-2.46748E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.97456E-04	1.71114E-02	-1.34884E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-1.10032E-04	-4.46997E-02	-1.15093E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-2.80524E-02	-7.45337E-02

Structural reflector block graphite (dark gray blocks)

CAPTURE CROSS SECTION

1	2.52143E-05
2	7.80193E-07
3	1.52184E-05
4	6.30057E-05
5	1.44666E-04
6	2.80568E-04

P0 SCATTERING

2.25266E-01	1.64362E-02	6.41527E-08	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	4.02031E-01	1.21760E-02	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	4.13940E-01	8.93073E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	9.25284E-04	3.67211E-01	5.53872E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	1.42550E-03	3.76900E-01	4.84607E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.20707E-01	3.23505E-01

P1 SCATTERING

2.95396E-02	-4.54741E-03	9.27714E-09	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	2.85452E-02	-3.58874E-03	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	2.49486E-02	-2.52372E-03	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	3.10328E-04	1.74302E-02	-1.37532E-02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	-1.19623E-04	-4.55517E-02	-1.16743E-02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	-2.88219E-02	-7.62649E-02

APPENDIX B: PIN FISSION DENSITY FIGURES

Fission density values at the pin level are presented in this appendix.

Table B1. Block-wide pin fission density values, 3-D stylized ARO core, axial layer 5 and 6

#	1	2	3	4	5	6	7
1		1.0347		0.9082	0.9202	1.1145	0.7790
2		1.0073		0.9951	1.0014	1.2840	0.8741
3		0.9695		1.0073	1.0195	1.3369	0.9050
4		0.8939		0.9976	1.0065	1.3995	0.9460
5		0.8466		0.9734	0.9810	1.4156	0.9659
6		0.7265		0.8783	0.8778	1.3772	0.9707
7		1.2543		0.9182	0.9333	0.9471	0.7780
8		1.0839		0.9588	0.9690	1.0972	0.8247
9		1.0427		0.9843	0.9924	1.1636	0.8590
10		0.9610		1.0030	1.0102	1.2479	0.9088
11		0.9177		0.9967	1.0027	1.2763	0.9308
12		0.8291		0.9576	0.9634	1.3131	0.9762
13		0.7796		0.9261	0.9301	1.3173	1.0020
14		0.7029		0.8683	0.8689	1.3751	1.1475

15		1.2586		0.9673	0.9803	0.9744	0.8207
16		1.1521		0.9623	0.9711	1.0056	0.8232
17		1.0503		0.9940	1.0028	1.1064	0.8730
18		1.0002		0.9981	1.0052	1.1419	0.8966
19		0.9053		0.9868	0.9947	1.1954	0.9406
20		0.8632		0.9723	0.9784	1.2202	0.9682
21		0.7740		0.9224	0.9281	1.2473	1.0354
22		0.7533		0.9155	0.9218	1.3180	1.1339
23		1.4857		1.0220	1.0394	0.9411	0.8616
24		1.3537		1.0015	1.0157	0.9471	0.8484
25		1.1869		0.9941	1.0026	0.9992	0.8546
26		1.1146		0.9976	1.0055	1.0286	0.8694
27		0.9987		1.0020	1.0094	1.0922	0.9092
28		0.9467		0.9954	1.0046	1.1196	0.9299
29		0.8522		0.9695	0.9785	1.1625	0.9866
30		0.8167		0.9558	0.9619	1.1962	1.0341
31		0.7737		0.9415	0.9472	1.3203	1.2061
32		0.7691		0.9511	0.9558	1.4242	1.3360
33		1.5693		1.0508	1.0627	0.9232	0.8804
34				1.0136	1.0233	0.9368	0.8601
35				1.0078	1.0144	0.9532	0.8599
36		1.1408		1.0090	1.0175	1.0057	0.8888
37		1.0651		1.0096	1.0158	1.0302	0.9073
38		0.9386		0.9973	1.0059	1.0793	0.9483
39		0.8897		0.9891	0.9960	1.1048	0.9795
40		0.8153		0.9635	0.9686	1.1704	1.0717
41		0.7952		0.9573	0.9632	1.2316	1.1529
42		0.7789		0.9692	0.9733	1.4226	1.4000
43				1.0415	1.0528	0.9004	0.8758
44				1.0282	1.0374	0.9076	0.8674
45				1.0205	1.0271	0.9403	0.8773
46				1.0166	1.0240	0.9615	0.8881
47		1.0659		1.0166	1.0229	1.0069	0.9240
48		0.9894		1.0122	1.0198	1.0311	0.9463
49		0.8814		0.9899	0.9965	1.0779	1.0043
50		0.8436		0.9775	0.9869	1.1142	1.0502
51		0.7958		0.9651	0.9692	1.2237	1.1937
52		0.7806		0.9640	0.9689	1.3143	1.3052
53		1.6590		1.0606	1.0718	0.8766	0.8860
54				1.0459	1.0533	0.8789	0.8770
55				1.0330	1.0367	0.8954	0.8738
56				1.0313	1.0330	0.9098	0.8793
57				1.0313	1.0369	0.9516	0.9072
58		1.1440		1.0318	1.0350	0.9707	0.9243
59		0.9771		1.0186	1.0250	1.0144	0.9666

60		0.9180		1.0093	1.0153	1.0389	0.9956
61		0.8366		0.9814	0.9878	1.0989	1.0768
62		0.8095		0.9706	0.9787	1.1533	1.1416
63	0.8532	0.7779	1.3103	0.9628	0.9678	1.3085	1.3357
64	0.8568	0.7698	1.4174	0.9641	0.9685	1.4152	1.4623
65		1.6906		1.0466	1.0547	0.8450	0.8725
66				1.0389	1.0456	0.8611	0.8723
67				1.0374	1.0423	0.8720	0.8741
68				1.0394	1.0424	0.9014	0.8930
69				1.0411	1.0447	0.9212	0.9057
70		1.1128		1.0478	1.0543	0.9711	0.9504
71		1.0266		1.0424	1.0485	0.9911	0.9709
72		0.9039		1.0100	1.0168	1.0267	1.0171
73		0.8601		0.9968	1.0022	1.0568	1.0516
74	0.8637	0.8004	1.1585	0.9706	0.9740	1.1481	1.1705
75	0.8549	0.7799	1.2169	0.9601	0.9666	1.2130	1.2525
76	0.8413	0.7504	1.3806	0.9432	0.9470	1.4004	1.4777
77		1.5651		1.0309	1.0340	0.8252	0.8577
78				1.0361	1.0394	0.8383	0.8646
79				1.0409	1.0422	0.8644	0.8774
80				1.0430	1.0474	0.8794	0.8885
81				1.0575	1.0619	0.9244	0.9270
82		1.1899		1.0722	1.0759	0.9545	0.9567
83		1.0099		1.0565	1.0631	0.9937	1.0013
84		0.9395		1.0331	1.0400	1.0061	1.0146
85	0.8913	0.8463	1.0807	0.9915	0.9987	1.0513	1.0783
86	0.8736	0.8121	1.1077	0.9767	0.9812	1.0894	1.1247
87	0.8474	0.7677	1.1942	0.9502	0.9537	1.2127	1.2782
88	0.8324	0.7454	1.2584	0.9324	0.9383	1.2920	1.3724
89		1.6645		0.9609	0.9624	0.7500	0.7944
90		1.5766		1.0046	1.0045	0.7915	0.8328
91				1.0311	1.0312	0.8286	0.8621
92				1.0428	1.0432	0.8450	0.8744
93				1.0510	1.0537	0.8773	0.9002
94				1.0643	1.0656	0.9013	0.9236
95	0.9359	0.9131	1.0543	1.0314	1.0359	1.0014	1.0337
96	0.9069	0.8638	1.0561	1.0055	1.0099	1.0198	1.0569
97	0.8693	0.7994	1.0985	0.9714	0.9741	1.0960	1.1521
98	0.8510	0.7724	1.1265	0.9510	0.9548	1.1463	1.2142
99	0.8065	0.7191	1.1962	0.9037	0.9080	1.2803	1.3804
100	0.7614	0.6732	1.2175	0.8533	0.8579	1.3335	1.4434
101		1.4884		1.0034	0.9999	0.7855	0.8318
102				1.0282	1.0282	0.8133	0.8589
103				1.0444	1.0395	0.8407	0.8809
104		1.4308		1.0524	1.0499	0.8562	0.8952

105		1.2157		1.0822	1.0807	0.9078	0.9451
106	0.9660	0.9411	1.0514	1.0554	1.0565	0.9859	1.0337
107	0.9048	0.8448	1.0503	1.0005	1.0036	1.0212	1.0801
108	0.8821	0.8113	1.0595	0.9798	0.9841	1.0563	1.1213
109	0.8430	0.7590	1.0962	0.9430	0.9458	1.1631	1.2494
110	0.8096	0.7232	1.0984	0.9057	0.9086	1.2059	1.3079
111		1.6689		0.9676		0.7407	0.7967
112		1.5789		1.0133		0.7797	0.8359
113		1.3854		1.0353		0.8144	0.8650
114		1.3210		1.0447		0.8287	0.8763
115		1.2329		1.0558		0.8537	0.9017
116		1.1830		1.0687		0.8787	0.9243
117	0.9487	0.9010	1.0312	1.0347		0.9760	1.0367
118	0.9191	0.8591	1.0275	1.0088		0.9954	1.0600
119	0.8780	0.7980	1.0457	0.9750		1.0722	1.1555
120	0.8581	0.7686	1.0530	0.9514		1.1246	1.2176
121	0.8114	0.7186	1.0722	0.9048		1.2606	1.3834
122	0.7625	0.6740	1.0402	0.8539		1.3138	1.4519
123		1.5690		1.0448		0.8021	0.8598
124		1.4456		1.0450		0.8111	0.8699
125		1.2736		1.0460		0.8268	0.8806
126		1.2180		1.0503		0.8386	0.8935
127	1.0782	1.1162	0.9940	1.0663		0.8753	0.9324
128	1.0592	1.0739	1.0117	1.0775		0.9029	0.9614
129	1.0043	0.9688	1.0250	1.0655		0.9422	1.0050
130	0.9653	0.9131	1.0180	1.0396		0.9514	1.0188
131	0.9089	0.8354	1.0120	0.9987		1.0029	1.0803
132	0.8891	0.8061	1.0177	0.9810		1.0444	1.1295
133	0.8579	0.7640	1.0398	0.9531		1.1705	1.2805
134	0.8407	0.7453	1.0468	0.9358		1.2563	1.3804
135		1.6896		1.0648		0.8119	0.8768
136		1.4072		1.0533		0.8164	0.8772
137		1.3080		1.0489		0.8185	0.8816
138	1.1430	1.1622	0.9677	1.0482		0.8370	0.8965
139	1.0987	1.1076	0.9764	1.0540		0.8494	0.9118
140	1.0381	1.0130	0.9942	1.0575		0.8902	0.9556
141	1.0089	0.9645	0.9990	1.0537		0.9098	0.9775
142	0.9475	0.8782	0.9945	1.0190		0.9479	1.0225
143	0.9223	0.8424	0.9926	1.0037		0.9794	1.0595
144	0.8850	0.7943	1.0034	0.9767		1.0788	1.1753
145	0.8728	0.7766	1.0115	0.9646		1.1472	1.2588
146	0.8529	0.7500	1.0393	0.9473		1.3417	1.4871
147		1.6509		1.0840		0.8268	0.8933
148		1.4952		1.0645		0.8175	0.8854
149	1.2731	1.2577	0.9572	1.0463		0.8163	0.8823

150	1.1930	1.1782	0.9571	1.0418		0.8226	0.8873
151	1.0895	1.0559	0.9711	1.0453		0.8466	0.9150
152	1.0510	1.0067	0.9740	1.0437		0.8635	0.9326
153	0.9868	0.9206	0.9789	1.0295		0.9014	0.9754
154	0.9589	0.8840	0.9781	1.0186		0.9269	1.0024
155	0.9109	0.8226	0.9761	0.9905		0.9941	1.0870
156	0.8965	0.8018	0.9828	0.9791		1.0518	1.1500
157	0.8768	0.7745	1.0013	0.9679		1.2158	1.3412
158	0.8749	0.7698	1.0204	0.9686		1.3219	1.4682
159	1.5007	1.4473	0.9637	1.0610		0.8158	0.8837
160	1.3630	1.3113	0.9562	1.0450		0.8127	0.8780
161	1.1807	1.1313	0.9533	1.0345		0.8192	0.8869
162	1.1176	1.0659	0.9571	1.0347		0.8299	0.8982
163	1.0363	0.9653	0.9645	1.0314		0.8621	0.9348
164	0.9998	0.9262	0.9645	1.0233		0.8801	0.9567
165	0.9439	0.8538	0.9620	1.0033		0.9308	1.0154
166	0.9204	0.8270	0.9621	0.9907		0.9715	1.0593
167	0.8861	0.7873	0.9681	0.9722		1.0945	1.2016
168	0.8825	0.7782	0.9801	0.9712		1.1855	1.3106
169	1.6532	1.5530	0.9716	1.0749		0.8214	0.8907
170	1.3348	1.2539	0.9457	1.0337		0.8038	0.8698
171	1.2312	1.1547	0.9405	1.0234		0.8039	0.8720
172	1.1043	1.0216	0.9484	1.0256		0.8301	0.8994
173	1.0585	0.9728	0.9539	1.0240		0.8443	0.9169
174	0.9873	0.8934	0.9520	1.0121		0.8823	0.9621
175	0.9565	0.8598	0.9520	1.0034		0.9089	0.9929
176	0.9040	0.8029	0.9409	0.9720		0.9903	1.0859
177	0.8905	0.7857	0.9451	0.9685		1.0569	1.1643
178	0.8867	0.7777	0.9736	0.9751		1.2674	1.4044
179	1.6031	1.4741	0.9522	1.0499		0.8046	0.8730
180	1.4274	1.3170	0.9354	1.0268		0.7937	0.8596
181	1.2002	1.1003	0.9320	1.0129		0.8003	0.8674
182	1.1333	1.0330	0.9369	1.0139		0.8113	0.8811
183	1.0439	0.9413	0.9488	1.0174		0.8476	0.9237
184	1.0070	0.9033	0.9477	1.0118		0.8677	0.9455
185	0.9392	0.8321	0.9332	0.9829		0.9154	1.0028
186	0.9113	0.8034	0.9251	0.9705		0.9558	1.0518
187	0.8765	0.7693	0.9258	0.9541		1.1031	1.2183
188	0.8786	0.7659	0.9395	0.9621		1.2161	1.3452
189	1.3567	1.2268	0.9068	0.9900		0.7700	0.8362
190	1.2242	1.1054	0.9039	0.9832		0.7711	0.8362
191	1.1185	1.0004	0.9369	1.0131		0.8150	0.8888
192	1.0721	0.9555	0.9445	1.0155		0.8349	0.9109
193	0.9972	0.8808	0.9398	1.0044		0.8753	0.9577
194	0.9600	0.8445	0.9305	0.9897		0.8993	0.9851

195	0.8767	0.7661	0.8883	0.9358		0.9592	1.0514
196	0.8614	0.7516	0.8906	0.9295		1.0436	1.1493
197	1.3993	1.2525	0.8641	0.9438		0.7287	0.7903
198	1.1933	1.0574	0.9032	0.9817		0.7733	0.8392
199	1.1504	1.0134	0.9280	1.0057		0.8027	0.8741
200	1.0671	0.9370	0.9459	1.0209		0.8477	0.9255
201	1.0270	0.8985	0.9460	1.0139		0.8692	0.9484
202	0.9423	0.8190	0.9147	0.9751		0.9082	0.9985
203	0.8925	0.7742	0.8857	0.9416		0.9331	1.0201
204	0.8121	0.7025	0.8380	0.8799		1.0615	1.1686
205	1.1746	1.0286	0.8580	0.9315		0.7304	0.7927
206	1.1482	0.9919	0.9397	1.0160		0.8169	0.8886
207	1.1075	0.9577	0.9525	1.0293		0.8451	0.9206
208	1.0283	0.8864	0.9481	1.0191		0.8861	0.9660
209	0.9762	0.8410	0.9278	0.9934		0.9014	0.9882
210	0.8425	0.7263	0.8348	0.8913		0.9040	0.9896

Table B2. Block-wide pin fission density values, 3-D stylized SRI core, axial layer 1 and 10

#	1	2	3	4	5	6	7
1		1.0234		0.9122	0.9260	1.1244	0.8210
2		1.0086		0.9922	1.0090	1.2662	0.9011
3		0.9781		1.0024	1.0209	1.3019	0.9209
4		0.9082		0.9876	1.0044	1.3266	0.9369
5		0.8626		0.9614	0.9765	1.3217	0.9378
6		0.7433		0.8543	0.8687	1.2560	0.9081
7		1.2208		0.9284	0.9434	0.9882	0.8348
8		1.0739		0.9635	0.9776	1.1094	0.8687
9		1.0403		0.9856	1.0001	1.1608	0.8922
10		0.9674		0.9967	1.0114	1.2138	0.9200
11		0.9297		0.9884	1.0036	1.2255	0.9297
12		0.8469		0.9459	0.9592	1.2261	0.9410
13		0.7991		0.9075	0.9214	1.2116	0.9467
14		0.7224		0.8387	0.8542	1.2186	1.0315
15		1.2306		0.9792	0.9922	1.0156	0.8814
16		1.1374		0.9702	0.9832	1.0326	0.8730
17		1.0473		0.9960	1.0100	1.1085	0.9043
18		1.0042		0.9977	1.0128	1.1300	0.9155
19		0.9186		0.9802	0.9954	1.1517	0.9328
20		0.8780		0.9626	0.9773	1.1555	0.9441
21		0.7931		0.9037	0.9173	1.1437	0.9710
22		0.7755		0.8939	0.9068	1.1844	1.0332
23		1.4405		1.0375	1.0509	1.0065	0.9335
24		1.3230		1.0162	1.0299	1.0029	0.9135

25		1.1763		1.0020	1.0136	1.0288	0.9029
26		1.1074		1.0014	1.0142	1.0483	0.9074
27		1.0038		1.0006	1.0139	1.0817	0.9252
28		0.9561		0.9915	1.0050	1.0904	0.9339
29		0.8705		0.9593	0.9736	1.1002	0.9553
30		0.8360		0.9427	0.9549	1.1118	0.9801
31		0.7938		0.9186	0.9319	1.1802	1.0876
32		0.7910		0.9203	0.9330	1.2461	1.1766
33		1.5181		1.0647	1.0774	0.9979	0.9602
34				1.0270	1.0377	0.9913	0.9237
35				1.0172	1.0276	0.9944	0.9150
36		1.1338		1.0154	1.0264	1.0248	0.9226
37		1.0658		1.0109	1.0228	1.0339	0.9268
38		0.9499		0.9930	1.0054	1.0507	0.9438
39		0.9056		0.9807	0.9925	1.0608	0.9580
40		0.8358		0.9453	0.9586	1.0835	1.0053
41		0.8162		0.9366	0.9502	1.1194	1.0559
42		0.8026		0.9324	0.9482	1.2403	1.2208
43				1.0568	1.0669	0.9765	0.9510
44				1.0440	1.0515	0.9724	0.9366
45				1.0317	1.0391	0.9836	0.9278
46				1.0269	1.0350	0.9922	0.9292
47		1.0669		1.0183	1.0288	1.0115	0.9410
48		0.9957		1.0089	1.0203	1.0203	0.9500
49		0.8980		0.9823	0.9930	1.0322	0.9733
50		0.8635		0.9663	0.9797	1.0479	0.9979
51		0.8177		0.9416	0.9547	1.1076	1.0854
52		0.8050		0.9351	0.9493	1.1621	1.1569
53		1.5917		1.0773	1.0853	0.9689	0.9720
54				1.0638	1.0712	0.9624	0.9576
55				1.0483	1.0532	0.9604	0.9393
56				1.0425	1.0472	0.9641	0.9366
57				1.0402	1.0471	0.9814	0.9438
58		1.1385		1.0337	1.0424	0.9896	0.9488
59		0.9859		1.0157	1.0263	1.0024	0.9639
60		0.9335		1.0023	1.0113	1.0074	0.9757
61		0.8564		0.9678	0.9777	1.0320	1.0181
62		0.8326		0.9536	0.9635	1.0607	1.0564
63	0.8626	0.8009	1.2068	0.9316	0.9455	1.1544	1.1807
64	0.8622	0.7935	1.2859	0.9270	0.9404	1.2241	1.2667
65		1.6126		1.0648	1.0701	0.9413	0.9589
66				1.0565	1.0607	0.9428	0.9486
67				1.0533	1.0567	0.9448	0.9452
68				1.0512	1.0550	0.9561	0.9456
69				1.0502	1.0563	0.9633	0.9497

70		1.1114		1.0497	1.0567	0.9850	0.9685
71		1.0328		1.0398	1.0470	0.9919	0.9780
72		0.9190		1.0026	1.0111	0.9964	0.9912
73		0.8786		0.9852	0.9934	1.0057	1.0089
74	0.8769	0.8242	1.0939	0.9502	0.9602	1.0523	1.0760
75	0.8645	0.8036	1.1358	0.9342	0.9449	1.0931	1.1294
76	0.8446	0.7736	1.2546	0.9062	0.9186	1.2126	1.2794
77		1.5051		1.0497	1.0514	0.9201	0.9432
78				1.0545	1.0555	0.9266	0.9461
79				1.0548	1.0565	0.9354	0.9468
80				1.0574	1.0605	0.9422	0.9489
81				1.0667	1.0713	0.9656	0.9671
82		1.1838		1.0744	1.0797	0.9820	0.9850
83		1.0174		1.0537	1.0607	0.9925	1.0010
84		0.9509		1.0277	1.0341	0.9883	1.0003
85	0.9047	0.8652	1.0448	0.9813	0.9886	0.9992	1.0239
86	0.8875	0.8352	1.0606	0.9602	0.9696	1.0183	1.0540
87	0.8564	0.7905	1.1184	0.9231	0.9329	1.0888	1.1470
88	0.8402	0.7696	1.1607	0.9016	0.9118	1.1397	1.2126
89		1.5745		0.9781	0.9761	0.8474	0.8801
90		1.5044		1.0244	1.0230	0.8882	0.9211
91				1.0510	1.0488	0.9154	0.9412
92				1.0580	1.0560	0.9244	0.9481
93				1.0639	1.0644	0.9378	0.9572
94				1.0738	1.0759	0.9532	0.9706
95	0.9480	0.9278	1.0381	1.0251	1.0288	0.9799	1.0143
96	0.9218	0.8835	1.0322	0.9963	1.0029	0.9824	1.0202
97	0.8832	0.8235	1.0514	0.9536	0.9609	1.0196	1.0738
98	0.8628	0.7960	1.0647	0.9296	0.9376	1.0467	1.1116
99	0.8151	0.7422	1.1066	0.8727	0.8802	1.1275	1.2135
100	0.7653	0.6942	1.1120	0.8168	0.8250	1.1554	1.2512
101		1.4281		1.0233	1.0175	0.8801	0.9163
102		1.3849		1.0490	1.0446	0.9049	0.9391
103				1.0607	1.0569	0.9200	0.9491
104				1.0662	1.0643	0.9275	0.9579
105		1.2063		1.0879	1.0895	0.9568	0.9877
106	0.9765	0.9551	1.0443	1.0469	1.0490	0.9796	1.0215
107	0.9178	0.8658	1.0246	0.9878	0.9923	0.9806	1.0353
108	0.8959	0.8348	1.0265	0.9658	0.9713	0.9974	1.0578
109	0.8563	0.7823	1.0421	0.9194	0.9260	1.0559	1.1387
110	0.8218	0.7468	1.0360	0.8793	0.8859	1.0793	1.1699
111		1.5748		0.9872		0.8428	0.8833
112		1.5020		1.0322		0.8831	0.9238
113		1.3432		1.0561		0.9057	0.9448
114		1.2904		1.0625		0.9133	0.9505

115		1.2159		1.0677		0.9236	0.9605
116		1.1724		1.0779		0.9360	0.9750
117	0.9607	0.9197	1.0250	1.0277		0.9652	1.0195
118	0.9326	0.8785	1.0142	1.0003		0.9683	1.0271
119	0.8919	0.8213	1.0139	0.9577		1.0094	1.0840
120	0.8707	0.7950	1.0138	0.9337		1.0379	1.1230
121	0.8205	0.7421	1.0106	0.8753		1.1234	1.2321
122	0.7711	0.6946	0.9716	0.8195		1.1552	1.2748
123		1.4948		1.0626		0.9057	0.9514
124		1.3898		1.0657		0.9091	0.9517
125		1.2473		1.0645		0.9095	0.9524
126		1.1992		1.0661		0.9149	0.9577
127	1.0767	1.1100	1.0226	1.0750		0.9305	0.9772
128	1.0621	1.0738	1.0370	1.0832		0.9463	0.9958
129	1.0120	0.9797	1.0338	1.0648		0.9560	1.0135
130	0.9764	0.9292	1.0191	1.0363		0.9536	1.0147
131	0.9246	0.8577	1.0009	0.9896		0.9705	1.0416
132	0.9042	0.8308	0.9967	0.9693		0.9937	1.0722
133	0.8712	0.7900	1.0007	0.9322		1.0734	1.1739
134	0.8527	0.7692	0.9989	0.9097		1.1308	1.2462
135		1.5995		1.0856		0.9225	0.9695
136		1.3581		1.0729		0.9115	0.9592
137		1.2711		1.0674		0.9090	0.9553
138	1.1309	1.1484	1.0067	1.0641		0.9083	0.9577
139	1.0934	1.1000	1.0089	1.0636		0.9132	0.9639
140	1.0421	1.0171	1.0193	1.0626		0.9297	0.9852
141	1.0158	0.9757	1.0171	1.0530		0.9355	0.9950
142	0.9588	0.8947	0.9979	1.0155		0.9452	1.0133
143	0.9352	0.8642	0.9904	0.9958		0.9585	1.0331
144	0.8981	0.8187	0.9853	0.9615		1.0165	1.1088
145	0.8858	0.8014	0.9837	0.9470		1.0644	1.1660
146	0.8619	0.7756	0.9920	0.9169		1.2022	1.3334
147		1.5690		1.1045		0.9361	0.9853
148		1.4316		1.0861		0.9226	0.9707
149	1.2422	1.2285	1.0027	1.0661		0.9056	0.9536
150	1.1740	1.1569	0.9997	1.0599		0.9017	0.9516
151	1.0857	1.0535	1.0040	1.0560		0.9072	0.9604
152	1.0505	1.0108	1.0035	1.0498		0.9126	0.9686
153	0.9963	0.9341	0.9973	1.0324		0.9239	0.9888
154	0.9696	0.9012	0.9902	1.0164		0.9333	1.0031
155	0.9232	0.8437	0.9758	0.9831		0.9683	1.0507
156	0.9092	0.8250	0.9726	0.9680		1.0034	1.0952
157	0.8892	0.7994	0.9778	0.9470		1.1156	1.2347
158	0.8857	0.7937	0.9847	0.9414		1.1971	1.3296
159	1.4391	1.3876	1.0159	1.0837		0.9176	0.9674

160	1.3196	1.2724	1.0039	1.0666		0.9044	0.9552
161	1.1628	1.1148	0.9946	1.0529		0.8960	0.9475
162	1.1075	1.0585	0.9939	1.0482		0.8953	0.9498
163	1.0373	0.9737	0.9943	1.0393		0.9058	0.9648
164	1.0074	0.9373	0.9893	1.0300		0.9128	0.9761
165	0.9535	0.8729	0.9732	1.0002		0.9321	1.0077
166	0.9325	0.8475	0.9663	0.9848		0.9555	1.0371
167	0.9021	0.8120	0.9587	0.9597		1.0340	1.1362
168	0.8960	0.8037	0.9630	0.9536		1.0999	1.2186
169	1.5724	1.4815	1.0279	1.0956		0.9281	0.9790
170	1.2971	1.2209	0.9934	1.0541		0.8933	0.9438
171	1.2051	1.1321	0.9843	1.0431		0.8849	0.9377
172	1.0975	1.0206	0.9885	1.0393		0.8914	0.9466
173	1.0563	0.9784	0.9868	1.0349		0.8962	0.9550
174	0.9936	0.9074	0.9776	1.0158		0.9104	0.9777
175	0.9646	0.8773	0.9685	1.0029		0.9222	0.9954
176	0.9154	0.8239	0.9457	0.9676		0.9653	1.0532
177	0.9028	0.8095	0.9435	0.9583		1.0109	1.1117
178	0.8992	0.8019	0.9569	0.9545		1.1644	1.2962
179	1.5280	1.4115	1.0064	1.0705		0.9079	0.9561
180	1.3771	1.2735	0.9879	1.0475		0.8867	0.9366
181	1.1793	1.0856	0.9759	1.0304		0.8765	0.9289
182	1.1207	1.0282	0.9788	1.0302		0.8809	0.9353
183	1.0455	0.9498	0.9797	1.0278		0.8956	0.9577
184	1.0119	0.9155	0.9757	1.0189		0.9039	0.9692
185	0.9484	0.8514	0.9505	0.9852		0.9221	0.9989
186	0.9218	0.8242	0.9374	0.9661		0.9455	1.0307
187	0.8889	0.7917	0.9234	0.9419		1.0455	1.1537
188	0.8903	0.7913	0.9310	0.9441		1.1294	1.2540
189	1.3115	1.1928	0.9564	1.0120		0.8568	0.9054
190	1.1958	1.0859	0.9489	1.0012		0.8500	0.9007
191	1.1091	0.9998	0.9782	1.0274		0.8819	0.9373
192	1.0689	0.9613	0.9813	1.0285		0.8918	0.9509
193	1.0017	0.8935	0.9684	1.0106		0.9075	0.9751
194	0.9668	0.8608	0.9540	0.9919		0.9161	0.9903
195	0.8874	0.7880	0.9010	0.9318		0.9391	1.0269
196	0.8727	0.7731	0.8933	0.9200		0.9984	1.0980
197	1.3436	1.2085	0.9113	0.9620		0.8176	0.8607
198	1.1698	1.0454	0.9482	0.9979		0.8487	0.8995
199	1.1367	1.0105	0.9706	1.0204		0.8715	0.9248
200	1.0666	0.9446	0.9839	1.0295		0.8999	0.9595
201	1.0312	0.9115	0.9774	1.0215		0.9083	0.9731
202	0.9512	0.8389	0.9385	0.9772		0.9186	0.9949
203	0.9026	0.7962	0.9033	0.9379		0.9234	1.0050
204	0.8206	0.7237	0.8392	0.8667		1.0023	1.1069

205	1.1493	1.0121	0.9023	0.9475		0.8072	0.8497
206	1.1344	0.9942	0.9820	1.0314		0.8845	0.9380
207	1.1026	0.9649	0.9940	1.0416		0.9038	0.9605
208	1.0313	0.9017	0.9805	1.0242		0.9200	0.9874
209	0.9821	0.8586	0.9541	0.9973		0.9215	0.9928
210	0.8518	0.7456	0.8514	0.8849		0.8897	0.9714

Table B3. Block-wide pin fission density values, 3-D stylized ARI core, axial layer 5 and 6

#	1	2	3	4	5	6	7
1		0.8250		0.9178	0.9262	1.3002	0.8912
2		0.8814		0.9997	1.0121	1.4087	0.9361
3		0.8888		1.0115	1.0241	1.4162	0.9304
4		0.8724		0.9966	1.0125	1.3652	0.8849
5		0.8527		0.9670	0.9842	1.3081	0.8469
6		0.7697		0.8588	0.8742	1.1289	0.7334
7		0.9164		0.9249	0.9343	1.1678	0.9331
8		0.8974		0.9644	0.9777	1.2705	0.9330
9		0.9033		0.9897	1.0027	1.3054	0.9379
10		0.8968		1.0047	1.0206	1.2983	0.9152
11		0.8859		0.9982	1.0110	1.2733	0.8943
12		0.8473		0.9502	0.9675	1.1786	0.8266
13		0.8159		0.9129	0.9292	1.1008	0.7794
14		0.7701		0.8376	0.8568	0.9361	0.7013
15		0.9824		0.9746	0.9855	1.1925	0.9775
16		0.9509		0.9690	0.9802	1.1928	0.9498
17		0.9364		1.0012	1.0111	1.2340	0.9456
18		0.9246		1.0052	1.0161	1.2228	0.9285
19		0.8891		0.9883	1.0002	1.1686	0.8832
20		0.8703		0.9691	0.9858	1.1218	0.8504
21		0.8212		0.9067	0.9244	0.9895	0.7696
22		0.8170		0.8913	0.9117	0.9366	0.7428
23		1.1153		1.0237	1.0342	1.2073	1.0596
24		1.0659		1.0073	1.0169	1.1873	1.0243
25		1.0172		1.0033	1.0124	1.1782	0.9776
26		0.9865		1.0047	1.0144	1.1723	0.9602
27		0.9398		1.0082	1.0206	1.1528	0.9292
28		0.9173		0.9982	1.0128	1.1221	0.9055
29		0.8730		0.9639	0.9799	1.0356	0.8446
30		0.8580		0.9420	0.9620	0.9844	0.8098
31		0.8449		0.9156	0.9346	0.8878	0.7551
32		0.8561		0.9116	0.9356	0.8380	0.7277
33		1.2115		1.0440	1.0558	1.2086	1.0970
34				1.0192	1.0282	1.1626	1.0284

35				1.0167	1.0246	1.1490	1.0035
36		1.0335		1.0203	1.0300	1.1338	0.9701
37		0.9901		1.0172	1.0274	1.1154	0.9509
38		0.9256		1.0006	1.0135	1.0596	0.9039
39		0.9020		0.9853	0.9991	1.0179	0.8749
40		0.8676		0.9465	0.9644	0.9228	0.8136
41		0.8615		0.9376	0.9538	0.8776	0.7849
42		0.8723		0.9216	0.9477	0.7790	0.7324
43				1.0407	1.0517	1.1760	1.0816
44				1.0319	1.0410	1.1517	1.0506
45				1.0306	1.0388	1.1267	1.0106
46				1.0308	1.0380	1.1122	0.9928
47		1.0043		1.0249	1.0349	1.0741	0.9548
48		0.9619		1.0191	1.0278	1.0445	0.9310
49		0.9069		0.9844	0.9993	0.9657	0.8764
50		0.8885		0.9720	0.9861	0.9224	0.8490
51		0.8704		0.9376	0.9552	0.8338	0.7966
52		0.8707		0.9271	0.9500	0.7870	0.7682
53		1.3309		1.0497	1.0617	1.1843	1.1233
54				1.0445	1.0521	1.1634	1.0979
55				1.0383	1.0453	1.1298	1.0501
56				1.0379	1.0460	1.1129	1.0311
57				1.0426	1.0514	1.0864	1.0027
58		1.0597		1.0429	1.0498	1.0665	0.9825
59		0.9672		1.0239	1.0321	1.0060	0.9394
60		0.9364		1.0088	1.0186	0.9697	0.9098
61		0.8950		0.9707	0.9850	0.8844	0.8557
62		0.8807		0.9532	0.9696	0.8404	0.8304
63	1.0314	0.8731	1.1728	0.9245	0.9435	0.7572	0.7869
64	1.0341	0.8759	1.2440	0.9129	0.9394	0.7212	0.7718
65		1.3830		1.0305	1.0441	1.1589	1.1142
66				1.0403	1.0446	1.1332	1.0820
67				1.0424	1.0453	1.1211	1.0662
68				1.0512	1.0548	1.0951	1.0392
69				1.0536	1.0587	1.0803	1.0255
70		1.0547		1.0594	1.0677	1.0502	1.0020
71		1.0065		1.0499	1.0570	1.0194	0.9782
72		0.9359		1.0109	1.0199	0.9363	0.9173
73		0.9114		0.9897	1.0029	0.8944	0.8894
74	1.0305	0.8813	1.0740	0.9489	0.9631	0.8149	0.8465
75	1.0247	0.8724	1.1097	0.9277	0.9475	0.7783	0.8298
76	1.0150	0.8620	1.2103	0.8893	0.9151	0.7149	0.8115
77		1.3305		1.0175	1.0303	1.1277	1.0930
78				1.0319	1.0373	1.1233	1.0886
79				1.0464	1.0497	1.1013	1.0651

80				1.0570	1.0563	1.0914	1.0547
81				1.0733	1.0774	1.0751	1.0426
82		1.1093		1.0835	1.0890	1.0658	1.0365
83		1.0106		1.0653	1.0719	1.0022	0.9948
84		0.9660		1.0376	1.0458	0.9541	0.9598
85	1.0401	0.9098	1.0374	0.9871	0.9967	0.8693	0.9040
86	1.0337	0.8911	1.0474	0.9627	0.9759	0.8315	0.8828
87	1.0157	0.8654	1.0902	0.9148	0.9331	0.7620	0.8581
88	1.0031	0.8508	1.1236	0.8878	0.9096	0.7370	0.8553
89		1.4094		0.9389	0.9491	1.0534	1.0313
90		1.3558		0.9915	1.0004	1.0976	1.0720
91				1.0328	1.0361	1.1020	1.0799
92				1.0458	1.0480	1.0973	1.0747
93				1.0647	1.0653	1.0803	1.0597
94				1.0815	1.0791	1.0762	1.0617
95	1.0605	0.9592	1.0403	1.0344	1.0402	0.9278	0.9657
96	1.0483	0.9255	1.0312	1.0041	1.0122	0.8861	0.9377
97	1.0281	0.8868	1.0375	0.9551	0.9641	0.8150	0.9067
98	1.0123	0.8685	1.0437	0.9247	0.9382	0.7830	0.8954
99	0.9740	0.8273	1.0710	0.8571	0.8772	0.7295	0.8877
100	0.9199	0.7821	1.0704	0.7974	0.8211	0.7039	0.8795
101		1.3144		0.9934	0.9983	1.0796	1.0643
102				1.0262	1.0288	1.1005	1.0834
103				1.0529	1.0487	1.0857	1.0733
104		1.2723		1.0634	1.0612	1.0781	1.0718
105		1.1302		1.0962	1.0961	1.0701	1.0767
106	1.0767	0.9828	1.0512	1.0600	1.0628	0.9492	1.0064
107	1.0419	0.9178	1.0226	0.9951	1.0024	0.8668	0.9517
108	1.0319	0.8961	1.0180	0.9678	0.9751	0.8339	0.9415
109	1.0052	0.8603	1.0216	0.9129	0.9255	0.7814	0.9366
110	0.9743	0.8295	1.0079	0.8698	0.8848	0.7527	0.9290
111		1.4821		0.9467		1.0563	1.0406
112		1.4101		0.9995		1.0909	1.0769
113		1.2611		1.0360		1.0945	1.0871
114		1.2071		1.0507		1.0880	1.0851
115		1.1374		1.0686		1.0650	1.0714
116		1.1138		1.0836		1.0585	1.0748
117	1.0604	0.9588	1.0303	1.0394		0.9202	1.0020
118	1.0459	0.9276	1.0143	1.0085		0.8811	0.9809
119	1.0271	0.8905	1.0039	0.9606		0.8260	0.9722
120	1.0145	0.8722	0.9978	0.9324		0.8028	0.9799
121	0.9757	0.8293	0.9811	0.8616		0.7790	1.0112
122	0.9254	0.7867	0.9369	0.8043		0.7680	1.0286
123		1.4284		1.0302		1.1149	1.1090
124		1.3288		1.0434		1.1065	1.1016

125		1.1896		1.0566		1.0777	1.0845
126		1.1445		1.0641		1.0652	1.0768
127	1.0163	1.0835	1.0403	1.0837		1.0426	1.0713
128	1.0449	1.0641	1.0532	1.0950		1.0326	1.0730
129	1.0636	1.0032	1.0463	1.0765		0.9739	1.0482
130	1.0567	0.9668	1.0260	1.0490		0.9321	1.0230
131	1.0376	0.9153	0.9989	0.9975		0.8652	0.9989
132	1.0302	0.8984	0.9895	0.9722		0.8437	1.0017
133	1.0166	0.8716	0.9808	0.9280		0.8109	1.0378
134	1.0087	0.8587	0.9729	0.9024		0.8137	1.0743
135		1.5506		1.0514		1.1419	1.1381
136		1.3175		1.0549		1.1081	1.1088
137		1.2302		1.0550		1.0901	1.0947
138	0.9694	1.1200	1.0200	1.0641		1.0503	1.0758
139	0.9914	1.0809	1.0228	1.0691		1.0332	1.0674
140	1.0335	1.0267	1.0351	1.0748		0.9987	1.0604
141	1.0409	0.9997	1.0300	1.0654		0.9717	1.0474
142	1.0388	0.9428	1.0040	1.0285		0.9066	1.0178
143	1.0360	0.9202	0.9923	1.0061		0.8787	1.0176
144	1.0297	0.8941	0.9787	0.9667		0.8354	1.0398
145	1.0280	0.8848	0.9703	0.9477		0.8317	1.0700
146	1.0223	0.8716	0.9646	0.9091		0.8493	1.1715
147		1.5421		1.0724		1.1555	1.1546
148		1.4088		1.0651		1.1247	1.1265
149	0.9295	1.2104	1.0158	1.0560		1.0766	1.0885
150	0.9489	1.1423	1.0130	1.0596		1.0536	1.0748
151	0.9913	1.0555	1.0192	1.0636		1.0170	1.0596
152	1.0073	1.0236	1.0194	1.0614		0.9952	1.0518
153	1.0287	0.9695	1.0086	1.0457		0.9430	1.0368
154	1.0314	0.9462	1.0001	1.0300		0.9146	1.0312
155	1.0268	0.9086	0.9763	0.9902		0.8651	1.0377
156	1.0268	0.8973	0.9676	0.9738		0.8498	1.0588
157	1.0356	0.8880	0.9604	0.9467		0.8449	1.1433
158	1.0424	0.8915	0.9629	0.9380		0.8656	1.2148
159	0.8835	1.3807	1.0237	1.0671		1.1140	1.1228
160	0.9092	1.2664	1.0142	1.0570		1.0839	1.0963
161	0.9522	1.1156	1.0092	1.0539		1.0377	1.0675
162	0.9726	1.0649	1.0103	1.0521		1.0169	1.0571
163	1.0080	1.0008	1.0077	1.0513		0.9737	1.0469
164	1.0169	0.9745	1.0003	1.0435		0.9472	1.0410
165	1.0198	0.9290	0.9785	1.0119		0.8931	1.0339
166	1.0201	0.9113	0.9691	0.9958		0.8712	1.0431
167	1.0271	0.8912	0.9537	0.9649		0.8471	1.1032
168	1.0363	0.8906	0.9485	0.9570		0.8508	1.1561
169	0.8660	1.4863	1.0345	1.0752		1.1383	1.1414

170	0.9162	1.2270	1.0053	1.0513		1.0630	1.0834
171	0.9363	1.1420	0.9982	1.0441		1.0361	1.0624
172	0.9785	1.0427	1.0007	1.0485		0.9973	1.0510
173	0.9963	1.0068	1.0004	1.0456		0.9778	1.0448
174	1.0124	0.9539	0.9903	1.0287		0.9282	1.0392
175	1.0161	0.9322	0.9770	1.0155		0.9042	1.0392
176	1.0092	0.8937	0.9479	0.9787		0.8547	1.0615
177	1.0167	0.8890	0.9412	0.9652		0.8472	1.1007
178	1.0434	0.8961	0.9444	0.9562		0.8644	1.2395
179	0.8860	1.4296	1.0138	1.0562		1.1041	1.1139
180	0.9095	1.2900	0.9969	1.0429		1.0649	1.0812
181	0.9454	1.1059	0.9897	1.0327		1.0146	1.0493
182	0.9696	1.0536	0.9908	1.0375		0.9976	1.0470
183	1.0035	0.9902	0.9935	1.0391		0.9647	1.0437
184	1.0120	0.9622	0.9893	1.0344		0.9363	1.0443
185	1.0069	0.9125	0.9582	0.9990		0.8847	1.0425
186	1.0019	0.8927	0.9425	0.9785		0.8597	1.0560
187	1.0077	0.8742	0.9193	0.9486		0.8405	1.1413
188	1.0235	0.8825	0.9246	0.9508		0.8504	1.2245
189	0.9081	1.2170	0.9644	1.0088		1.0239	1.0392
190	0.9252	1.1108	0.9609	1.0054		0.9965	1.0236
191	0.9874	1.0343	0.9913	1.0377		0.9887	1.0444
192	1.0056	1.0018	0.9957	1.0421		0.9724	1.0452
193	1.0148	0.9473	0.9815	1.0255		0.9262	1.0421
194	1.0087	0.9198	0.9640	1.0064		0.8972	1.0442
195	0.9737	0.8596	0.9079	0.9429		0.8301	1.0506
196	0.9778	0.8510	0.8945	0.9288		0.8216	1.1079
197	0.8918	1.2404	0.9174	0.9628		0.9857	0.9975
198	0.9524	1.0754	0.9611	1.0051		0.9856	1.0199
199	0.9901	1.0470	0.9869	1.0320		0.9932	1.0406
200	1.0258	0.9929	1.0024	1.0472		0.9679	1.0525
201	1.0297	0.9649	0.9928	1.0388		0.9474	1.0520
202	1.0078	0.9024	0.9481	0.9924		0.8795	1.0457
203	0.9796	0.8649	0.9115	0.9537		0.8401	1.0425
204	0.9320	0.8048	0.8422	0.8776		0.7845	1.1134
205	0.9273	1.0440	0.9140	0.9562		0.9469	0.9727
206	1.0237	1.0362	0.9981	1.0451		0.9972	1.0511
207	1.0444	1.0130	1.0108	1.0586		0.9895	1.0619
208	1.0464	0.9608	0.9946	1.0455		0.9429	1.0629
209	1.0271	0.9218	0.9676	1.0148		0.9036	1.0522
210	0.9343	0.8163	0.8604	0.9025		0.7919	1.0034

Table B4. Core normalized pin fission density, 2-D stylized ARO core

#	1	2	3	4	5	6	7
1		1.3039		0.7797	0.8011	1.1439	0.7506
2		1.2705		0.8523	0.8736	1.3173	0.8414
3		1.2245		0.8651	0.8852	1.3737	0.8719
4		1.1262		0.8575	0.8761	1.4358	0.9128
5		1.0657		0.8374	0.8540	1.4537	0.9314
6		0.9139		0.7518	0.7657	1.4178	0.9356
7		1.5821		0.7890	0.8128	0.9695	0.7491
8		1.3661		0.8224	0.8437	1.1238	0.7948
9		1.3161		0.8436	0.8645	1.1915	0.8267
10		1.2100		0.8584	0.8779	1.2794	0.8756
11		1.1567		0.8547	0.8735	1.3098	0.8970
12		1.0441		0.8235	0.8402	1.3494	0.9408
13		0.9831		0.7944	0.8100	1.3527	0.9665
14		0.8851		0.7444	0.7574	1.4156	1.1105
15		1.5864		0.8309	0.8543	0.9972	0.7925
16		1.4527		0.8253	0.8471	1.0289	0.7938
17		1.3223		0.8532	0.8732	1.1366	0.8421
18		1.2612		0.8564	0.8758	1.1733	0.8632
19		1.1409		0.8479	0.8660	1.2294	0.9065
20		1.0866		0.8359	0.8534	1.2522	0.9334
21		0.9748		0.7916	0.8073	1.2816	1.0008
22		0.9495		0.7877	0.8023	1.3552	1.0945
23		1.8780		0.8781	0.9040	0.9642	0.8295
24		1.7080		0.8612	0.8849	0.9710	0.8173
25		1.4987		0.8528	0.8736	1.0236	0.8236
26		1.4030		0.8552	0.8752	1.0571	0.8373
27		1.2590		0.8592	0.8779	1.1218	0.8766
28		1.1931		0.8549	0.8731	1.1483	0.8982
29		1.0748		0.8327	0.8501	1.1941	0.9529
30		1.0281		0.8208	0.8374	1.2282	0.9996
31		0.9721		0.8098	0.8253	1.3591	1.1657
32		0.9657		0.8166	0.8318	1.4658	1.2921
33		1.9827		0.9002	0.9255	0.9444	0.8482
34				0.8706	0.8919	0.9589	0.8282
35				0.8635	0.8841	0.9754	0.8300
36		1.4369		0.8670	0.8862	1.0319	0.8555
37		1.3427		0.8659	0.8843	1.0575	0.8716
38		1.1833		0.8561	0.8739	1.1065	0.9148
39		1.1220		0.8479	0.8656	1.1336	0.9451
40		1.0262		0.8255	0.8427	1.2025	1.0354
41		0.9990		0.8221	0.8387	1.2676	1.1135
42		0.9793		0.8304	0.8459	1.4678	1.3513
43				0.8936	0.9157	0.9243	0.8420
44				0.8828	0.9030	0.9306	0.8364

45				0.8758	0.8949	0.9649	0.8443
46				0.8747	0.8932	0.9851	0.8550
47		1.3438		0.8736	0.8912	1.0337	0.8892
48		1.2462		0.8686	0.8857	1.0571	0.9108
49		1.1109		0.8501	0.8670	1.1067	0.9676
50		1.0625		0.8411	0.8582	1.1444	1.0133
51		0.9992		0.8278	0.8438	1.2602	1.1522
52		0.9836		0.8279	0.8440	1.3514	1.2583
53		2.0935		0.9102	0.9321	0.8994	0.8516
54				0.8983	0.9185	0.8999	0.8439
55				0.8861	0.9042	0.9180	0.8414
56				0.8833	0.9013	0.9317	0.8464
57				0.8858	0.9033	0.9744	0.8726
58		1.4405		0.8849	0.9021	0.9960	0.8893
59		1.2302		0.8746	0.8916	1.0403	0.9314
60		1.1570		0.8657	0.8821	1.0650	0.9593
61		1.0529		0.8428	0.8591	1.1309	1.0398
62		1.0180		0.8348	0.8511	1.1852	1.1030
63	0.9092	0.9767	1.1887	0.8263	0.8426	1.3462	1.2892
64	0.9097	0.9680	1.2851	0.8272	0.8430	1.4585	1.4123
65		2.1361		0.8984	0.9181	0.8661	0.8376
66				0.8918	0.9092	0.8833	0.8380
67				0.8902	0.9070	0.8937	0.8418
68				0.8917	0.9077	0.9247	0.8581
69				0.8941	0.9102	0.9448	0.8724
70		1.4027		0.9000	0.9165	0.9954	0.9144
71		1.2937		0.8945	0.9111	1.0166	0.9355
72		1.1379		0.8675	0.8841	1.0548	0.9808
73		1.0822		0.8549	0.8714	1.0854	1.0170
74	0.9198	1.0076	1.0503	0.8328	0.8490	1.1804	1.1294
75	0.9096	0.9808	1.1034	0.8243	0.8406	1.2510	1.2093
76	0.8927	0.9438	1.2523	0.8098	0.8254	1.4450	1.4270
77		1.9804		0.8844	0.9005	0.8463	0.8245
78				0.8886	0.9038	0.8595	0.8319
79				0.8916	0.9069	0.8849	0.8451
80				0.8955	0.9105	0.9015	0.8566
81				0.9093	0.9245	0.9476	0.8932
82		1.5004		0.9194	0.9350	0.9781	0.9209
83		1.2707		0.9077	0.9235	1.0212	0.9642
84		1.1817		0.8874	0.9035	1.0327	0.9792
85	0.9487	1.0647	0.9784	0.8537	0.8688	1.0810	1.0391
86	0.9305	1.0229	1.0040	0.8394	0.8550	1.1220	1.0875
87	0.9014	0.9643	1.0842	0.8153	0.8308	1.2485	1.2320
88	0.8845	0.9376	1.1400	0.8011	0.8164	1.3338	1.3257
89		2.1054		0.8245	0.8378	0.7689	0.7633

90		1.9931		0.8629	0.8766	0.8113	0.8018
91				0.8854	0.8988	0.8497	0.8302
92				0.8926	0.9065	0.8662	0.8422
93				0.9023	0.9161	0.8990	0.8668
94				0.9138	0.9278	0.9243	0.8890
95	0.9968	1.1490	0.9535	0.8855	0.9002	1.0290	0.9975
96	0.9672	1.0877	0.9568	0.8646	0.8796	1.0469	1.0209
97	0.9266	1.0065	0.9941	0.8344	0.8489	1.1270	1.1140
98	0.9056	0.9713	1.0184	0.8175	0.8317	1.1793	1.1739
99	0.8580	0.9038	1.0847	0.7758	0.7901	1.3185	1.3311
100	0.8085	0.8464	1.1045	0.7319	0.7458	1.3738	1.3936
101		1.8798		0.8610	0.8714	0.8048	0.7999
102				0.8832	0.8945	0.8337	0.8249
103				0.8954	0.9075	0.8626	0.8472
104		1.8067		0.9025	0.9146	0.8795	0.8615
105		1.5329		0.9276	0.9406	0.9310	0.9093
106	1.0285	1.1849	0.9514	0.9043	0.9184	1.0141	0.9964
107	0.9628	1.0636	0.9492	0.8592	0.8734	1.0494	1.0405
108	0.9391	1.0210	0.9590	0.8421	0.8553	1.0861	1.0827
109	0.8976	0.9547	0.9953	0.8092	0.8225	1.1947	1.2067
110	0.8623	0.9093	0.9989	0.7788	0.7916	1.2418	1.2609
111		2.1110		0.8320		0.7593	0.7651
112		1.9950		0.8689		0.8004	0.8033
113		1.7504		0.8897		0.8350	0.8316
114		1.6662		0.8964		0.8492	0.8442
115		1.5527		0.9052		0.8776	0.8685
116		1.4899		0.9162		0.9010	0.8912
117	1.0113	1.1353	0.9333	0.8879		1.0030	0.9991
118	0.9785	1.0800	0.9298	0.8665		1.0223	1.0223
119	0.9344	1.0036	0.9462	0.8367		1.1039	1.1156
120	0.9120	0.9694	0.9549	0.8195		1.1574	1.1761
121	0.8629	0.9038	0.9723	0.7776		1.2987	1.3345
122	0.8134	0.8471	0.9437	0.7333		1.3553	1.4010
123		1.9794		0.8949		0.8222	0.8275
124		1.8246		0.8969		0.8314	0.8349
125		1.6075		0.8978		0.8485	0.8487
126		1.5363		0.9009		0.8609	0.8603
127	1.1486	1.4059	0.9004	0.9148		0.8982	0.8975
128	1.1287	1.3532	0.9177	0.9243		0.9250	0.9255
129	1.0681	1.2179	0.9271	0.9127		0.9655	0.9684
130	1.0285	1.1500	0.9195	0.8915		0.9785	0.9835
131	0.9694	1.0517	0.9170	0.8572		1.0312	1.0429
132	0.9475	1.0156	0.9207	0.8430		1.0739	1.0915
133	0.9130	0.9618	0.9413	0.8191		1.2040	1.2360
134	0.8951	0.9369	0.9497	0.8049		1.2913	1.3327

135		2.1332		0.9145		0.8319	0.8421
136		1.7766		0.9031		0.8360	0.8430
137		1.6489		0.8998		0.8403	0.8466
138	1.2166	1.4663	0.8752	0.8996		0.8586	0.8634
139	1.1700	1.3955	0.8826	0.9018		0.8732	0.8779
140	1.1067	1.2749	0.9018	0.9072		0.9131	0.9203
141	1.0744	1.2147	0.9053	0.9012		0.9329	0.9420
142	1.0082	1.1044	0.8998	0.8738		0.9739	0.9867
143	0.9819	1.0618	0.8995	0.8609		1.0060	1.0227
144	0.9424	0.9993	0.9088	0.8388		1.1073	1.1344
145	0.9283	0.9770	0.9169	0.8298		1.1792	1.2146
146	0.9072	0.9435	0.9427	0.8142		1.3808	1.4349
147		2.0872		0.9292		0.8458	0.8582
148		1.8874		0.9143		0.8387	0.8502
149	1.3557	1.5906	0.8664	0.8979		0.8382	0.8475
150	1.2707	1.4837	0.8670	0.8940		0.8439	0.8531
151	1.1603	1.3325	0.8786	0.8957		0.8700	0.8800
152	1.1188	1.2699	0.8826	0.8942		0.8861	0.8977
153	1.0513	1.1589	0.8867	0.8828		0.9253	0.9397
154	1.0216	1.1123	0.8860	0.8734		0.9507	0.9676
155	0.9693	1.0335	0.8847	0.8501		1.0231	1.0472
156	0.9522	1.0070	0.8893	0.8420		1.0800	1.1098
157	0.9324	0.9734	0.9091	0.8327		1.2488	1.2938
158	0.9309	0.9672	0.9247	0.8330		1.3613	1.4168
159	1.6004	1.8252	0.8719	0.9118		0.8372	0.8498
160	1.4520	1.6555	0.8641	0.8981		0.8319	0.8444
161	1.2581	1.4244	0.8636	0.8886		0.8406	0.8528
162	1.1916	1.3410	0.8659	0.8863		0.8512	0.8641
163	1.1032	1.2169	0.8740	0.8843		0.8841	0.8990
164	1.0670	1.1649	0.8746	0.8789		0.9037	0.9209
165	1.0037	1.0739	0.8703	0.8595		0.9556	0.9773
166	0.9791	1.0393	0.8697	0.8500		0.9971	1.0224
167	0.9454	0.9896	0.8768	0.8357		1.1232	1.1601
168	0.9399	0.9790	0.8881	0.8355		1.2182	1.2643
169	1.7632	1.9588	0.8800	0.9231		0.8424	0.8571
170	1.4246	1.5834	0.8560	0.8876		0.8233	0.8376
171	1.3111	1.4541	0.8522	0.8794		0.8243	0.8388
172	1.1756	1.2893	0.8611	0.8805		0.8502	0.8658
173	1.1260	1.2258	0.8634	0.8783		0.8659	0.8827
174	1.0508	1.1246	0.8634	0.8676		0.9061	0.9265
175	1.0184	1.0817	0.8601	0.8589		0.9343	0.9573
176	0.9617	1.0083	0.8520	0.8354		1.0159	1.0461
177	0.9472	0.9881	0.8560	0.8313		1.0872	1.1230
178	0.9439	0.9766	0.8829	0.8380		1.3023	1.3560
179	1.7087	1.8577	0.8628	0.9013		0.8247	0.8399

180	1.5238	1.6603	0.8481	0.8813		0.8127	0.8278
181	1.2804	1.3874	0.8442	0.8695		0.8191	0.8346
182	1.2072	1.3021	0.8488	0.8707		0.8325	0.8493
183	1.1135	1.1871	0.8589	0.8737		0.8701	0.8897
184	1.0736	1.1372	0.8580	0.8684		0.8909	0.9122
185	0.9990	1.0467	0.8444	0.8444		0.9408	0.9663
186	0.9689	1.0098	0.8378	0.8318		0.9834	1.0130
187	0.9331	0.9651	0.8388	0.8192		1.1365	1.1766
188	0.9342	0.9629	0.8515	0.8255		1.2513	1.2997
189	1.4456	1.5471	0.8220	0.8515		0.7875	0.8038
190	1.3056	1.3941	0.8179	0.8439		0.7892	0.8057
191	1.1925	1.2608	0.8491	0.8699		0.8379	0.8561
192	1.1440	1.2038	0.8548	0.8726		0.8580	0.8773
193	1.0618	1.1072	0.8515	0.8626		0.8992	0.9219
194	1.0217	1.0612	0.8424	0.8491		0.9244	0.9497
195	0.9333	0.9637	0.8058	0.8031		0.9854	1.0163
196	0.9153	0.9435	0.8060	0.7981		1.0733	1.1093
197	1.4933	1.5802	0.7814	0.8112		0.7458	0.7609
198	1.2730	1.3330	0.8176	0.8421		0.7920	0.8083
199	1.2256	1.2779	0.8400	0.8625		0.8233	0.8411
200	1.1392	1.1789	0.8579	0.8760		0.8708	0.8916
201	1.0957	1.1309	0.8558	0.8705		0.8921	0.9141
202	1.0042	1.0316	0.8291	0.8374		0.9328	0.9591
203	0.9506	0.9747	0.8028	0.8073		0.9565	0.9844
204	0.8625	0.8833	0.7585	0.7542		1.0907	1.1283
205	1.2541	1.2960	0.7769	0.7999		0.7486	0.7642
206	1.2229	1.2540	0.8511	0.8726		0.8393	0.8579
207	1.1809	1.2082	0.8640	0.8841		0.8693	0.8888
208	1.0958	1.1168	0.8588	0.8743		0.9096	0.9313
209	1.0387	1.0585	0.8395	0.8524		0.9271	0.9510
210	0.8979	0.9136	0.7567	0.7638		0.9289	0.9554

Table B5. Core normalized pin fission density, 2-D stylized SRI core

#	1	2	3	4	5	6	7
1		0.7677		0.7935	0.7847	1.3448	0.8607
2		0.8266		0.8850	0.8746	1.5569	0.9744
3		0.8375		0.9070	0.8967	1.6276	1.0149
4		0.8311		0.9144	0.9041	1.7080	1.0714
5		0.8163		0.9003	0.8902	1.7324	1.0977
6		0.7442		0.8213	0.8118	1.6964	1.1099
7		0.8429		0.7807	0.7752	1.1307	0.8488
8		0.8336		0.8374	0.8301	1.3213	0.9129
9		0.8439		0.8687	0.8605	1.4051	0.9542

10		0.8444		0.9014	0.8932	1.5165	1.0203
11		0.8385		0.9052	0.8974	1.5557	1.0504
12		0.8115		0.8870	0.8800	1.6102	1.1108
13		0.7881		0.8627	0.8556	1.6160	1.1445
14		0.7551		0.8214	0.8162	1.6972	1.3233
15		0.9043		0.8255	0.8210	1.1643	0.8998
16		0.8794		0.8317	0.8267	1.2058	0.9075
17		0.8719		0.8797	0.8738	1.3402	0.9742
18		0.8650		0.8924	0.8860	1.3877	1.0037
19		0.8423		0.8996	0.8940	1.4613	1.0630
20		0.8295		0.8942	0.8893	1.4916	1.0997
21		0.7932		0.8609	0.8568	1.5327	1.1872
22		0.7969		0.8637	0.8601	1.6235	1.3033
23		1.0218		0.8512	0.8499	1.1171	0.9330
24		0.9801		0.8463	0.8439	1.1294	0.9250
25		0.9392		0.8615	0.8576	1.2011	0.9437
26		0.9138		0.8744	0.8702	1.2439	0.9652
27		0.8808		0.8971	0.8929	1.3281	1.0212
28		0.8649		0.9005	0.8968	1.3625	1.0516
29		0.8337		0.8924	0.8895	1.4236	1.1239
30		0.8243		0.8878	0.8849	1.4670	1.1831
31		0.8263		0.8901	0.8880	1.6290	1.3878
32		0.8418		0.9047	0.9026	1.7595	1.5428
33		1.1064		0.8626	0.8639	1.0886	0.9491
34				0.8587	0.8574	1.1167	0.9396
35				0.8640	0.8618	1.1403	0.9472
36		0.9561		0.8884	0.8858	1.2154	0.9876
37		0.9217		0.8964	0.8935	1.2488	1.0125
38		0.8729		0.9038	0.9017	1.3138	1.0717
39		0.8569		0.9032	0.9018	1.3496	1.1125
40		0.8350		0.8949	0.8942	1.4374	1.2270
41		0.8367		0.8981	0.8980	1.5184	1.3236
42		0.8622		0.9218	0.9217	1.7632	1.6157
43				0.8607	0.8622	1.0662	0.9459
44				0.8624	0.8632	1.0790	0.9457
45				0.8791	0.8778	1.1286	0.9667
46				0.8883	0.8872	1.1571	0.9844
47		0.9370		0.9067	0.9055	1.2223	1.0348
48		0.9028		0.9108	0.9095	1.2529	1.0652
49		0.8631		0.9078	0.9073	1.3182	1.1403
50		0.8523		0.9061	0.9063	1.3666	1.1987
51		0.8474		0.9067	0.9082	1.5090	1.3723
52		0.8551		0.9138	0.9156	1.6220	1.5017
53		1.2119		0.8542	0.8602	1.0291	0.9464
54				0.8563	0.8599	1.0348	0.9440

55				0.8694	0.8707	1.0656	0.9543
56				0.8783	0.8789	1.0866	0.9659
57				0.9030	0.9028	1.1456	1.0066
58		0.9830		0.9123	0.9112	1.1746	1.0316
59		0.9085		0.9199	0.9199	1.2349	1.0907
60		0.8854		0.9186	0.9193	1.2666	1.1280
61		0.8570		0.9102	0.9115	1.3514	1.2313
62		0.8523		0.9093	0.9114	1.4184	1.3106
63	0.8787	0.8582	1.3793	0.9142	0.9169	1.6172	1.5390
64	0.8916	0.8681	1.4959	0.9216	0.9248	1.7529	1.6892
65		1.2567		0.8329	0.8414	0.9868	0.9273
66				0.8541	0.8583	1.0166	0.9407
67				0.8654	0.8681	1.0338	0.9512
68				0.8906	0.8910	1.0794	0.9815
69				0.9040	0.9044	1.1073	1.0035
70		0.9803		0.9306	0.9308	1.1739	1.0620
71		0.9413		0.9345	0.9353	1.2042	1.0934
72		0.8869		0.9237	0.9250	1.2554	1.1551
73		0.8698		0.9181	0.9199	1.2941	1.2024
74	0.8623	0.8540	1.2076	0.9097	0.9123	1.4136	1.3434
75	0.8657	0.8520	1.2747	0.9073	0.9105	1.4999	1.4418
76	0.8743	0.8546	1.4577	0.9039	0.9085	1.7377	1.7083
77		1.2106		0.8255	0.8331	0.9651	0.9161
78				0.8428	0.8483	0.9854	0.9305
79				0.8713	0.8738	1.0246	0.9574
80				0.8872	0.8889	1.0481	0.9766
81				0.9225	0.9239	1.1114	1.0295
82		1.0266		0.9433	0.9444	1.1512	1.0669
83		0.9458		0.9518	0.9533	1.2098	1.1287
84		0.9103		0.9393	0.9413	1.2269	1.1512
85	0.8573	0.8698	1.1134	0.9190	0.9216	1.2900	1.2306
86	0.8566	0.8581	1.1484	0.9111	0.9144	1.3422	1.2916
87	0.8579	0.8467	1.2530	0.8992	0.9034	1.4981	1.4703
88	0.8555	0.8399	1.3233	0.8902	0.8948	1.6030	1.5854
89		1.2737		0.7488	0.7589	0.8688	0.8389
90		1.2277		0.7973	0.8055	0.9219	0.8871
91				0.8449	0.8499	0.9753	0.9315
92				0.8640	0.8677	0.9992	0.9511
93				0.8974	0.8993	1.0467	0.9908
94				0.9195	0.9212	1.0801	1.0214
95	0.8634	0.9043	1.0740	0.9402	0.9428	1.2231	1.1737
96	0.8565	0.8802	1.0832	0.9255	0.9284	1.2481	1.2054
97	0.8537	0.8556	1.1372	0.9085	0.9116	1.3488	1.3238
98	0.8493	0.8438	1.1711	0.8966	0.9007	1.4137	1.3989
99	0.8297	0.8175	1.2583	0.8639	0.8690	1.5853	1.5919

100	0.7932	0.7792	1.2866	0.8201	0.8261	1.6526	1.6687
101		1.1916		0.8007	0.8075	0.9151	0.8888
102		1.1585		0.8343	0.8400	0.9524	0.9221
103				0.8711	0.8745	0.9957	0.9591
104				0.8901	0.8924	1.0207	0.9817
105		1.0410		0.9374	0.9390	1.0891	1.0471
106	0.8684	0.9252	1.0648	0.9545	0.9573	1.2035	1.1702
107	0.8530	0.8746	1.0741	0.9223	0.9257	1.2515	1.2312
108	0.8496	0.8601	1.0912	0.9115	0.9143	1.2980	1.2851
109	0.8429	0.8390	1.1438	0.8898	0.8943	1.4329	1.4384
110	0.8226	0.8151	1.1536	0.8620	0.8669	1.4909	1.5062
111		1.3351		0.7500		0.8537	0.8401
112		1.2744		0.7978		0.9055	0.8884
113		1.1453		0.8446		0.9549	0.9325
114		1.0998		0.8638		0.9769	0.9520
115		1.0431		0.8963		1.0195	0.9920
116		1.0239		0.9183		1.0503	1.0228
117	0.8546	0.9039	1.0443	0.9398		1.1911	1.1755
118	0.8485	0.8811	1.0464	0.9248		1.2167	1.2072
119	0.8476	0.8569	1.0766	0.9081		1.3198	1.3252
120	0.8432	0.8451	1.0921	0.8962		1.3868	1.3999
121	0.8246	0.8185	1.1225	0.8636		1.5603	1.5956
122	0.7882	0.7806	1.0945	0.8200		1.6291	1.6765
123		1.2886		0.8259		0.9300	0.9177
124		1.2020		0.8424		0.9467	0.9322
125		1.0824		0.8704		0.9770	0.9596
126		1.0457		0.8852		0.9960	0.9790
127	0.7967	0.9972	0.9708	0.9211		1.0487	1.0329
128	0.8230	0.9835	0.9973	0.9420		1.0846	1.0706
129	0.8482	0.9378	1.0231	0.9509		1.1403	1.1320
130	0.8459	0.9086	1.0218	0.9381		1.1595	1.1542
131	0.8424	0.8713	1.0313	0.9180		1.2285	1.2336
132	0.8436	0.8607	1.0422	0.9106		1.2832	1.2946
133	0.8463	0.8492	1.0772	0.8989		1.4438	1.4730
134	0.8446	0.8425	1.0924	0.8895		1.5509	1.5908
135		1.3971		0.8340		0.9365	0.9297
136		1.1911		0.8535		0.9525	0.9432
137		1.1199		0.8641		0.9634	0.9538
138	0.7520	1.0243	0.9287	0.8885		0.9947	0.9854
139	0.7722	0.9931	0.9449	0.9015		1.0163	1.0076
140	0.8122	0.9516	0.9800	0.9282		1.0716	1.0675
141	0.8248	0.9300	0.9917	0.9328		1.0991	1.0982
142	0.8322	0.8877	0.9999	0.9222		1.1549	1.1602
143	0.8354	0.8736	1.0058	0.9170		1.1968	1.2074
144	0.8430	0.8585	1.0290	0.9086		1.3234	1.3480

145	0.8482	0.8557	1.0440	0.9063		1.4126	1.4456
146	0.8586	0.8575	1.0844	0.9028		1.6580	1.7146
147		1.3903		0.8539		0.9540	0.9500
148		1.2711		0.8550		0.9514	0.9480
149	0.7128	1.0995	0.9017	0.8670		0.9623	0.9581
150	0.7325	1.0418	0.9120	0.8760		0.9744	0.9711
151	0.7719	0.9711	0.9405	0.9005		1.0139	1.0126
152	0.7895	0.9454	0.9527	0.9093		1.0373	1.0383
153	0.8133	0.9044	0.9718	0.9174		1.0911	1.0975
154	0.8207	0.8884	0.9783	0.9168		1.1251	1.1351
155	0.8294	0.8636	0.9899	0.9086		1.2176	1.2377
156	0.8367	0.8592	1.0013	0.9078		1.2887	1.3161
157	0.8560	0.8635	1.0358	0.9124		1.4956	1.5415
158	0.8694	0.8723	1.0583	0.9196		1.6345	1.6918
159	0.6734	1.2471	0.8897	0.8585		0.9506	0.9505
160	0.6961	1.1476	0.8913	0.8598		0.9508	0.9510
161	0.7354	1.0187	0.9084	0.8751		0.9719	0.9733
162	0.7537	0.9769	0.9195	0.8850		0.9886	0.9917
163	0.7872	0.9251	0.9433	0.9036		1.0359	1.0425
164	0.7994	0.9044	0.9515	0.9076		1.0636	1.0726
165	0.8128	0.8714	0.9608	0.9049		1.1323	1.1490
166	0.8196	0.8620	0.9671	0.9039		1.1851	1.2063
167	0.8358	0.8554	0.9880	0.9046		1.3414	1.3773
168	0.8505	0.8625	1.0069	0.9118		1.4581	1.5045
169	0.6570	1.3402	0.8885	0.8605		0.9525	0.9547
170	0.6995	1.1144	0.8832	0.8551		0.9432	0.9463
171	0.7186	1.0403	0.8886	0.8598		0.9499	0.9542
172	0.7583	0.9567	0.9154	0.8835		0.9892	0.9964
173	0.7741	0.9276	0.9255	0.8921		1.0122	1.0211
174	0.7965	0.8874	0.9393	0.8999		1.0676	1.0816
175	0.8037	0.8719	0.9439	0.8992		1.1049	1.1230
176	0.8116	0.8474	0.9480	0.8916		1.2090	1.2362
177	0.8228	0.8476	0.9592	0.8955		1.2975	1.3318
178	0.8593	0.8696	1.0027	0.9185		1.5604	1.6151
179	0.6715	1.2887	0.8714	0.8469		0.9346	0.9391
180	0.6912	1.1674	0.8664	0.8418		0.9268	0.9320
181	0.7255	1.0087	0.8816	0.8555		0.9450	0.9521
182	0.7460	0.9640	0.8948	0.8681		0.9659	0.9743
183	0.7801	0.9133	0.9215	0.8912		1.0192	1.0309
184	0.7905	0.8927	0.9275	0.8951		1.0474	1.0623
185	0.7968	0.8552	0.9266	0.8875		1.1135	1.1360
186	0.7999	0.8416	0.9263	0.8832		1.1681	1.1950
187	0.8174	0.8381	0.9413	0.8857		1.3566	1.3974
188	0.8375	0.8518	0.9617	0.8997		1.4968	1.5472
189	0.6911	1.1018	0.8407	0.8194		0.9004	0.9076

190	0.7056	1.0108	0.8468	0.8252		0.9080	0.9164
191	0.7595	0.9475	0.8963	0.8724		0.9739	0.9854
192	0.7766	0.9221	0.9099	0.8848		1.0023	1.0150
193	0.7939	0.8808	0.9207	0.8930		1.0583	1.0762
194	0.7954	0.8605	0.9184	0.8878		1.0922	1.1128
195	0.7778	0.8128	0.8918	0.8552		1.1711	1.2008
196	0.7872	0.8123	0.8989	0.8583		1.2793	1.3149
197	0.6748	1.1207	0.7918	0.7738		0.8491	0.8560
198	0.7257	0.9793	0.8480	0.8291		0.9128	0.9229
199	0.7574	0.9560	0.8796	0.8599		0.9542	0.9659
200	0.7919	0.9146	0.9143	0.8927		1.0192	1.0335
201	0.7995	0.8933	0.9191	0.8959		1.0477	1.0648
202	0.7914	0.8460	0.9041	0.8785		1.1039	1.1262
203	0.7750	0.8147	0.8815	0.8549		1.1345	1.1610
204	0.7505	0.7702	0.8476	0.8146		1.3016	1.3390
205	0.7034	0.9503	0.7996	0.7843		0.8609	0.8704
206	0.7839	0.9487	0.8914	0.8745		0.9734	0.9870
207	0.8028	0.9310	0.9141	0.8959		1.0135	1.0285
208	0.8128	0.8913	0.9230	0.9038		1.0692	1.0875
209	0.8026	0.8613	0.9094	0.8897		1.0942	1.1151
210	0.7384	0.7703	0.8318	0.8115		1.1030	1.1281

Table B6. Core normalized pin fission density, 2-D stylized ARI core

#	1	2	3	4	5	6	7
1		1.0674		0.9325	0.9788	1.0438	0.7675
2		1.1395		1.0168	1.0693	1.1330	0.8081
3		1.1484		1.0295	1.0843	1.1375	0.8028
4		1.1278		1.0134	1.0692	1.0962	0.7652
5		1.0998		0.9838	1.0392	1.0509	0.7310
6		0.9903		0.8732	0.9246	0.9082	0.6335
7		1.1838		0.9412	0.9876	0.9397	0.8066
8		1.1606		0.9830	1.0328	1.0198	0.8060
9		1.1693		1.0082	1.0596	1.0472	0.8109
10		1.1582		1.0215	1.0758	1.0442	0.7924
11		1.1439		1.0134	1.0680	1.0229	0.7726
12		1.0927		0.9669	1.0218	0.9450	0.7141
13		1.0543		0.9268	0.9811	0.8839	0.6741
14		0.9937		0.8507	0.9055	0.7522	0.6053
15		1.2704		0.9919	1.0413	0.9581	0.8428
16		1.2303		0.9871	1.0359	0.9572	0.8204
17		1.2087		1.0192	1.0712	0.9881	0.8150
18		1.1932		1.0212	1.0747	0.9817	0.8024
19		1.1483		1.0047	1.0592	0.9384	0.7626

20		1.1238		0.9858	1.0403	0.9026	0.7353
21		1.0595		0.9208	0.9759	0.7961	0.6649
22		1.0553		0.9071	0.9632	0.7546	0.6415
23		1.4440		1.0424	1.0945	0.9702	0.9148
24		1.3807		1.0261	1.0761	0.9526	0.8828
25		1.3158		1.0202	1.0697	0.9448	0.8430
26		1.2737		1.0230	1.0734	0.9421	0.8294
27		1.2152		1.0242	1.0776	0.9243	0.8014
28		1.1863		1.0162	1.0701	0.9022	0.7812
29		1.1288		0.9805	1.0352	0.8333	0.7287
30		1.1069		0.9601	1.0156	0.7919	0.7007
31		1.0914		0.9293	0.9872	0.7118	0.6522
32		1.1023		0.9260	0.9874	0.6715	0.6283
33		1.5668		1.0647	1.1186	0.9674	0.9466
34				1.0387	1.0890	0.9342	0.8870
35				1.0335	1.0830	0.9221	0.8656
36		1.3347		1.0376	1.0880	0.9103	0.8372
37		1.2801		1.0344	1.0859	0.8951	0.8200
38		1.1967		1.0174	1.0700	0.8501	0.7796
39		1.1662		1.0026	1.0566	0.8193	0.7560
40		1.1198		0.9631	1.0188	0.7428	0.7030
41		1.1126		0.9500	1.0076	0.7055	0.6788
42		1.1268		0.9384	1.0010	0.6240	0.6324
43				1.0594	1.1113	0.9415	0.9342
44				1.0513	1.1013	0.9247	0.9094
45				1.0490	1.0977	0.9037	0.8725
46				1.0480	1.0970	0.8917	0.8562
47		1.2997		1.0439	1.0950	0.8619	0.8248
48		1.2441		1.0352	1.0866	0.8385	0.8044
49		1.1728		1.0037	1.0568	0.7768	0.7576
50		1.1494		0.9869	1.0414	0.7430	0.7334
51		1.1244		0.9538	1.0117	0.6700	0.6871
52		1.1255		0.9434	1.0042	0.6313	0.6637
53		1.7237		1.0684	1.1241	0.9496	0.9691
54				1.0619	1.1139	0.9321	0.9463
55				1.0572	1.1062	0.9058	0.9078
56				1.0574	1.1053	0.8935	0.8910
57				1.0626	1.1112	0.8720	0.8645
58		1.3715		1.0598	1.1092	0.8555	0.8486
59		1.2501		1.0425	1.0926	0.8082	0.8098
60		1.2089		1.0269	1.0782	0.7786	0.7872
61		1.1537		0.9864	1.0409	0.7102	0.7401
62		1.1381		0.9690	1.0248	0.6762	0.7182
63	1.0742	1.1270	1.1887	0.9385	0.9985	0.6083	0.6803
64	1.0796	1.1302	1.2615	0.9275	0.9912	0.5779	0.6659

65		1.7934		1.0502	1.1047	0.9282	0.9622
66				1.0575	1.1070	0.9096	0.9346
67				1.0613	1.1084	0.8988	0.9207
68				1.0688	1.1155	0.8789	0.8953
69				1.0732	1.1200	0.8678	0.8839
70		1.3640		1.0787	1.1264	0.8416	0.8615
71		1.3003		1.0685	1.1180	0.8166	0.8421
72		1.2090		1.0284	1.0788	0.7517	0.7934
73		1.1776		1.0065	1.0583	0.7186	0.7710
74	1.0730	1.1385	1.0897	0.9646	1.0192	0.6540	0.7315
75	1.0682	1.1257	1.1244	0.9446	1.0014	0.6247	0.7172
76	1.0590	1.1101	1.2287	0.9040	0.9664	0.5735	0.7028
77		1.7255		1.0390	1.0884	0.9033	0.9434
78				1.0511	1.0987	0.8996	0.9376
79				1.0655	1.1105	0.8838	0.9186
80				1.0732	1.1180	0.8754	0.9097
81				1.0924	1.1386	0.8605	0.8975
82		1.4352		1.1035	1.1502	0.8535	0.8935
83		1.3045		1.0843	1.1327	0.8037	0.8573
84		1.2471		1.0553	1.1047	0.7660	0.8280
85	1.0845	1.1746	1.0510	1.0028	1.0534	0.6971	0.7814
86	1.0755	1.1498	1.0607	0.9785	1.0300	0.6668	0.7636
87	1.0588	1.1164	1.1054	0.9315	0.9867	0.6128	0.7413
88	1.0463	1.0986	1.1402	0.9037	0.9614	0.5929	0.7392
89		1.8270		0.9568	1.0050	0.8446	0.8906
90		1.7547		1.0100	1.0574	0.8777	0.9252
91				1.0514	1.0954	0.8842	0.9310
92				1.0654	1.1086	0.8807	0.9280
93				1.0836	1.1262	0.8653	0.9144
94				1.0987	1.1417	0.8616	0.9139
95	1.1086	1.2364	1.0533	1.0519	1.0990	0.7451	0.8354
96	1.0915	1.1953	1.0429	1.0211	1.0685	0.7105	0.8112
97	1.0717	1.1440	1.0503	0.9704	1.0205	0.6535	0.7836
98	1.0575	1.1195	1.0581	0.9415	0.9928	0.6292	0.7750
99	1.0153	1.0664	1.0852	0.8724	0.9268	0.5877	0.7694
100	0.9620	1.0082	1.0835	0.8114	0.8666	0.5653	0.7598
101		1.7020		1.0126	1.0549	0.8668	0.9190
102				1.0462	1.0883	0.8803	0.9347
103				1.0709	1.1117	0.8704	0.9276
104		1.6503		1.0834	1.1234	0.8644	0.9239
105		1.4624		1.1168	1.1582	0.8587	0.9281
106	1.1224	1.2700	1.0640	1.0784	1.1230	0.7638	0.8697
107	1.0877	1.1850	1.0345	1.0132	1.0584	0.6950	0.8240
108	1.0752	1.1562	1.0299	0.9852	1.0312	0.6689	0.8133
109	1.0501	1.1103	1.0343	0.9294	0.9780	0.6267	0.8100

110	1.0162	1.0700	1.0207	0.8841	0.9338	0.6052	0.8042
111		1.9194		0.9651		0.8416	0.8970
112		1.8269		1.0172		0.8736	0.9312
113		1.6323		1.0577		0.8771	0.9386
114		1.5624		1.0706		0.8724	0.9361
115		1.4736		1.0886		0.8540	0.9253
116		1.4420		1.1041		0.8499	0.9271
117	1.1046	1.2382	1.0434	1.0578		0.7384	0.8667
118	1.0895	1.1992	1.0274	1.0268		0.7077	0.8483
119	1.0719	1.1488	1.0161	0.9764		0.6624	0.8405
120	1.0584	1.1244	1.0095	0.9475		0.6456	0.8450
121	1.0179	1.0715	0.9936	0.8789		0.6264	0.8759
122	0.9651	1.0130	0.9494	0.8183		0.6175	0.8907
123		1.8481		1.0516		0.8933	0.9564
124		1.7189		1.0624		0.8866	0.9516
125		1.5384		1.0763		0.8646	0.9355
126		1.4809		1.0840		0.8540	0.9303
127	1.0637	1.4022	1.0532	1.1034		0.8353	0.9262
128	1.0917	1.3768	1.0671	1.1148		0.8271	0.9283
129	1.1110	1.2980	1.0597	1.0961		0.7811	0.9058
130	1.1003	1.2505	1.0398	1.0668		0.7480	0.8845
131	1.0819	1.1829	1.0127	1.0145		0.6949	0.8629
132	1.0749	1.1591	1.0036	0.9903		0.6757	0.8650
133	1.0623	1.1260	0.9951	0.9436		0.6542	0.8969
134	1.0502	1.1080	0.9870	0.9166		0.6551	0.9289
135		2.0081		1.0696		0.9150	0.9808
136		1.7026		1.0742		0.8861	0.9565
137		1.5961		1.0769		0.8708	0.9451
138	1.0132	1.4494	1.0336	1.0842		0.8423	0.9270
139	1.0356	1.4004	1.0378	1.0889		0.8289	0.9213
140	1.0774	1.3291	1.0477	1.0951		0.8007	0.9146
141	1.0876	1.2924	1.0432	1.0857		0.7789	0.9052
142	1.0826	1.2190	1.0175	1.0447		0.7266	0.8821
143	1.0796	1.1911	1.0060	1.0234		0.7046	0.8794
144	1.0736	1.1532	0.9899	0.9822		0.6735	0.8987
145	1.0713	1.1408	0.9837	0.9626		0.6683	0.9251
146	1.0662	1.1236	0.9774	0.9230		0.6829	1.0148
147		1.9965		1.0928		0.9256	0.9949
148		1.8216		1.0843		0.9021	0.9738
149	0.9692	1.5657	1.0289	1.0778		0.8609	0.9409
150	0.9918	1.4786	1.0277	1.0774		0.8433	0.9285
151	1.0357	1.3673	1.0328	1.0830		0.8138	0.9159
152	1.0527	1.3253	1.0318	1.0811		0.7968	0.9089
153	1.0715	1.2546	1.0215	1.0639		0.7559	0.8956
154	1.0751	1.2244	1.0124	1.0485		0.7338	0.8912

155	1.0717	1.1732	0.9882	1.0091		0.6931	0.8956
156	1.0731	1.1584	0.9808	0.9923		0.6818	0.9135
157	1.0796	1.1460	0.9740	0.9625		0.6799	0.9891
158	1.0883	1.1494	0.9747	0.9527		0.6950	1.0500
159	0.9227	1.7880	1.0380	1.0862		0.8942	0.9688
160	0.9504	1.6394	1.0281	1.0764		0.8686	0.9473
161	0.9954	1.4453	1.0232	1.0735		0.8302	0.9219
162	1.0165	1.3797	1.0221	1.0731		0.8130	0.9132
163	1.0506	1.2937	1.0212	1.0701		0.7798	0.9033
164	1.0600	1.2589	1.0151	1.0619		0.7603	0.8986
165	1.0648	1.1981	0.9930	1.0307		0.7173	0.8936
166	1.0666	1.1766	0.9822	1.0140		0.7001	0.9024
167	1.0705	1.1502	0.9655	0.9823		0.6795	0.9517
168	1.0801	1.1501	0.9638	0.9727		0.6840	1.0014
169	0.9039	1.9247	1.0479	1.0961		0.9115	0.9852
170	0.9558	1.5899	1.0187	1.0673		0.8517	0.9338
171	0.9780	1.4789	1.0119	1.0620		0.8295	0.9181
172	1.0235	1.3493	1.0164	1.0679		0.7999	0.9076
173	1.0390	1.3025	1.0141	1.0648		0.7830	0.9031
174	1.0569	1.2330	1.0018	1.0483		0.7446	0.8962
175	1.0602	1.2038	0.9909	1.0349		0.7249	0.8980
176	1.0548	1.1537	0.9606	0.9955		0.6866	0.9167
177	1.0606	1.1449	0.9538	0.9832		0.6801	0.9499
178	1.0894	1.1559	0.9563	0.9730		0.6953	1.0729
179	0.9249	1.8488	1.0275	1.0769		0.8865	0.9604
180	0.9490	1.6704	1.0100	1.0589		0.8540	0.9321
181	0.9881	1.4325	1.0025	1.0536		0.8134	0.9063
182	1.0115	1.3634	1.0064	1.0567		0.7996	0.9027
183	1.0471	1.2796	1.0093	1.0603		0.7725	0.9022
184	1.0557	1.2439	1.0024	1.0524		0.7539	0.9000
185	1.0507	1.1773	0.9719	1.0168		0.7088	0.8987
186	1.0469	1.1513	0.9547	0.9965		0.6904	0.9113
187	1.0519	1.1280	0.9327	0.9669		0.6738	0.9886
188	1.0694	1.1375	0.9350	0.9650		0.6830	1.0594
189	0.9498	1.5749	0.9795	1.0276		0.8201	0.8987
190	0.9653	1.4386	0.9742	1.0229		0.7977	0.8840
191	1.0310	1.3377	1.0066	1.0580		0.7923	0.9019
192	1.0488	1.2951	1.0091	1.0610		0.7803	0.9038
193	1.0606	1.2244	0.9950	1.0454		0.7433	0.9018
194	1.0556	1.1894	0.9769	1.0265		0.7202	0.9022
195	1.0178	1.1085	0.9175	0.9612		0.6651	0.9065
196	1.0212	1.0986	0.9066	0.9471		0.6592	0.9561
197	0.9332	1.6049	0.9324	0.9778		0.7899	0.8603
198	0.9947	1.3927	0.9744	1.0242		0.7895	0.8796
199	1.0338	1.3526	0.9992	1.0505		0.7947	0.8970

200	1.0707	1.2817	1.0132	1.0667		0.7776	0.9090
201	1.0747	1.2462	1.0057	1.0586		0.7594	0.9094
202	1.0513	1.1666	0.9616	1.0122		0.7064	0.9025
203	1.0219	1.1160	0.9233	0.9710		0.6730	0.8994
204	0.9719	1.0375	0.8513	0.8935		0.6293	0.9612
205	0.9692	1.3535	0.9276	0.9743		0.7584	0.8385
206	1.0708	1.3401	1.0119	1.0644		0.7992	0.9060
207	1.0914	1.3084	1.0243	1.0786		0.7942	0.9184
208	1.0933	1.2406	1.0093	1.0638		0.7584	0.9177
209	1.0724	1.1914	0.9805	1.0341		0.7261	0.9105
210	0.9741	1.0531	0.8713	0.9191		0.6347	0.8673