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Benchmark Calculation for Surry Unit 1 Cycles 1–3 Using the SCALE 6.3/Polaris–PARCS v3.4.2 Code Package

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OAK RIDGE National Laboratory

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Nuclear Energy and Fuel Cycle Division

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ABBREVIATIONS

BA	burnable absorber
BOC	beginning of cycle
BP	burnable poison
BWR	boiling water reactor
CR	control rod
ENDF	Evaluated Nuclear Data File
EPRI	Electric Power Research Institute
$F_{\Delta H}^{N}$	enthalpy rise hot channel factor
HFP	hot full power
HZP	hot zero power
Inc–718	Inconel–718
ORNL	Oak Ridge National Laboratory
PARCS	Purdue Advanced Reactor Core Simulator
PWR	pressurized water reactor
Pyrex	borosilicate
RMS	root mean square
SS–304	stainless steel 304
SU1	Surry Unit 1
VEPCO	Virginia Electric and Power Company
Zr–4	Zircaloy–4

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ABSTRACT

The benchmark calculations were performed for Surry Unit 1 cycles 1–3 to validate the SCALE 6.3/Polaris–Purdue Advanced Reactor Core Simulator (PARCS) v3.4.2 with the ENDF/B–VII.1 56–group library by comparing the simulated results with the measured data. The benchmark results will be used to evaluate uncertainties of the SCALE/Polaris–PARCS code package for pressurized water reactor physics analysis for key nuclear parameters such as reactivity, control bank worth, temperature coefficients, and pin and assembly power peaking factors. This report details plant and fuel design specifications and input data for SCALE/Polaris, GenPMAXS, and PARCS. Additional details are provided for the input and output files produced for the benchmark calculations. The benchmark results were summarized such that they can be used in evaluating uncertainties with other benchmark results for key nuclear parameters.

1. INTRODUCTION

Surry Unit 1 (SU1) [1] is a Westinghouse Electric Company three–loop pressurized water reactor (PWR) operated by the Virginia Electric and Power Company (VEPCO). The reactor began operation at 2,441 MW_{th} (824 MW_e) power in 1973. The benchmark provides measured reactor data for boron letdown curves and 3D in–core flux maps.

This study performed the benchmark calculations for the SU1 benchmark problems to validate the SCALE 6.3/Polaris [2, 3]–GenPMAXS v6.3.1 [4] – Purdue Advanced Reactor Core Simulator (PARCS) v3.4.2 [5] code package for PWR analysis with the ENDF/B–VII.1 AMPX 56–group library [6]. The simulated benchmark results were compared with the measured data, and they will be used in the validation of the SCALE 6.3/PARCS–GenPMAXS–PARCS v3.4.2 code package by evaluating uncertainties for key nuclear parameters such as reactivity, control bank worth, temperature coefficients, and pin and assembly power peaking factors.

The Polaris–GenPMAXS–PARCS code package is briefly overviewed herein, and detailed information is provided for the plant design data and measured data in Section 2. Because the measured data were obtained for hot full power (HFP), the design data must be thermally expanded to prepare input data for Polaris, GenPMAXS, and PARCS. Therefore, the data were thermally expanded for this study. In Section 3, the simulated benchmark results are summarized and compared with the measured data. Additional details are provided for the input and output files generated from the benchmark calculations. Section 4 discusses the pending issues in Polaris and PARCS, and Section 5 presents the summary and concluding remarks.

2. CODE PACKAGE AND DESIGN SPECIFICATION

2.1 PROCEDURE AND CODE PACKAGE

Benchmark calculations for SU1 cycles 1–3 were performed using the SCALE 6.3/Polaris–GenPMAXS v6.3.1–PARCS v3.4.2 code package with the ENDF/B–VII.1 AMPX 56–group library. Figure 2.1 is a flowchart of the Polaris–GenPMAXS–PARCS code package process used to simulate PWRs. The SCALE/Polaris code, developed by Oak Ridge National Laboratory, is a 2D lattice physics code to generate 2–group homogenized cross sections and pin power form factors for fuel assemblies and reflectors. The Polaris depletion calculations were performed at the reference states with various branch calculations to cover all the probable states in the reactor. The GenPMAXS code, developed by the University of Michigan, prepares a cross–section table set for each type of fuel assembly and reflector in which 2–group macroscopic cross sections are tabulated as a function of burnup, boron concentration, moderator and fuel temperatures, moderator density, and control rod (CR) insertion. Once cross–section table sets have been prepared for all types of fuel assemblies and radial and axial reflectors, whole–core nodal diffusion calculations are performed using the PARCS code. Typically, a simplified internal thermal–hydraulics model can be used for the PWR physics analysis.

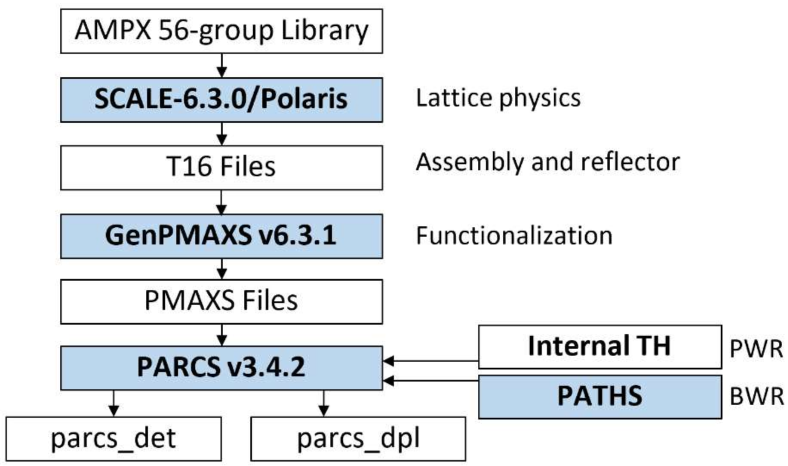


Figure 2.1. Flowchart of the Polais–GenPMAXS–PARCS procedure.

The SCALE 6.3/Polaris, GenPMAXS v6.3.1, and PARCS v3.4.2 with the ENDF/B–VII.1 AMPX 56–group library were used in these benchmark calculations. Table 2.1 provides detailed information on the programs and data used in the calculations.

Table 2.1. Programs used in the benchmark calculations

Program	File name	Version	md5sum	Reference
SCALE/Polaris	scalerte	6.3.0	c30aa9d4841d51636ea08f2aa71cf1e5	[2, 3]
ENDF/B–VII.1 56–group library	scale.rev00.xn56g19v7.1	6.3.0	2a1ab889c81354758bd85b3c0593db7a	[6]
GenPMAXS	genpmaxs–v6.3.1–linux2–intel–x64–release.x	6.3.1	5a0428587c6ba65e2028e6dc98d29488	[4]
PARCS	parcs–v342–linux2–intel–x64–release.x	3.4.2	fd005b709d0b597dd6910129d03fe8f5	[5]

2.2 SPECIFICATION OF THE SU1 CORE

2.2.1 Design Data

The SU1 [1] is a Westinghouse Electric Company three–loop, multicycle, PWR operated by VEPCO that began operation at 2,441 MW_{th} power in 1973. The benchmark provides measured reactor data for boron letdown curves and 3D in–core flux maps from 31 instrumented assemblies.

Table 2.2 provides key design specifications of the SU1 core for cycles 1−3. Table 2.3 provides specifications of the SU1 fuel assemblies and radial and axial reflectors. Because the Electric Power Research Institute (EPRI) report does not provide specification for top and bottom reflectors, the Watts Bar Unit 1 axial reflector data [7] were used in this benchmark calculation. Because the plant measured data are for the HFP condition, the geometry and composition specifications were thermally expanded at the HFP temperature using the thermal expansion coefficients provided in Table 2.4. These thermally expanded data can be used in the Polaris, GenPMAXS, and PARCS inputs. The thermally expanded dimension (l_T) at temperature T can be calculated using

$$l_T = l_{25} \times (1.0 + \Delta T \times \varepsilon), \quad (2.1)$$

where ΔT is the temperature difference between 25°C and the actual temperature (T), and ε denotes the thermal expansion coefficient. l_{25} is the target dimension (e.g., core height) at 25°C.

Table 2.2. Specification of the SU1 core

Parameter	Design data	Hot dimension
Core power	2441 MWth	
Operating pressure	2250 psia (15.51 MPa)	
Core flow rate	45. 8 × 10^6 kg/hr	
Inlet temperature	560 F (293.33°C)	
Number of fuel assemblies	157	
Assembly 1 (cycle 1)	1.87 w/o ^{235}U 15 × 15	
Assembly 2 (cycle 1)	2.57 w/o ^{235}U 15 × 15	
Assembly 3 (cycle 1)	3.12 w/o ^{235}U 15 × 15	
Assembly 4A (cycle 2)	1.86 w/o ^{235}U 15 × 15	
Assembly 4B (cycle 2)	2.61 w/o ^{235}U 15 × 15	
Assembly 4C (cycle 2)	3.33 w/o ^{235}U 15 × 15	
Assembly 4X (cycle 2)	1.86 w/o ^{235}U 17 × 17	
Assembly 5 (cycle 3)	2.10 w/o ^{235}U 15 × 15	
Total heavy metal mass (cycle 1)	81.8 MT	
Pin lattice configuration	15 × 15	
Active fuel length[a]	366.903cm	368.83 cm
Number of fuel rods	204	
Number of grid spacers	7 (Inconel–718, 6 in active zone)	
Assembly pitch	21.50364 cm	21.60912 cm
Pin pitch	1.43 cm	1.43243 cm
Fuel pellet radius	0.46469 cm	0.46714 cm
Cladding inner/outer radius	0.47422/0.53594 cm	0.47502/0.53685 cm
Number of control banks	53	
CR material (lower)	AgInCd	
Burnable poison material	Borosilicate glass, 12.5 w/o B_2O_3	

[a] Averaged active height (nominal: 365.76 cm)

Table 2.3. Specification of the SU1 fuel assemblies and reflectors

Item	Material	Density (g/cm^3)	Subitem (unit)	Thermal exp. Coeff. ($°C^{-1}$)	Dimension (cm)	
					Cold	Hot
Active height	UO_2			1.052E–05	366.903	368.8323
Assembly pitch	SS–304			1.730E–05	21.50364	21.60912
Pin pitch	Inc–718	8.192		13.000E–06	1.43	1.43527
Assembly gap					0.05364	0.08006
Fuel	UO_2		Outer radius (cm)	1.052E–05	0.464693	0.46714
Pyrex	He		Outer radius (cm)		0.2838	
	SS–304	8.03			0.3004	
	He				0.3086	
	B_2O_3–SiO_2	2.23			0.5029	
	He				0.5086	
	SS–304	8.03			0.5582	
Clad	Zr–4	6.56	Inner radius (cm)	6.000E–06	0.474218	0.47502
			Outer radius (cm)	6.000E–06	0.53594	0.53685
Instrument tube	Zr–4	6.56	Inner radius(cm)	6.000E–06	0.613918	0.61496
			Outer radius(cm)	6.000E–06	0.690118	0.69129
Guide tube	Zr–4	6.56	Inner radius(cm)	6.000E–06	0.613918	0.61496
			Outer radius(cm)	6.000E–06	0.690118	0.69129
Spacer grid	Inc–718	8.192	weight (g)		675	
			Height (cm)		3.81	
			Volume (g/cm^3)		83.39746	
Radial reflector	SS–304	8.03	Water gap (cm)		0.1524	
			Baffle thick (cm)		2.54	
			Water		—	
Top reflector	Zr–4(29*), SS–304(55), H_2O(16)		Plenum		8.556	
	Zr–4(23), SS–304(45), Inc–718(20), H_2O(12)		Plenum + Grid		3.866	
	Zr–4(29), SS–304(55), H_2O(16)		Plenum		3.578	
	Zr–4(88), H_2O(12)		Plug		1.670	
	Zr–4(7), H_2O(93)		Nozzle + Gap		2.129	
	SS–304(76), H_2O(24)		Top nozzle		8.827	
	SS–304(93), H_2O(7)		Support plate		7.600	
Bottom reflector	Zr–4(44), Inc–718(21), H_2O(35)		Gap		5.898	
	SS–304(80), H_2O(20)		Bottom nozzle		6.053	
	SS–304(91), H_2O(20)		Support plate		5.000	
	Zr–4(44), Inc–718(21), H_2O(35)		Gap		20.000	

Table 2.4. Thermal expansion coefficients.

Material	Thermal expansion coefficient ($°C^{-1}$)	Reference
Zircaloy–4	6.0E–6	[8]
SS–304	17.3E–6	[9]
UO_2	10.52E–6	[10]
Inc–718	13.0E–6	[11]

The following rules can be used in obtaining thermally expanded dimensions.

- Equation (2.1) was used for x, y, and radial expansions.
- Hot pin pitch was determined by expanding the Inconel–718 (Inc–718) spacer grid material.
- Hot assembly pitch was determined by expanding the SS–304 bottom plate material.

- Active height was determined by utilizing the same radial thermal expansion ratio of the UO_2 fuel assembly.
- Thermal expansion was not applied to control rod and burnable poison materials since the effect of moderator displacement would be minimal. The thickness of spacer grid surrounding fuel pin was determined by conserving the total mass of space grids with the thermally expanded hot pin pitch length.

Table 2.5 provides the cold and hot atomic number densities for UO_2 fuel by conserving total uranium mass per each fuel assembly. The hot atomic number densities were used in the Polaris calculations to generate assembly homogenized 2–group cross sections for nodal diffusion calculations. Table 2.6 provides atomic number densities for structure materials such as Zircaloy–4 (Zr–4), Inc–718, SS–304, and BA and CR materials. The SU1 cycles 1−3 include the borosilicate (Pyrex) BAs. Figures 2.2−2.6 illustrate fuel assembly configurations with various loadings of UO_2 fuel rods and Pyrex BAs.

Table 2.5. Atomic number densities for UO_2 fuels

Type	Fuel type	As–built ^{235}U wt%	Density (g/cm^3)		Mass (kg U)	Nuclide	ID	Atomic number density (#/barn–cm)	
			Cold	Hot				Cold	Hot
1	1.868_bp00	1.868	10.052	9.80508	449.921	^{234}U	92234	6.72682E–06	6.62181E–06
						^{235}U	92235	4.23789E–04	4.17174E–04
						^{238}U	92238	2.19900E–02	2.16467E–02
						^{16}O	8016	4.47333E–02	4.40350E–02
						^{17}O	8017	2.01805E–05	1.98654E–05
						^{18}O	8018	9.41754E–05	9.27053E–05
2	2.573_bp00	2.573	9.987	9.83101	447.029	^{234}U	92234	6.68385E–06	6.57951E–06
						^{235}U	92235	5.81495E–04	5.72418E–04
						^{238}U	92238	2.16891E–02	2.13505E–02
						^{16}O	8016	4.44476E–02	4.37538E–02
						^{17}O	8017	2.00516E–05	1.97385E–05
						^{18}O	8018	9.35740E–05	9.21132E–05
3	3.117_bp00	3.117	9.880	9.72577	439.800	^{234}U	92234	6.61264E–06	6.50941E–06
						^{235}U	92235	6.94327E–04	6.83488E–04
						^{238}U	92238	2.13390E–02	2.10059E–02
						^{16}O	8016	4.39741E–02	4.32876E–02
						^{17}O	8017	1.98379E–05	1.95282E–05
						^{18}O	8018	9.25770E–05	9.11318E–05
4A	3.330_bp00	3.330	10.138	9.97973	453.771	^{234}U	92234	6.78727E–06	6.68132E–06
						^{235}U	92235	7.60175E–04	7.48308E–04
						^{238}U	92238	2.18482E–02	2.15072E–02
						^{16}O	8016	4.51354E–02	4.44308E–02
						^{17}O	8017	2.03618E–05	2.00440E–05
						^{18}O	8018	9.50218E–05	9.35385E–05
4B	2.610_bp00	2.610	10.17	10.01124	455.209	^{234}U	92234	6.80635E–06	6.70010E–06
						^{235}U	92235	5.98959E–04	5.89609E–04
						^{238}U	92238	2.20798E–02	2.17351E–02
						^{16}O	8016	4.52622E–02	4.45557E–02
						^{17}O	8017	2.04191E–05	2.01003E–05
						^{18}O	8018	9.52889E–05	9.38014E–05
4C	1.860_bp00	1.860	10.149	9.99056	454.242	^{234}U	92234	6.78993E–06	6.68394E–06
						^{235}U	92235	4.27766E–04	4.21088E–04
						^{238}U	92238	2.22031E–02	2.18565E–02
						^{16}O	8016	4.51531E–02	4.44482E–02
						^{17}O	8017	2.03698E–05	2.00518E–05
						^{18}O	8018	9.50591E–05	9.35751E–05
4X	1.860_bp00	1.860	10.139	9.980722	456.189	^{234}U	92234	6.78324E–06	6.67735E–06

						^{235}U	92235	4.27344E–04	4.20673E–04
						^{238}U	92238	2.21812E–02	2.18349E–02
						^{16}O	8016	4.51086E–02	4.44044E–02
						^{17}O	8017	2.03497E–05	2.00321E–05
						^{18}O	8018	9.49654E–05	9.34829E–05
5	2.100_bp00	2.100	10.213	10.05357	457.137	^{234}U	92234	6.83293E–06	6.72627E–06
						^{235}U	92235	4.85138E–04	4.77565E–04
						^{238}U	92238	2.22890E–02	2.19411E–02
						^{16}O	8016	4.54390E–02	4.47297E–02
						^{17}O	8017	2.04988E–05	2.01788E–05
						^{18}O	8018	9.56611E–05	9.41677E–05

Table 2.6. Atomic number densities for structure materials (1/2)

Material	Density (g/cm^3)		Nuclide	ID	Atomic number density (#/barn–cm)	
	cold	hot			Cold	Hot
Zr–4	6.56	6.52663	^{16}O	8016	3.0791E–04	3.0634E–04
			^{17}O	8017	1.1729E–07	1.1669E–07
			^{18}O	8018	6.3274E–07	6.2952E–07
			^{50}Cr	24050	3.3013E–06	3.2845E–06
			^{52}Cr	24052	6.3662E–05	6.3338E–05
			^{53}Cr	24053	7.2187E–06	7.1820E–06
			^{54}Cr	24054	1.7969E–06	1.7877E–06
			^{54}Fe	26054	8.6833E–06	8.6391E–06
			^{56}Fe	26056	1.3631E–04	1.3562E–04
			^{57}Fe	26057	3.1480E–06	3.1319E–06
			^{58}Fe	26058	4.1894E–07	4.1681E–07
			^{90}Zr	40090	2.1861E–02	2.1750E–02
			^{91}Zr	40091	4.7674E–03	4.7431E–03
			^{92}Zr	40092	7.2870E–03	7.2500E–03
			^{94}Zr	40094	7.3848E–03	7.3472E–03
			^{96}Zr	40096	1.1897E–03	1.1837E–03
			^{112}Sn	50112	4.6807E–06	4.6569E–06
			^{114}Sn	50114	3.1848E–06	3.1686E–06
			^{115}Sn	50115	1.6406E–06	1.6323E–06
			^{116}Sn	50116	7.0163E–05	6.9806E–05
			^{117}Sn	50117	3.7060E–05	3.6872E–05
			^{118}Sn	50118	1.1687E–04	1.1628E–04
			^{119}Sn	50119	4.1451E–05	4.1240E–05
			^{120}Sn	50120	1.5721E–04	1.5641E–04
			^{122}Sn	50122	2.2342E–05	2.2229E–05
			^{124}Sn	50124	2.7940E–05	2.7798E–05
Inc–718	8.2		^{50}Cr	24050	7.8239E–04	
			^{52}Cr	24052	1.5088E–02	
			^{53}Cr	24053	1.7108E–03	
			^{54}Cr	24054	4.2586E–04	
			^{54}Fe	26054	1.4797E–03	
			^{56}Fe	26056	2.3229E–02	
			^{57}Fe	26057	5.3645E–04	
			^{58}Fe	26058	7.1392E–05	
			^{55}Mn	25055	7.8201E–04	
			^{58}Ni	28058	2.9320E–02	
			^{60}Ni	28060	1.1294E–02	
			^{61}Ni	28061	4.9094E–04	
			^{62}Ni	28062	1.5653E–03	
			^{64}Ni	28064	3.9864E–04	
			^{28}Si	14028	5.6757E–04	
			^{29}Si	14029	2.8820E–05	

			^{30}Si	14030	1.8998E–05	
Borosilicate glass (Pyrex)	2.2599		^{10}B	5010	9.2773E–04	
			^{11}B	5011	3.7323E–03	
			^{16}O	8016	4.5395E–02	
			^{17}O	8017	1.4273E–05	
			^{18}O	8018	9.2773E–05	
			^{23}Na	11023	2.4264E–03	
			^{27}Al	13027	5.0668E–04	
			^{28}Si	14028	1.6849E–02	
			^{29}Si	14029	8.5637E–04	
			^{30}Si	14030	5.6377E–04	

Table 2.6. Atomic number densities for structure materials (2/2)

Material	Density (g/cm^3)		Nuclide	ID	Atomic number density (#/barn–cm)	
	cold	hot			Cold	Hot
Borosilicate glass (Pyrex) Once burnt	2.26		^{10}B	5010	5.7981E–05	
			^{11}B	5011	4.6095E–03	
			^{16}O	8016	4.5467E–02	
			^{23}Na	11023	2.4302E–03	
			^{27}Al	13027	5.0749E–04	
			^{28}Si	14028	1.6871E–02	
			^{29}Si	14029	8.6003E–04	
			^{30}Si	14030	5.6725E–04	
AgInCd	10.16		^{107}Ag	47107	2.3523e–02	
			^{109}Ag	47109	2.1854e–02	
			^{106}Cd	48106	3.3882e–05	
			^{108}Cd	48108	2.4166e–05	
			^{110}Cd	48110	3.3936e–04	
			^{111}Cd	48111	3.4821e–04	
			^{112}Cd	48112	6.5611e–04	
			^{113}Cd	48113	3.3275e–04	
			^{114}Cd	48114	7.8252e–04	
			^{116}Cd	48116	2.0443e–04	
			^{113}In	49113	3.4219e–04	
			^{115}In	49115	7.6511e–03	
B_4C	1.76		^{10}B	5010	1.5206e–02	
			^{11}B	5011	6.1514e–02	
			^{12}C	6012	1.8972e–02	
			^{13}C	6013	2.1252e–04	
SS 304	8.03		^{50}Cr	24050	7.6778e–04	
			^{52}Cr	24052	1.4806e–02	
			^{53}Cr	24053	1.6789e–03	
			^{54}Cr	24054	4.1791e–04	
			^{54}Fe	26054	3.4620e–03	
			^{56}Fe	26056	5.4345e–02	
			^{57}Fe	26057	1.2551e–03	
			^{58}Fe	26058	1.6703e–04	
			^{55}Mn	25055	1.7604e–03	
			^{58}Ni	28058	5.6089e–03	
			^{60}Ni	28060	2.1605e–03	
			^{61}Ni	28061	9.3917e–05	
			^{62}Ni	28062	2.9945e–04	
			^{64}Ni	28064	7.6261e–05	
			^{28}Si	14028	9.5281e–04	
			^{29}Si	14029	4.8381e–05	
			^{30}Si	14030	3.1893e–05	

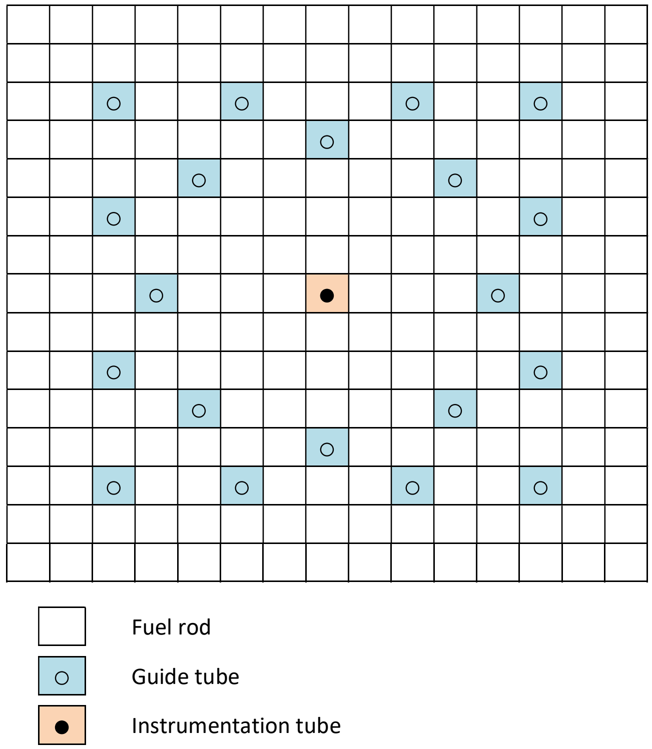


Figure 2.2. Type 1, 2, 3, 4A, 4B, 4C, and 5 fuel assembly configurations without BA.

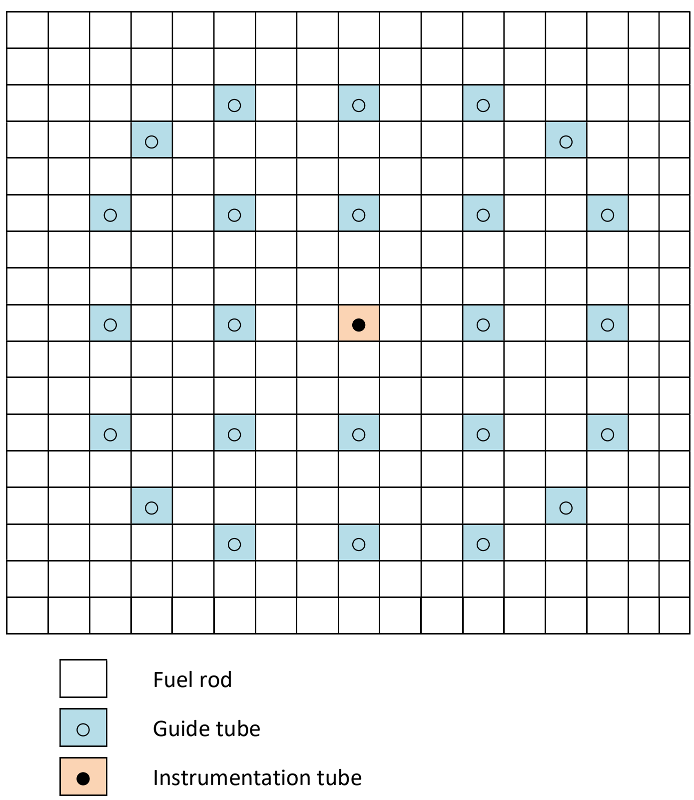


Figure 2.3. Type 4X 17 × 17 fuel assembly configuration without BA.

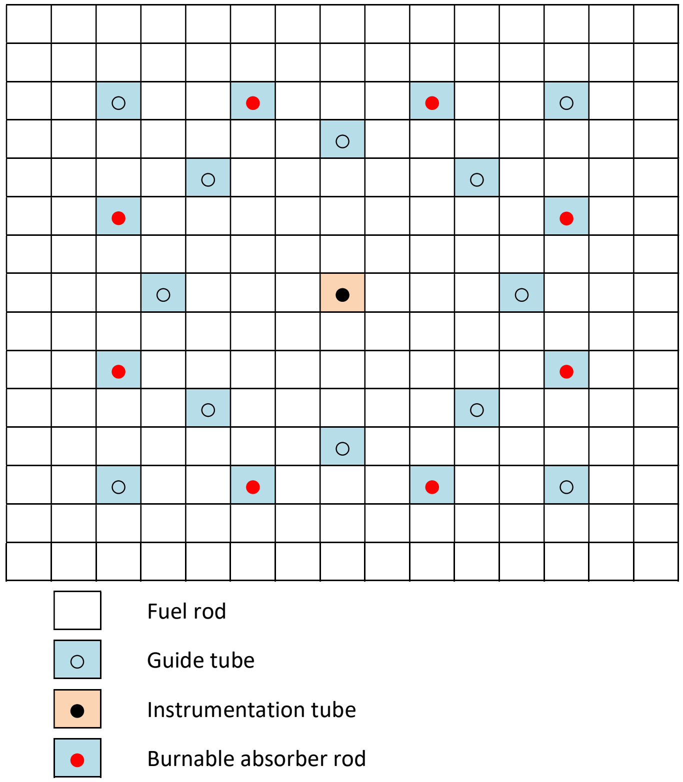


Figure 2.4. Fuel assembly configurations with 8 BAs.

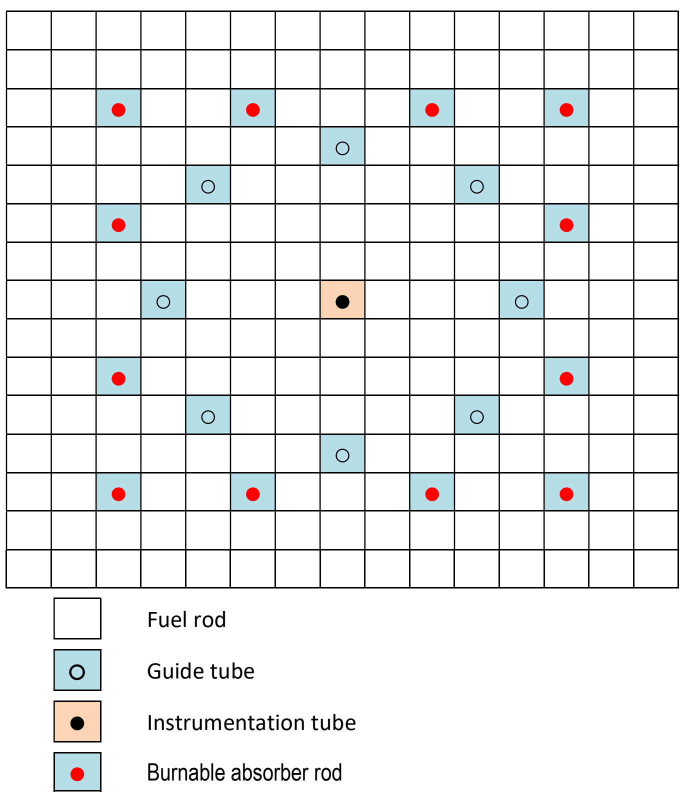


Figure 2.5. Fuel assembly configurations with 12 BAs.

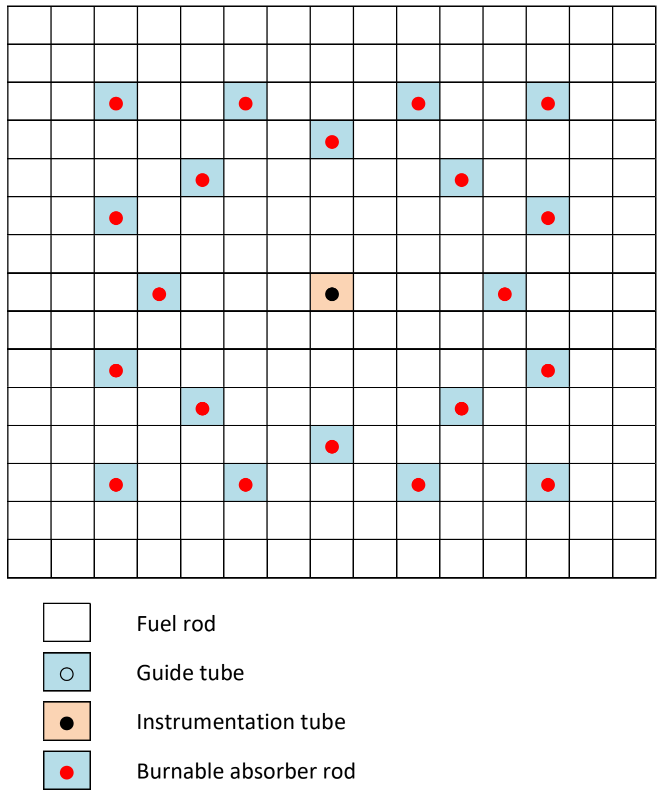


Figure 2.6. Fuel assembly configurations with 20 BAs.

Because the EPRI report [1] includes some errors in loading patterns, they were corrected as provided in Table 2.7. Figure 2.7 illustrates the fuel assembly loading pattern of the SU1 cycle 2 in the EPRI report. Fuel assembly types 4A and 4C were switched with each other, which would be much more reasonable in the sense that high enriched fuel assemblies are located at core periphery as similar with the SU1 cycle 1 loading pattern. In addition, the original loading pattern in the EPRI report would result in unrealistic differences in critical boron concentrations and flux maps. There are also some duplicated fuel assembly identifications and then missing identifications. The corrected loading pattern could introduce reasonable benchmark results.

Figure 2.8 provides the cycle 1 fuel assembly loading pattern for which three 1.86, 2.57 and 3.12 wt% ^{235}U enrichment fuels were used, and assembly types B and C include 12 BAs. Figure 2.9 illustrates the cycle 2 loading pattern with fresh assembly loadings with 1.86, 2.61, and 3.33 wt% ^{235}U fuels and shuffling of once–burned fuel assemblies. Two 17 × 17 fuel assemblies with 1.86 wt% ^{235}U fuels were loaded in cycle 2. Not all the type C once–burned fuel assemblies were used in cycle 2; some were used in cycle 3. Figure 2.10 illustrates the cycle 3 loading pattern with fresh assembly loadings with 2.1 wt% ^{235}U fuels and shuffling of once– and twice–burned fuel assemblies. Control and shutdown bank positions are provided in Figure 2.11. Because the bank S at L5 is incorrect in the EPRI report, the position was corrected. Figure 2.12 illustrates the locations of the ^{235}U fission chambers as in–core detectors taken from the measured flux map data and the EPRI report for Turkey Point [12]. Table 2.8 provides the fuel assembly types and numbers loaded in cycles 1−3. The SU1 axial configuration for fuel, spacer grids, and reflectors is shown in Table 2.9, where the first spacer grid location was determined partly based on the in–core power map data.

Table 2.7. Correction of the assembly IDs

Cycle	EPRI report	Correction	Location	Comments
1	C–7	C–1	P10	duplication
2	4A 1.86 wt%	4A 3.33 wt%	many	switched with each other
	4C 3.33 wt%	4C 1.86 wt%	many	
	4B–7	4B–1	H13	duplication
	4C–7	4C–1	J6	duplication
3	4A–2	4A–3	G1	symmetry is broken
	4A–3	4A–2	B7	
	4A–30	4A–23	E14	duplication
	4A–75	4A–25	J1	missing
	4A–73	4A–38	L14	missing

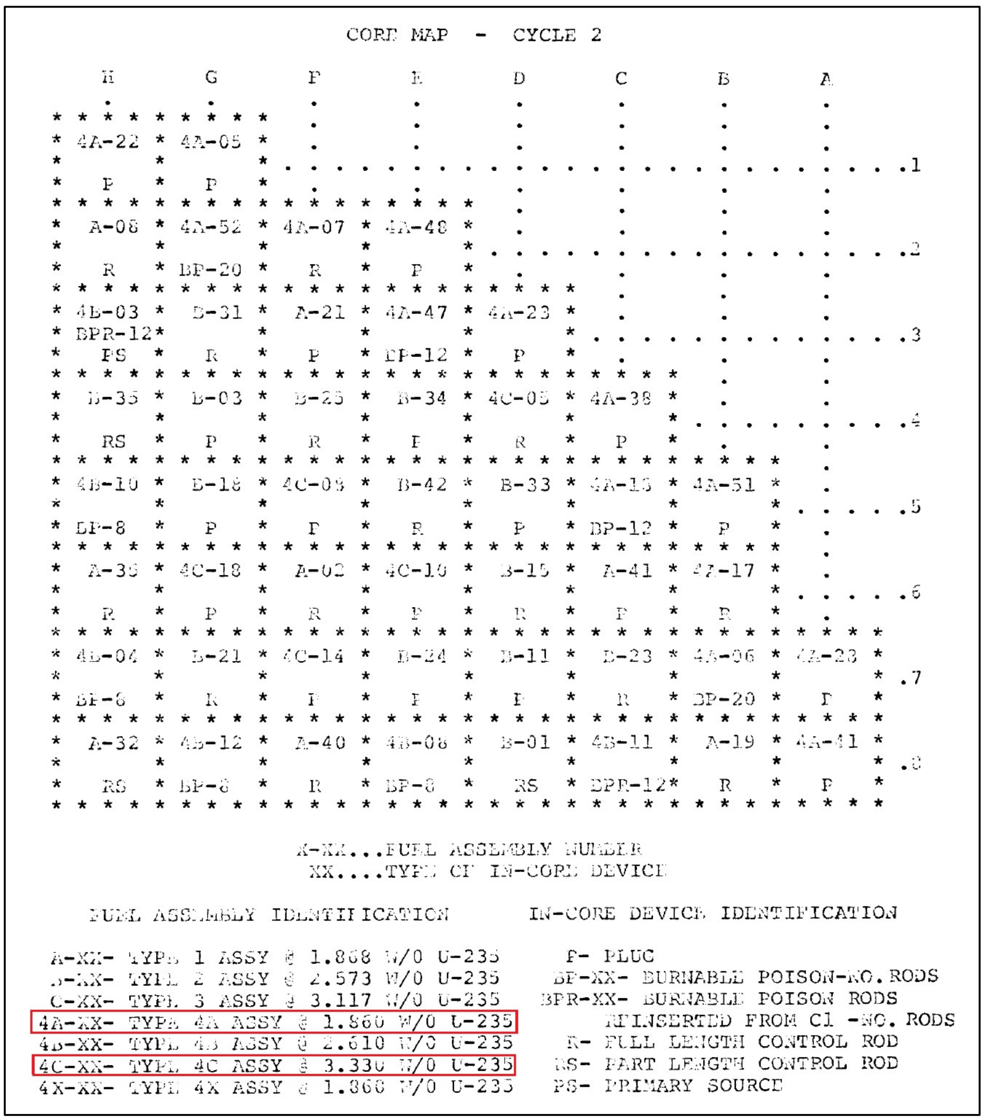


Figure 2.7. Loading pattern of the SU1 cycle 2 in the EPRI report.

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							C–30 P	C–27 P	C–16 P						
2					C–31 P	C–28	C–51 BP12	A–35	C–2 BP12	C–3	C–20 P				
3				C–47 P	C–21 BP12	B–10 BP12	A–9	B–35 BP12	A–52	B–18 BP12	C–13 BP12	C–6 P			
4			C–43 P	A–18	B–28 BP12	A–22	B–19 BP12	A–8	B–25 BP12	A–21	B–31 BP12	A–2	C–32 P		
5		C–46 P	C–7 BP12	B–50 BP12	A–46	B–52 BP12	A–6 P	B–17 BP12	A–39 P	B–3 BP12	A–25	B–23 BP12	C–40 BP12	C–33 P	
6		C–26	B–47 BP12	A–20	B–2 BP12	A–11	B–7 BP12	A–49	B–34 BP12	A–30	B–11 BP12	A–41	B–24 BP12	C–15	
7	C–34 P	C–8 BP12	A–17	B–6 BP12	A–16 P	B–8 BP12	A–1	B–36 BP12	A–3	B–33 BP12	A–37 P	B–15 BP12	A–24	C–44 BP12	C–39 P
8	C–38 P	A–38	B–27 BP12	A–48	B–45 BP12	A–51	B–26 BP12	A–32	B–42 BP12	A–31	B–21 BP12	A–19	B–1 BP12	A–40	C–49 P
9	C–35 P	C–25 BP12	A–50	B–9 BP12	A–53 P	B–44 BP12	A–10	B–14 BP12	A–7	B–29 BP12	A–23 P	B–30 BP12	A–43	C–36 BP12	C–29 P
10		C–1*	B–16 BP12	A–13	B–46 BP12	A–42	B–20 BP12	A–12	B–39 BP12	A–15	B–37 BP12	A–34	B–40 BP12	C–10	
11		C–45 P	C–18 BP12	B–4 BP12	A–14	B–13 BP12	A–44 P	B–49 BP12	A–47 P	B–5 BP12	A–33	B–43 BP12	C–19 BP12	C–23 P	
12			C–24 P	A–45	B–32 BP12	A–27	B–48 BP12	A–5	B–22 BP12	A–4	B–12 BP12	A–28	C–4 P		
13				C–12 P	C–11 BP12	B–51 BP12	A–26	B–41 BP12	A–36	B–38 BP12	C–17 BP12	C–9 P			
14					C–22 P	C–14	C–50 BP12	A–29	C–52 BP12	C–48	C–37 P				
15							C–41 P	C–42 P	C–5 P						

*Note: See Table 2.7 for correction.

- A–XX: Assembly 1.868 wt% ^{235}U
- B–XX: Assembly 2.573 wt% ^{235}U
- C–XX: Assembly 3.117 wt% ^{235}U
- P: Plug
- BP: Burnable absorber

Figure 2.8. Layout of fuel assemblies and BAs in the SU1 cycle 1.

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							4A–32 P	4A–22 P	4A–5 P						
2					4A–13 P	4A–36	4A–40 BP20	A–8	4A–52 BP20	4A–7	4A–48 P				
3				4A–30 P	4A–15 BP12	A–22 P	B–28	4B–3 BPR12	B–31	A–21 P	4A–47 BP12	4A–23 P			
4			4A–20 P	4C–4	B–7 P	B–19	B–52 P	B–35	B–3 P	B–25	B–34 P	4C–5	4A–38 P		
5		4A–27 P	4A–9 BP12	B–8 P	B–36	4X–1 P	B–10 P	4B–10 BP8	B–18 P	4C–8 P	B–42	B–33 P	4A–18 BP12	4A–51 P	
6		4A–45	A–20 P	B–6	4C–17 P	A–18	4C–1* P	A–35	4C–18 P	A–2	4C–10 P	B–15	A–41 P	4A–17	
7	4A–43 P	4A–4 BP20	B–50	B–2 P	B–47 P	4C–6 P	B–17	4B–4 BP8	B–21	4C–14 P	B–24 P	B–11 P	B–23	4A–6 BP20	4A–28 P
8	4A–39 P	A–48	4B–5 BPR12	B–27	4B–9 BP8	A–38	4B–7 BP8	A–32	4B–12 BP8	A–40	4B–8 BP8	B–1	4B–11 BPR12	A–19	4A–41 P
9	4A–14 P	4A–26 BP20	B–4	B–46 P	B–16 P	4C–9 P	B–45	4B–6 BP8	B–49	4C–7 P	B–40 P	B–37 P	B–43	4A–50 BP20	4A–49 P
10		4A–21	A–13 P	B–9	4C–3 P	A–45	4C–15 P	A–29	4C–16 P	A–28	4C–12 P	B–30	A–34 P	4A–2	
11		4A–42 P	4A–16 BP12	B–44 P	B–26	4C–11 P	B–51 P	4B–2 BP8	B–38 P	4X–2 P	B–14	B–29 P	4A–34 BP12	4A–12 P	
12			4A–37 P	4C–2	B–20 P	B–48	B–13 P	B–41	B–5 P	B–22	B–39 P	4C–13	4A–24 P		
13				4A–29 P	4A–35 BP12	A–27 P	B–32	4B–1* BPR12	B–12	A–4 P	4A–1 BP12	4A–11 P			
14					4A–44 P	4A–8	4A–46 BP20	A–5	4A–33 BP20	4A–19	4A–10 P				
15							4A–3 P	4A–31 P	4A–25 P						

*Note: See Table 2.7 for correction. BPR12 is from cycle 1 only with BA.

- A–XX: Assembly 1.868 wt% ^{235}U
- B–XX: Assembly 2.573 wt% ^{235}U
- 4A–XX: Assembly type 4A 3.330 wt% ^{235}U
- 4B–XX: Assembly type 4B 2.610 wt% ^{235}U
- 4C–XX: Assembly type 4C 1.860 wt% ^{235}U
- 4X–XX: Assembly type 4X 1.860 wt% ^{235}U
- P: Plug
- BP: Burnable absorber

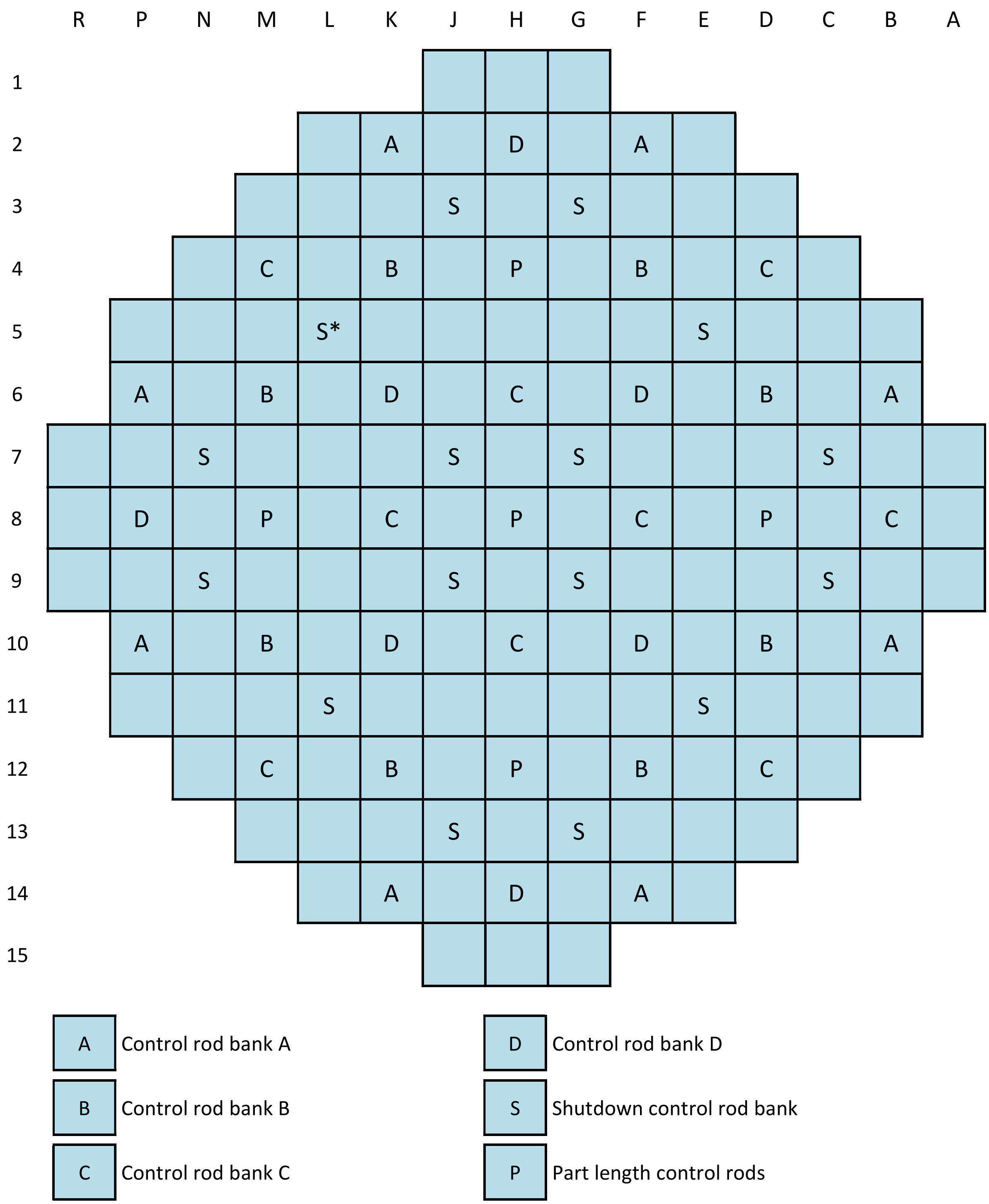
Figure 2.9. Layout of fuel assemblies and BAs in the SU1 cycle 2.

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							4A–25 P*	4A–31 P	4A–3 P*						
2					4A–11 P	4A–33	4A–7 P	C–20	4A–36 P	4A–46	4A–29 P				
3				4A–10 P	4A–1 P	C–30 BP12	A–9	C–3	A–52	C–16 BP12	4A–35 P	4A–44 P			
4			4A–12 P	C–37	4X–1 P	5A–15	C–17 P	C–2	C–11 P	5A–6	4C–8 P	C–45	4A–42 P		
5		4A–24 P	4A–34 P	4C–17 P	C–28	5A–1 P	4C–1 P	C–51 P	4C–18 P	5A–8 P	C–15	4C–10 P	4A–16 P	4A–37 P	
6		4A–50	C–37 BP12	5A–13	5A–2 P	4C–4	C–32 P	A–46	C–43 P	4C–5	5A–14 P	5A–3	C–39 BP12	4A–26	
7	4A–49 P	4A–21 P	A–17	C–19 P	4C–6 P	C–12 P	4B–10	C–42 P	4B–8	C–9 P	4C–14 P	C–18 P	A–24	4A–2* P	4A–14 P
8	4A–41 P	C–46	C–26 BP12	C–8	C–25 P	A–14	C–49 P	A–12	C–38 P	A–25	C–44 P	C–36	C–10 BP12	C–23	4A–39 P
9	4A–28 P	4A–45 P	A–50	C–40 P	4C–9 P	C–47 P	4B–9	C–27 P	4B–2	C–6 P	4C–7 P	C–1 P	A–43	4A–17 P	4A–43 P
10		4A–6	C–35 BP12	5A–11	5A–12 P	4C–2	C–4 P	A–33	C–24 P	4C–13	5A–9 P	5A–10	C–29 BP12	4A–4	
11		4A–30 P	4A–18 P	4C–3 P	C–7	5A–16 P	4C–15 P	C–52 P	4C–16 P	5A–4 P	C–48	4C–12 P	4A–9 P	4A–20 P	
12			4A–51 P	C–33	4C–11 P	5A–5	C–13 P	C–50	C–21 P	5A–7	4X–2 P	C–31	4A–27 P		
13				4A–48 P	4A–47 P	C–41 BP12	A–76	C–14	A–36	C–5 BP12	4A–15 P	4A–13 P			
14					4A–38 P*	4A–52	4A–19 P	C–22	4A–8 P	4A–40	4A–23 P*				
15							4A–5 P	4A–22 P	4A–32 P						

*Note: See Table 2.7 for correction.

A–XX	Assembly 1.868 wt% ^{235}U
C–XX	Assembly 3.117 wt% ^{235}U
4A–XX	Assembly type 4A 3.330 wt% ^{235}U
4B–XX	Assembly type 4B 2.610 wt% ^{235}U
4C–XX	Assembly type 4C 1.860 wt% ^{235}U
4X–XX	Assembly type 4X 1.860 wt% ^{235}U
5–XX	Assembly type 5 2.100 wt% ^{235}U
P	Plug
BP	Burnable absorber

Figure 2.10. Layout of fuel assemblies and BAs in the SU1 cycle 3.



*Note: Bank S location is incorrect in the EPRI report EPRI NP–79–2–LD [1].

Figure 2.11. Layout of control banks in the SU1 cycles 1–3.

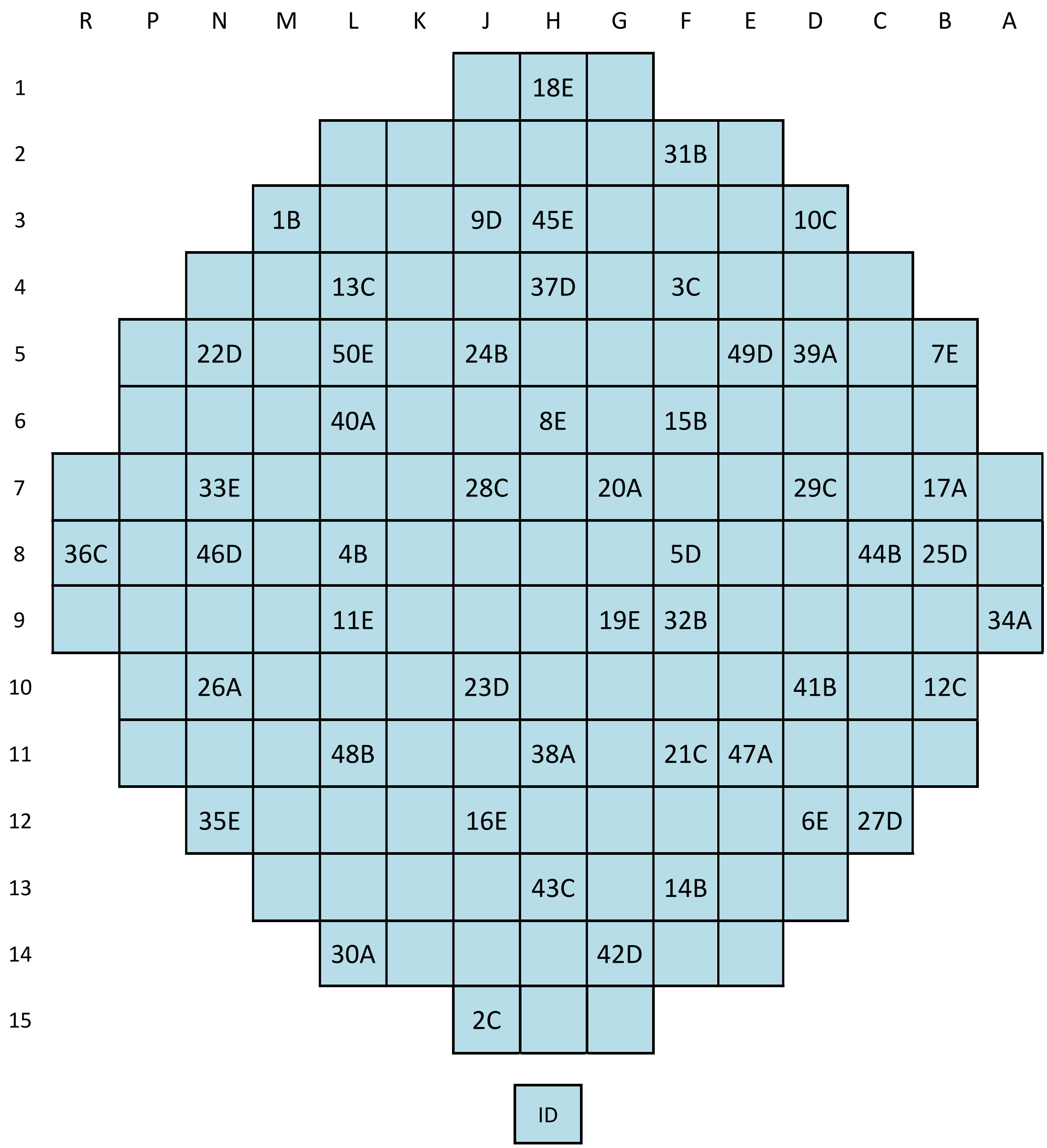


Figure 2.12. Core instrumentation locations in SU1 cycles 1–3.

Table 2.8. Assembly types for the SU1 cycles 1−3

Cycle	Type	^{235}U wt%	Power density (W/g)	BA	PARCS assembly no.	Description	Remark
1	1	1.868	34.8938	0	10	1.868 wt% 00–BA	
	2	2.573	34.8938	0	20	2.573 wt% 00–BA	
				12	22	2.573 wt% 12–BA	Pyrex
	3	3.117	34.8938	0	30	3.117 wt% 00–BA	
				12	32	3.117 wt% 12–BA	Pyrex
2	4A	3.330	34.4587	0	40	3.330 wt% 00–BA	
				12	42	3.330 wt% 12–BA	Pyrex
				20	43	3.330 wt% 20–BA	Pyrex
	4B	2.610	34.4587	8	51	2.610 wt% 08–BA	Pyrex
				12	54	2.610 wt% 12–BA	Pyrex
	4C	1.860	34.4587	0	60	1.860 wt% 00–BA	
	4X	1.860	34.4587	0	70	1.860 wt% 00–BA	
3	5	2.100	34.0250	0	80	2.100 wt% 00–BA	

Table 2.9. SU1 core axial configurations

No.	Axial materials	Height (cm)		Distance (cm)	No. of meshes
		Cold	Hot		
1	Top reflector	396.241	398.170	14.098	1
2	Fuel rod	382.143	384.072	29.844	2
3	Spacer grid 6	352.499	354.228	3.810	1
4	Fuel rod	348.689	350.418	63.039	6
5	Spacer grid 5	285.977	287.379	3.810	1
6	Fuel rod	282.167	283.569	63.039	6
7	Spacer grid 4	219.454	220.530	3.810	1
8	Fuel rod	215.644	216.720	63.039	6
9	Spacer grid 3	152.931	153.682	3.810	1
10	Fuel rod	149.121	149.872	63.039	6
11	Spacer grid 2	86.409	86.833	3.810	1
12	Fuel rod	82.599	83.023	57.850	6
13	Spacer grid 1	25.050	25.173	3.810	1
14	Fuel rod	21.240	21.363	6.123	1
15	Bottom reflector	15.240	15.240	15.240	1
16		0.000	0.000	0.000	41

2.2.2 Measured Data

The measured data used in the current study were obtained from the publicly available operating history of SU1 cycles 1–3, including a critical boron history and in–core detector responses. Figures 2.13 and 2.14 and Tables 2.10 to 2.11 provide the operational histories for powers, control bank D insertion, and inlet temperatures at burnups for cycle 1 and 2, respectively. The EPRI report does not provide a detailed operational history for SU1 cycle 3. Table 2.12 provides the information for the measured in–core detector response, including burnups, corresponding burnup points in the PARCS models, and in–core detector locations. The EPRI report does not provide in–core flux map data directly, but 3D local powers at in–core detector locations converted from in–core flux map data using the INCORE code are provided [1]. Therefore, 3D assembly powers should be compared with the measured 3D assembly powers.

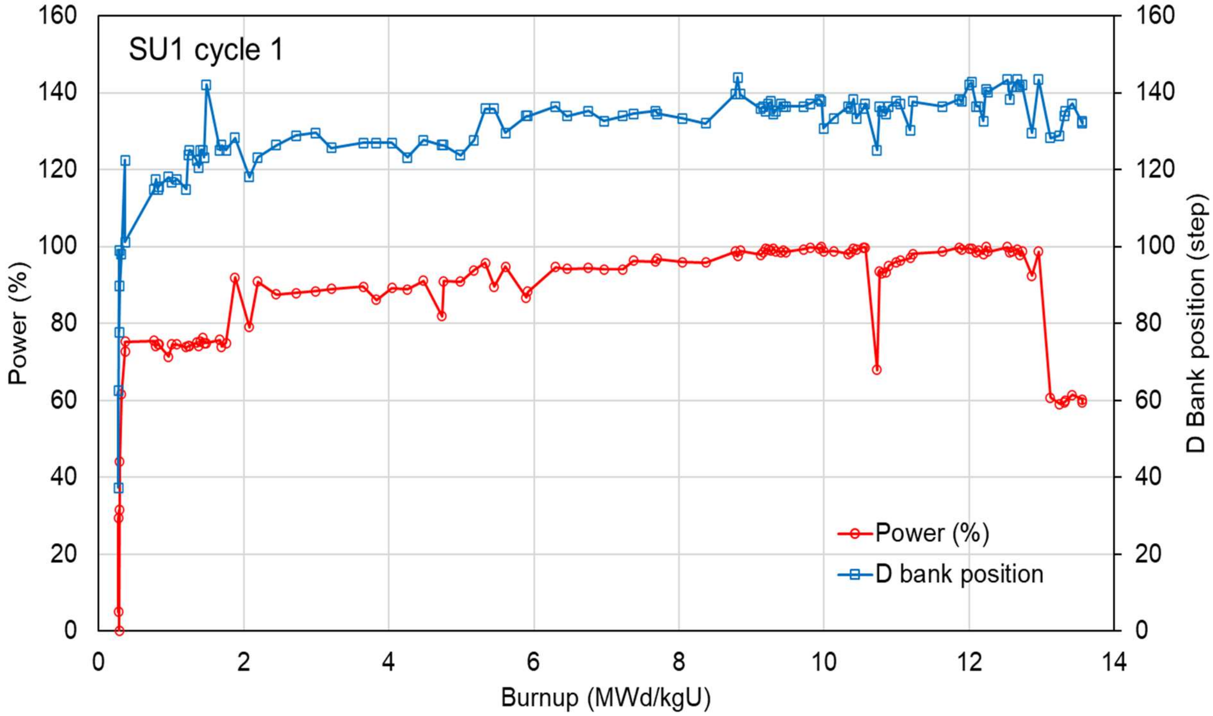


Figure 2.13. Power and D bank position history for SU1 cycle 1.

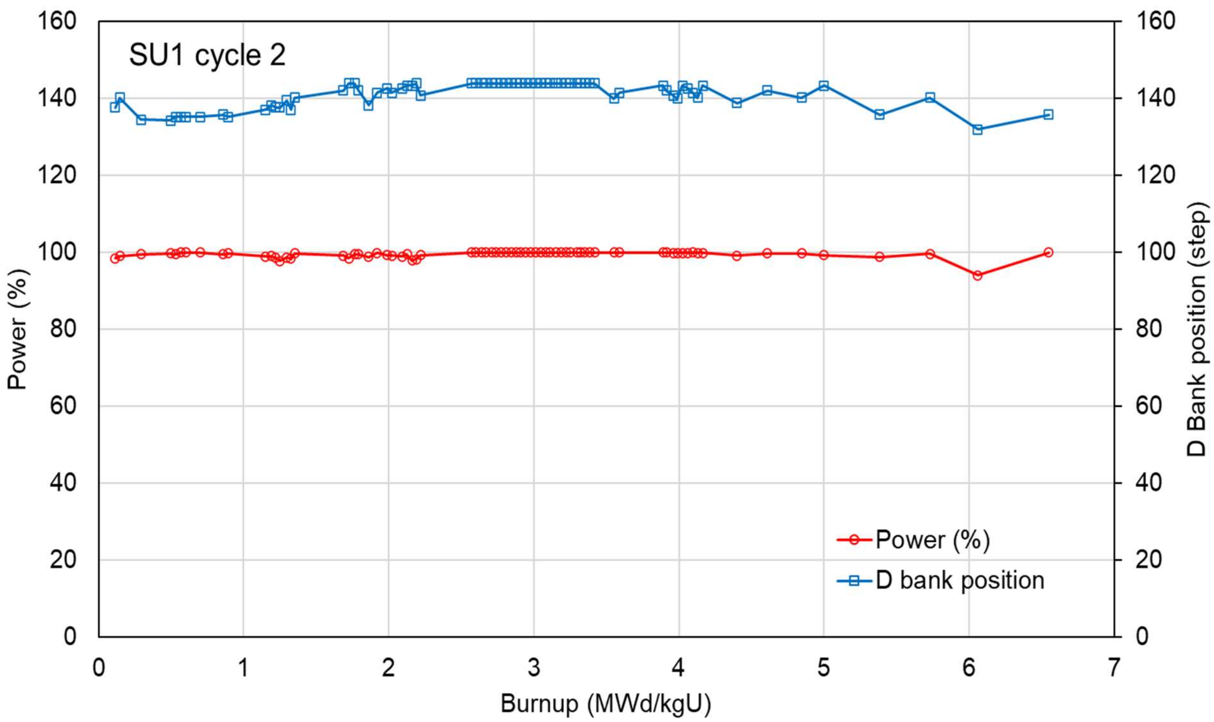


Figure 2.14. Power and D bank position history for SU1 cycle 2.

Table 2.10. SU1 cycle 1 operational history

No	Burnup (MWd/t)	Power (%)	D bank step[a]	T_{in} (K)	No	Burnup (MWd/t)	Power (%)	D bank step	T_{in} (K)	No	Burnup (MWd/t)	Power (%)	D bank step	T_{in} (K)
1	274	4.96	62.5	567.43	41	4,753[b]	90.95	126.3	571.35	81	10,445	99.10	133.3	570.70
2	274	29.29	37.3	568.79	42	4,990	90.91	123.8	570.70	82	10,540	99.75	135.8	571.13
3	283	31.42	99.0	568.85	43	5,176	93.81	127.6	570.70	83	10,570	99.75	137.1	570.86
4	284	0.00	77.7	568.85	44	5,328	95.66	135.8	570.83	84	10,732	67.92	125.1	569.50
5	288	44.08	89.7	569.34	45	5,450	89.55	135.8	570.33	85	10,765	93.53	136.4	570.39
6	313	61.49	97.9	571.23	46	5,608	94.72	129.5	572.52	86	10,796	93.16	135.2	570.39
7	364	72.72	122.5	572.03	47	5,890	86.77	133.9	570.52	87	10,859	93.36	134.5	570.55
8	365	75.26	101.1	571.63	48	5,915	88.28	133.9	571.10	88	10,891	95.00	136.4	570.64
9	764	75.42	114.9	571.88	49	6,296	94.59	136.4	571.07	89	10,990	95.90	137.7	570.83
10	790	74.19	117.5	571.44	50	6,456	94.22	133.9	570.86	90	11,050	96.27	137.1	570.92
11	815	74.52	114.9	571.78	51	6,750	94.39	135.2	570.76	91	11,190	96.97	130.3	571.01
12	826	74.52	115.6	572.37	52	6,968	94.02	132.6	571.17	92	11,225	98.07	137.7	570.70
13	963	71.36	118.1	572.00	53	7,227	94.02	133.9	571.26	93	11,630	98.61	136.4	570.70
14	1,009	74.56	116.6	568.85	54	7,370	96.35	134.5	570.70	94	11,865	99.67	138.3	570.70
15	1,077	74.56	117.5	572.15	55	7,676	96.11	135.2	571.01	95	11,895	99.26	137.7	571.01
16	1,207	73.86	114.9	571.94	56	7,700	96.76	134.5	571.01	96	12,000	99.47	142.1	571.01
17	1,232	74.03	123.8	572.21	57	8,045	95.94	133.3	571.32	97	12,035	99.34	142.7	571.01
18	1,252	74.19	125.1	572.15	58	8,370	95.86	132.0	570.70	98	12,100	98.57	136.4	570.70
19	1,353	75.01	122.5	571.41	59	8,775	98.69	139.6	571.32	99	12,135	99.06	136.4	570.70
20	1,379	74.23	120.6	570.33	60	8,810	97.46	144.0	571.01	100	12,200	98.07	132.6	571.01
21	1,405	75.34	125.1	571.94	61	8,845	98.93	139.6	571.32	101	12,230	99.92	140.8	571.01
22	1,431	76.16	125.1	572.12	62	9,130	97.79	135.8	571.01	102	12,260	98.65	140.2	571.01
23	1,456	74.85	123.2	570.67	63	9,165	98.57	136.4	571.01	103	12,530	99.80	143.4	571.32
24	1,485	74.89	142.1	570.86	64	9,200	99.34	135.2	571.01	104	12,560	98.53	138.3	571.01
25	1,671	75.71	125.1	570.67	65	9,235	99.14	137.1	572.55	105	12,595	98.81	141.5	571.01
26	1,693	73.90	126.3	571.01	66	9,270	98.85	137.7	571.01	106	12,665[b]	99.22	143.4	571.32
27	1,755	74.85	125.1	570.24	67	9,305	99.39	134.5	571.32	107	12,700	97.71	141.5	571.32
28	1,880[b]	91.97	128.2	570.24	68	9,333	98.81	135.2	571.01	108	12,730	98.77	142.1	571.01
29	2,075	78.98	118.1	571.01	69	9,405	98.57	137.1	571.01	109	12,865	92.34	129.5	571.01
30	2,190	90.82	123.2	572.06	70	9,438	98.85	136.4	571.01	110	12,960	98.61	143.4	571.01
31	2,449	87.55	126.3	571.20	71	9,470	98.57	136.4	571.01	111	13,120	60.63	128.2	570.70
32	2,720	87.96	128.8	571.50	72	9,715	99.30	136.4	571.01	112	13,250	58.99	128.8	570.09
33	2,990	88.41	129.5	571.66	73	9,810	99.67	137.1	571.01	113	13,310[b]	59.40	133.9	570.39
34	3,204	89.02	125.7	571.72	74	9,935	99.51	138.3	570.70	114	13,330	59.81	135.2	570.09
35	3,646	89.51	126.9	569.19	75	9,965	99.84	137.7	571.01	115	13,420	61.45	137.1	571.01
36	3,830	86.11	126.9	571.54	76	9,995	98.65	130.7	570.70	116	13,560	60.18	132.0	570.39
37	4,043	89.14	126.9	571.75	77	10,130[b]	98.73	133.3	570.70	117	13,560	59.40	132.6	570.39
38	4,257	88.82	123.2	571.50	78	10,335	98.07	136.4	571.01					
39	4,476	91.11	127.6	571.23	79	10,365	98.44	135.8	571.01					
40	4,732	81.85	126.3	570.92	80	10,405	99.43	138.3	571.01					

[a] Bank step 144 is fully out.
[b] In–core power map data given in the EPRI report (Highlighted cells)

Table 2.11. SU1 cycle 2 operational history

No	Burnup (MWd/t)	Power (%)	D bank step[a]	T_{in} (K)	No	Burnup (MWd/t)	Power (%)	D bank step	T_{in} (K)	No	Burnup (MWd/t)	Power (%)	D bank step	T_{in} (K)
1	115[b]	98.44	137.7	568.71	26	2,090	98.93	142.7	564.26	51	3,250	100.00	144.0	567.59
2	145	99.10	140.2	569.26	27	2,125	99.55	143.4	569.82	52	3,300	100.00	144.0	567.59
3	290[b]	99.55	134.5	569.26	28	2,160	97.87	143.4	566.48	53	3,320	100.00	144.0	567.59
4	495	99.80	134.3	569.26	29	2,190	98.24	144.0	569.82	54	3,350	100.00	144.0	567.59
5	530	99.55	135.2	568.71	30	2,220	99.34	140.8	569.82	55	3,385	100.00	144.0	567.59
6	565	100.00	135.2	569.26	31	2,570	100.00	144.0	567.59	56	3,420	100.00	144.0	567.59
7	600	100.00	135.2	569.26	32	2,600	100.00	144.0	567.59	57	3,552	100.00	140.0	569.82
8	700	100.00	135.2	569.26	33	2,640	100.00	144.0	567.59	58	3,590	100.00	141.5	569.82
9	860	99.55	135.8	569.82	34	2,670	100.00	144.0	567.59	59	3,890	100.00	143.4	569.26
10	895	99.75	135.2	569.82	35	2,710	100.00	144.0	567.59	60	3,915	100.00	142.1	569.26
11	1,150	98.93	137.1	569.26	36	2,740	100.00	144.0	567.59	61	3,960	99.92	140.8	569.82
12	1,190	99.02	138.3	569.82	37	2,775	100.00	144.0	567.59	62	3,990	99.88	140.0	569.82
13	1,220	98.61	137.7	569.82	38	2,810	100.00	144.0	567.59	63	4,025	99.88	143.4	569.26
14	1,250	97.75	137.7	569.26	39	2,845	100.00	144.0	567.59	64	4,060[b]	99.92	142.7	566.48
15	1,295	98.77	139.6	566.48	40	2,880	100.00	144.0	567.59	65	4,095	100.00	141.5	569.26
16	1,325	98.32	137.1	569.82	41	2,910	100.00	144.0	567.59	66	4,130	99.84	140.2	569.26
17	1,350	99.71	140.2	570.37	42	2,945	100.00	144.0	567.59	67	4,165	99.88	143.4	569.82
18	1,685	99.22	142.1	569.82	43	2,980	100.00	144.0	567.59	68	4,400	99.14	138.9	569.82
19	1,725	98.44	144.0	569.26	44	3,010	100.00	144.0	567.59	69	4,610	99.80	142.1	569.65
20	1,765	99.55	144.0	569.26	45	3,045	100.00	144.0	567.59	70	4,845	99.75	140.2	569.59
21	1,790	99.51	142.1	570.37	46	3,085	100.00	144.0	567.59	71	5,000	99.26	143.4	569.59
22	1,860	98.81	138.3	570.37	47	3,110	100.00	144.0	567.59	72	5,385	98.81	135.8	569.82
23	1,920	99.88	141.5	570.37	48	3,150	100.00	144.0	567.59	73	5,730	99.67	140.2	569.59
24	1,990	99.34	142.7	570.37	49	3,190	100.00	144.0	567.59	74	6,060	94.06	132.0	568.76
25	2,020[b]	99.14	141.5	569.82	50	3,220	100.00	144.0	567.59	75	6,550[b]	100.00	135.8	568.76

[a] Bank step 144 is fully out.
[b] In–core power map data

Table 2.12. In–core power map data

Cycle			Cycle 1					Cycle 2				
Measured			**Map 43**	**Map 53**	**Map 68**	**Map 71**	**Map 73**	**Map 9**	**Map 10**	**Map 13**	**Map 17**	**Map 20**
PARCS point			29	42	78	107	114	2	4	26	65	76
Burnup (MWd/kgU)			1.88	4.753	10.13	12.665	13.31	0.115	0.290	2.02	4.06	6.55
No.	ID	Location										
1	18E	H01	○	○	○	○	○	○	○	○	○	
2	31B	F02	○	○	○	○	○	○	○	○	○	○
3	1B	M03										
4	9D	J03	○	○								
5	45E	H03	○	○								
6	10C	D03	○	○	○	○	○	○	○	○	○	○
7	13C	L04										
8	37D	H04		○								
9	3C	F04	○									
10	22D	N05	○	○	○	○	○	○	○	○	○	○
11	50E	L05										
12	24B	J05	○	○								
13	49D	E05										
14	39A	D05	○	○								
15	7E	B05	○	○	○	○	○	○	○	○	○	
16	40A	L06	○					○				○
17	8E	H06										
18	15B	F06										
19	33E	N07	○	○				○			○	○
20	28C	J07	○					○				○
21	20A	G07										
22	29C	D07			○	○	○					
23	17A	B07		○								
24	36C	R08	○	○		○		○	○	○	○	○
25	46D	N08	○	○				○			○	○
26	4B	L08	○	○	○	○	○	○	○	○	○	
27	5D	F08										
28	44B	C08										
29	25D	B08		○								
30	11E	L09	○	○		○	○	○	○	○	○	
31	19E	G09	○									
32	32B	F09	○									
33	34A	A09		○								
34	26A	N10	○	○	○	○	○	○	○	○	○	○
35	23D	J10	○	○					○			
36	41B	D10		○		○					○	
37	12C	B10		○								
38	48B	L11	○	○	○	○	○	○	○	○	○	○
39	38A	H11	○	○								
40	21C	F11	○	○		○	○	○	○	○	○	○
41	47A	E11				○						
42	35E	N12	○	○	○	○	○	○	○	○	○	○
43	16E	J12		○								
44	6E	D12	○									
45	27D	C12	○	○				○				○
46	43C	H13	○									
47	14B	F13	○									
48	30A	L14	○	○	○	○		○	○	○	○	○
49	42D	G14										
50	2C	J15	○	○	○	○	○	○	○	○	○	○

3. BENCHMARK CALCULATIONS AND RESULTS

3.1 BENCHMARK CALCULATION

3.1.1 Polaris Calculations

The SCALE 6.3/Polaris inputs were prepared using the data provided in Section 2 to process assembly–homogenized 2–group cross sections for whole–core nodal diffusion calculations. To cover all the possible reactor states, the 2–group cross sections were tabulated as a function of burnup, moderator, and fuel temperatures, moderator density, soluble boron concentration, and CRs. Table 3.1 provides assembly type state information for eight history cases. Another eight history cases are for an assembly with spacer grids. This spacer grid should be considered in the Polaris lattice physics calculation. SU1 has seven Inc–718 spacer grids and six Inc–718 spacer grids are included in the active fuel zone, but the top spacer grid is not included in the active fuel zone. Therefore, two sets of cross–section table sets should be provided for each assembly.

To complete the functionalization of the cross–section table sets, various branch calculations should be performed at each burnup point for each history case. Tables 3.2 and 3.3 provide the information for branch states for assembly type without and with BA, respectively. Because the Pyrex BAs are located at the guide tubes, branch cases 28–36 for assembly type without BA are not included in the assembly with BA. Bank A and Bank B represent the full and partial length CR rods, respectively. Furthermore, in the Polaris calculations, Pyrex BAs are considered as a control rod bank, consistent with their treatment as a control rod bank in the PARCS calculation Table 3.4 provides the branch cases for reflectors for which no depletion calculation was performed. Figure 3.1 illustrates the Polaris models for radial, top, and bottom axial reflectors.

Appendices A.1−A.4 provide the Polaris inputs for fuel assembly a_1.868_bp00 (A.1) and for radial (A.2), axial top (A.3), and bottom (A.4) reflectors. Table 3.5 provides the Polaris input and output files for SU1 cycles 1−3. A sample file name with 'b1_1.868_bp00_cr1_dc60_p0500_tf0800.inp' indicates

- b1: Surry Unit 1 assembly type index,
- 1.868: 1.868 ^{235}U wt%,
- bp00: no burnable poison,
- dc60: 0.608316 g/cm^3 moderator density,
- p0500: 500 ppm,
- tf0800: 800K fuel temperature, and
- inp: Polaris input.

Table 3.5 includes the actual states for ^{235}U wt%, burnable poisons, moderator densities, soluble boron concentrations, and fuel temperatures, and the Polaris file types.

Table 3.1. History cases for each assembly type

History	History File name	Control rod–in	Moderator temperature (K)	Density (g/cm^3)	Soluble boron (ppm)	Fuel temperature (K)	Spacer grid
A1	cr0_dc77_p0500_tf0800	no	550	0.769987	500	800	no
A2	cr0_dc60_p0500_tf0800	no	615	0.608316	500	800	no
A3	cr0_dc70_p1500_tf0800	no	585	0.700809	1,500	800	no
A4	cr0_dc70_p0000_tf0800	no	585	0.700809	0	800	no
A5	cr0_dc70_p0500_tf1600	no	585	0.700809	500	1,600	no
A6	cr0_dc70_p0500_tf0560	no	585	0.700809	500	560	no

A7	cr0_dc70_p0500_tf0800	no	585	0.700809	500	800	no
A8	cr1_dc70_p0500_tf0800	yes	585	0.700809	500	800	no
B1	cr0_dc77_p0500_tf0800	no	550	0.769987	500	800	yes
B2	cr0_dc60_p0500_tf0800	no	615	0.608316	500	800	yes
B3	cr0_dc70_p1500_tf0800	no	585	0.700809	1,500	800	yes
B4	cr0_dc70_p0000_tf0800	no	585	0.700809	0	800	yes
B5	cr0_dc70_p0500_tf1600	no	585	0.700809	500	1,600	yes
B6	cr0_dc70_p0500_tf0560	no	585	0.700809	500	560	yes
B7	cr0_dc70_p0500_tf0800	no	585	0.700809	500	800	yes
B8	cr1_dc70_p0500_tf0800	yes	585	0.700809	500	800	yes

Table 3.2. Branch states for assembly type without BA

Case	Control bank		All	Moderator		Fuel	History
	B	A	Temperature (K)	Density (g/cm^3)	Soluble boron (ppm)	Temperature (K)	
1	false	false	615.0	0.608316	0.1	560.0	
2	false	false	615.0	0.608316	500.0	560.0	
3	false	false	615.0	0.608316	1,500.0	560.0	
4	false	false	585.0	0.700809	0.1	560.0	
5	false	false	585.0	0.700809	500.0	560.0	A6
6	false	false	585.0	0.700809	1,500.0	560.0	
7	false	false	550.0	0.769987	0.1	560.0	
8	false	false	550.0	0.769987	500.0	560.0	
9	false	false	550.0	0.769987	1,500.0	560.0	
10	false	false	615.0	0.608316	0.1	800.0	
11	false	false	615.0	0.608316	500.0	800.0	A2, B2
12	false	false	615.0	0.608316	1,500.0	800.0	
13	false	false	585.0	0.700809	0.1	800.0	A4, B4
14	false	false	585.0	0.700809	500.0	800.0	A7, B7
15	false	false	585.0	0.700809	1,500.0	800.0	A3, B3
16	false	false	550.0	0.769987	0.1	800.0	
17	false	false	550.0	0.769987	500.0	800.0	A1, B1
18	false	false	550.0	0.769987	1,500.0	800.0	
19	false	false	615.0	0.608316	0.1	1,600.0	
20	false	false	615.0	0.608316	500.0	1,600.0	
21	false	false	615.0	0.608316	1,500.0	1,600.0	
22	false	false	585.0	0.700809	0.1	1,600.0	
23	false	false	585.0	0.700809	500.0	1,600.0	A5, B5
24	false	false	585.0	0.700809	1,500.0	1,600.0	
25	false	false	550.0	0.769987	0.1	1,600.0	
26	false	false	550.0	0.769987	500.0	1,600.0	
27	false	false	550.0	0.769987	1,500.0	1,600.0	
28	true	false	615.0	0.608316	0.1	800.0	
29	true	false	615.0	0.608316	500.0	800.0	
30	true	false	615.0	0.608316	1,500.0	800.0	
31	true	false	585.0	0.700809	0.1	800.0	
32	true	false	585.0	0.700809	500.0	800.0	A8, B8
33	true	false	585.0	0.700809	1,500.0	800.0	
34	true	false	550.0	0.769987	0.1	800.0	
35	true	false	550.0	0.769987	500.0	800.0	

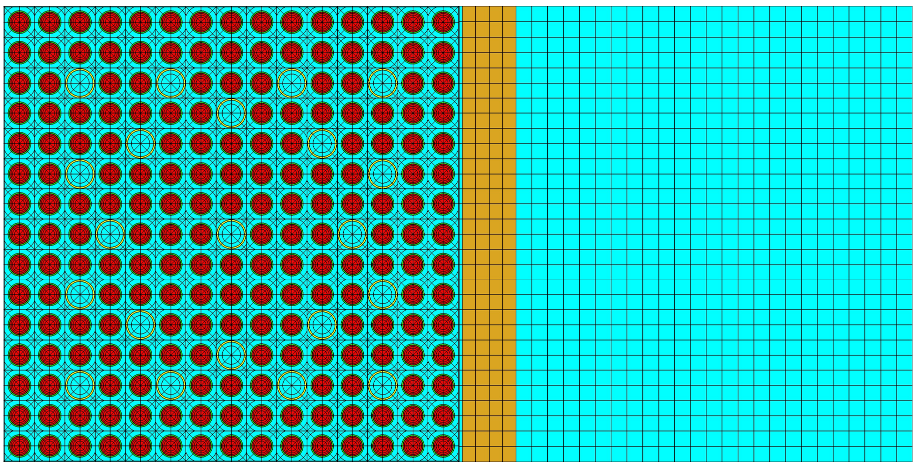
36	true	false	550.0	0.769987	1,500.0	800.0	
37	false	true	615.0	0.608316	0.1	800.0	
38	false	true	615.0	0.608316	500.0	800.0	
39	false	true	615.0	0.608316	1,500.0	800.0	
40	false	true	585.0	0.700809	0.1	800.0	
41	false	true	585.0	0.700809	500.0	800.0	
42	false	true	585.0	0.700809	1,500.0	800.0	
43	false	true	550.0	0.769987	0.1	800.0	
44	false	true	550.0	0.769987	500.0	800.0	
45	false	true	550.0	0.769987	1,500.0	800.0	

Table 3.3. Branch states for assembly type with BA

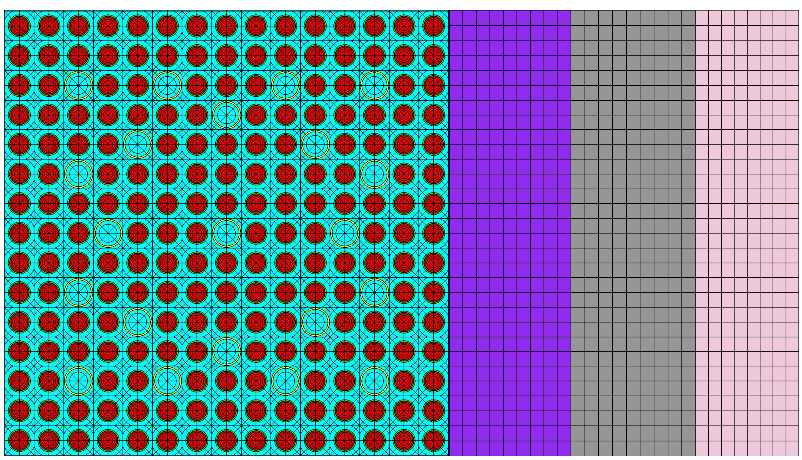
Case	Control bank		All	Moderator		Fuel	Remark
	BA	Rod	Temperature (K)	Density (g/cm^3)	Soluble boron (ppm)	Temperature (K)	
1	false	—	615.0	0.608316	0.1	560.0	
2	false	—	615.0	0.608316	500.0	560.0	
3	false	—	615.0	0.608316	1,500.0	560.0	
4	false	—	585.0	0.700809	0.1	560.0	
5	false	—	585.0	0.700809	500.0	560.0	A6
6	false	—	585.0	0.700809	1,500.0	560.0	
7	false	—	550.0	0.769987	0.1	560.0	
8	false	—	550.0	0.769987	500.0	560.0	
9	false	—	550.0	0.769987	1,500.0	560.0	
10	false	—	615.0	0.608316	0.1	800.0	
11	false	—	615.0	0.608316	500.0	800.0	A2, B2
12	false	—	615.0	0.608316	1,500.0	800.0	
13	false	—	585.0	0.700809	0.1	800.0	A4, B4
14	false	—	585.0	0.700809	500.0	800.0	A7, B7
15	false	—	585.0	0.700809	1,500.0	800.0	A3, B3
16	false	—	550.0	0.769987	0.1	800.0	
17	false	—	550.0	0.769987	500.0	800.0	A1, B1
18	false	—	550.0	0.769987	1,500.0	800.0	
19	false	—	615.0	0.608316	0.1	1,600.0	
20	false	—	615.0	0.608316	500.0	1,600.0	
21	false	—	615.0	0.608316	1,500.0	1,600.0	
22	false	—	585.0	0.700809	0.1	1,600.0	
23	false	—	585.0	0.700809	500.0	1,600.0	A5, B5
24	false	—	585.0	0.700809	1,500.0	1,600.0	
25	false	—	550.0	0.769987	0.1	1,600.0	
26	false	—	550.0	0.769987	500.0	1,600.0	
27	false	—	550.0	0.769987	1,500.0	1,600.0	
28	true	—	615.0	0.608316	0.1	800.0	
29	true	—	615.0	0.608316	500.0	800.0	
30	true	—	615.0	0.608316	1,500.0	800.0	
31	true	—	585.0	0.700809	0.1	800.0	
32	true	—	585.0	0.700809	500.0	800.0	A8, B8
33	true	—	585.0	0.700809	1,500.0	800.0	
34	true	—	550.0	0.769987	0.1	800.0	
35	true	—	550.0	0.769987	500.0	800.0	
36	true	—	550.0	0.769987	1,500.0	800.0	

Table 3.4. Branch states for reflectors

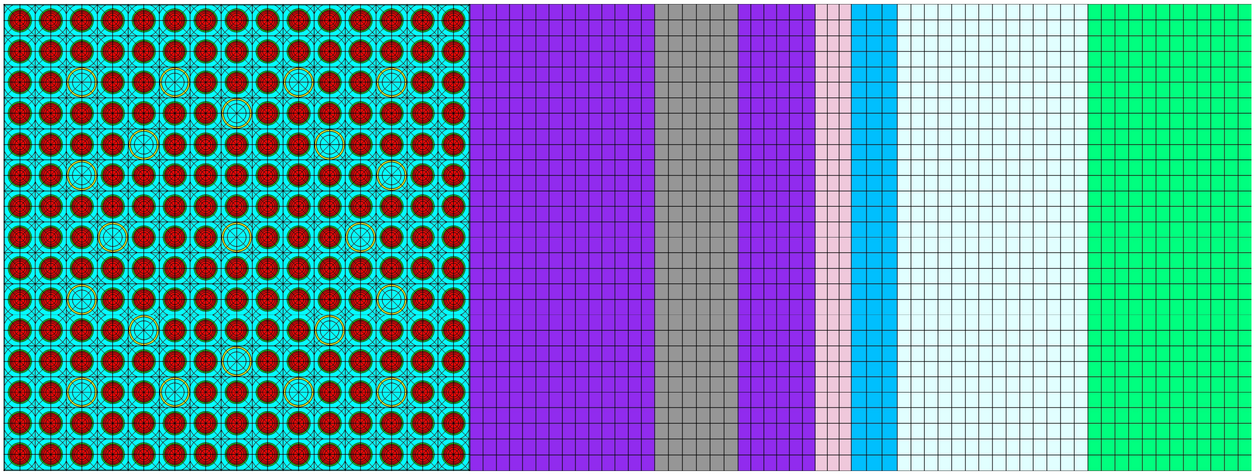
Case	Control bank		All	Moderator		Fuel
	BA	Rod	Temperature (K)	Density (g/cm^3)	Soluble boron (ppm)	Temperature (K)
Reference	false	false	550.0	0.769987	600	800.0
1	false	false	550.0	0.769987	0	800.0
1	false	false	550.0	0.769987	1,800	800.0
2	false	false	580.0	0.700809	600	800.0



(A) Radial reflector (Assembly−Water−Baffle−Water).



(B) Bottom axial reflector (Assembly−Nozzle w/ Gap−Nozzle−Support Plate).



(C) Top axial reflector (Assembly–Plenum– Plenum w/ Grid– Plenum–Plug–Nozzle w/ Gap–Nozzle–Support Plate).

Figure 3.1. Polaris models for reflectors.

Table 3.5. Polaris input and output files for SU1

Assembly type	Dir	File name	Description
a_1.868_bp00	./bare/b1_1.8_00bp	b1_1.868_bp00_cr?_dc??_p????_tf????.*	bp?? Number of BAs bp00: no BA bp12: 12 BAs cr? Control rod cr0: out cr1: in dc?? moderator density dc60: 0.608316 dc70: 0.700809 dc77: 0.769987 p???? boron concentration p0000: 0 ppm p0500: 500 ppm p1500: 1500 ppm tf???? Fuel temperature tf0560: 560 K tf0800: 800 K tf1600: 1600 K * File names inp: input file idc: msg: message file out: output file png: geometry image t16: few–group cross sections f71: ORIGEN concentration f33: ORIGEN library
b_2.573_bp00	./bare/b2_2.5_00bp	b2_2.573_bp00_cr?_dc??_p????_tf????.*	
b_2.573_bp12	./bare/b2_2.5_12bp	b2_2.573_bp12_cr?_dc??_p????_tf????.*	
c_3.117_bp00	./bare/b3_3.1_00bp	b3_3.117_bp00_cr?_dc??_p????_tf????.*	
c_3.117_bp12	./bare/b3_3.1_12bp	b3_3.117_bp12_cr?_dc??_p????_tf????.*	
4a_3.330_bp00	./bare/b4a_3.3_00bp	b4a_3.330_bp00_cr?_dc??_p????_tf????.*	
4a_3.330_bp12	./bare/b4a_3.3_12bp	b4a_3.330_bp12_cr?_dc??_p????_tf????.*	
4a_3.330_bp20	./bare/b4a_3.3_20bp	b4a_3.330_bp20_cr?_dc??_p????_tf????.*	
4b_2.610_bp00	./bare/b4b_2.6_00bp	b4b_2.610_bp00_cr?_dc??_p????_tf????.*	
4b_2.610_bp08	./bare/b4b_2.6_08bp	b4b_2.610_bp08_cr?_dc??_p????_tf????.*	
4b_2.610_bp12	./bare/b4b_2.6_12bp	b4b_2.610_bp12_cr?_dc??_p????_tf????.*	
4c_1.860_bp00	./bare/b4c_1.8_00bp	b4c_1.860_bp00_cr?_dc??_p????_tf????.*	
4x_1.860_bp00	./bare/b4x_1.8_00bp	b4x_1.860_bp00_cr?_dc??_p????_tf????.*	
5_2.100_bp00	./bare/b5_2.1_00bp	b5_2.100_bp00_cr?_dc??_p????_tf????.*	
a_1.868_bp00	./spacer/b1_1.8_00bp	b1_1.868_bp00_cr?_dc??_p????_tf????.*	
b_2.573_bp00	./spacer/b2_2.5_00bp	b2_2.573_bp00_cr?_dc??_p????_tf????.*	
b_2.573_bp12	./spacer/b2_2.5_12bp	b2_2.573_bp12_cr?_dc??_p????_tf????.*	
c_3.117_bp00	./spacer/b3_3.1_00bp	b3_3.117_bp00_cr?_dc??_p????_tf????.*	
c_3.117_bp12	./spacer/b3_3.1_12bp	b3_3.117_bp12_cr?_dc??_p????_tf????.*	
4a_3.330_bp00	./spacer/b4a_3.3_00bp	b4a_3.330_bp00_cr?_dc??_p????_tf????.*	
4a_3.330_bp12	./spacer/b4a_3.3_12bp	b4a_3.330_bp12_cr?_dc??_p????_tf????.*	
4a_3.330_bp20	./spacer/b4a_3.3_20bp	b4a_3.330_bp20_cr?_dc??_p????_tf????.*	
4b_2.610_bp00	./spacer/b4b_2.6_00bp	b4b_2.610_bp00_cr?_dc??_p????_tf????.*	
4b_2.610_bp08	./spacer/b4b_2.6_08bp	b4b_2.610_bp08_cr?_dc??_p????_tf????.*	
4b_2.610_bp12	./spacer/b4b_2.6_12bp	b4b_2.610_bp12_cr?_dc??_p????_tf????.*	
4c_1.860_bp00	./spacer/b4c_1.8_00bp	b4c_1.860_bp00_cr?_dc??_p????_tf????.*	
4x_1.860_bp00	./spacer/b4x_1.8_00bp	b4x_1.860_bp00_cr?_dc??_p????_tf????.*	
5_2.100_bp00	./spacer/b5_2.1_00bp	b5_2.100_bp00_cr?_dc??_p????_tf????.*	
Radial reflector	./reflector	polaris_rad.*	
Top reflector	./reflector	polaris_top.*	
Bottom reflector	./reflector	polaris_bot.*	

3.1.2 Cross–Section Table Set Generation Using GenPMAXS

Appendices B.1−B.4 provide the GenPMAXS inputs for the fuel assembly type A 1.868_bp00 and radial edge, as well as the axial top and bottom reflectors.

- B.1 GenPMAXS input for the fuel assembly type A 1.868_bp00
- B.2 GenPMAXS input for radial edge reflector
- B.3 GenPMAXS input for axial top reflector
- B.4 GenPMAXS input for axial bottom reflector

Table 3.6 provides the GenPMAXS input and output files. There can be various GenPMAXS input files for various radial reflectors including edge, diagonal, east, west, south, north, southeast, southwest, northeast, northwest, and non–sided radial reflectors.

Table 3.6. GenPMAXS input and output files for SU1

Assembly type	Dir	Filename	Description
a_1.868_bp00	./fuel	b1_1.868_bp00.*	Dir ./GenPMAXS * inp: input files kinf: kinf summary out: output file PMAX: cross–section table set
b_2.573_bp00	./fuel	b2_2.573_bp00.*	
b_2.573_bp12	./fuel	b2_2.573_bp12.*	
c_3.117_bp00	./fuel	b3_3.117_bp00.*	
c_3.117_bp12	./fuel	b3_3.117_bp12.*	
4a_3.330_bp00	./fuel	b4a_3.330_bp00.*	
4a_3.330_bp12	./fuel	b4a_3.330_bp12.*	
4a_3.330_bp20	./fuel	b4a_3.330_bp20.*	
4b_2.610_bp00	./fuel	b4b_2.610_bp00.*	
4b_2.610_bp08	./fuel	b4b_2.610_bp08.*	
4b_2.610_bp12	./fuel	b4b_2.610_bp12.*	
4c_1.860_bp00	./fuel	b4c_1.860_bp00.*	
4x_1.860_bp00	./fuel	b4x_1.860_bp00.*	
5_2.100_bp00	./fuel	b5_2.100_bp00.*	
a_1.868_bp00	./fuel_spacer	b1_1.868_bp00.*	
b_2.573_bp00	./fuel_spacer	b2_2.573_bp00.*	
b_2.573_bp12	./fuel_spacer	b2_2.573_bp12.*	
c_3.117_bp00	./fuel_spacer	b3_3.117_bp00.*	
c_3.117_bp12	./fuel_spacer	b3_3.117_bp12.*	
4a_3.330_bp00	./fuel_spacer	b4a_3.330_bp00.*	
4a_3.330_bp12	./fuel_spacer	b4a_3.330_bp12.*	
4a_3.330_bp20	./fuel_spacer	b4a_3.330_bp20.*	
4b_2.610_bp00	./fuel_spacer	b4b_2.610_bp00.*	
4b_2.610_bp08	./fuel_spacer	b4b_2.610_bp08.*	
4b_2.610_bp12	./fuel_spacer	b4b_2.610_bp12.*	
4c_1.860_bp00	./fuel_spacer	b4c_1.860_bp00.*	
4x_1.860_bp00	./fuel_spacer	b4x_1.860_bp00.*	
5_2.100_bp00	./fuel_spacer	b5_2.100_bp00.*	
Radial reflector non–sided	./reflector	refl_rad.*	
Radial reflector diagonal	./reflector	refl_rad_diag.*	
Radial reflector edge	./reflector	refl_rad_edge.*	
Radial reflector east	./reflector	refl_rad_E.*	
Radial reflector west	./reflector	refl_rad_W.*	
Radial reflector south	./reflector	refl_rad_S.*	
Radial reflector north	./reflector	refl_rad_N.*	
Radial reflector southeast	./reflector	refl_rad_SE.*	
Radial reflector southwest	./reflector	refl_rad_SW.*	
Radial reflector northeast	./reflector	refl_rad_NE.*	
Radial reflector northwest	./reflector	refl_rad_NW.*	
Top reflector	./bare	refl_top.*	
Bottom reflector	./bare	refl_bot.*	

Table 3.7. PARCS input and output files for SU1

Cycle	Condition	File name	Description
All		depl_detect_full.geom	Detector
1	HFP	c1_depl_s.inp	PARCS input
		depl–cyc1–s.parcs_out	Output
		depl–cyc1–s.parcs_cyc–01	History file
		depl–cyc1–s.parcs_det	Detector response
		depl–cyc1–s.parcs_dpl	Summary
2	HZP	c1_c2_shuf_s.inp	PARCS input
		cyc2_BOC–s.parcs_out	Output
		cyc2_BOC–s.parcs_cyc–02	History file
		cyc2_BOC–s.parcs_dpl	Summary
	HFP	c2_depl_s.inp	PARCS input
		depl–cyc2–s.parcs_out	Output
		depl–cyc2–s.parcs_cyc–01	Restart file
		depl–cyc2–s.parcs_det	Detector response
		depl–cyc2–s.parcs_dpl	Summary
3	HZP	c2_c3_shuf_s.inp	PARCS input
		cyc3_BOC–s.parcs_out	Output
		cyc3_BOC–s.parcs_cyc–02	History file
		cyc3_BOC–s.parcs_dpl	Detector response
		su_c1_lay.mcyc	Cycle 1 loading pattern for history
		su_c2_lay.mcyc	Cycle 2 loading pattern for history
	HFP	c3_depl_s.inp	PARCS input
		depl–cyc3–s.parcs_out	Output
		depl–cyc3–s.parcs_cyc–01	History file
		depl–cyc3–s.parcs_det	Detector response
		depl–cyc3–s.parcs_dpl	Summary

3.1.3 Whole–Core Nodal Diffusion Calculations Using PARCS

Appendices C.1−C.8 provide the PARCS inputs for SU1 cycles 1−3 HFP calculations. The HZP PARCS input files are only for fuel shuffling.

- C.1 PARCS input for the in–core detector map "depl_detect_full.geom" file
- C.2 PARCS input for the cycle 1 loading pattern "su_c1_lay.mcyc" file
- C.3 PARCS input for the HFP cycle 1 "c1_depl_s.inp" file
- C.4 PARCS input for the HZP cycle 2 fuel shuffling "c1_c2_shuf_s.inp" file
- C.5 PARCS input for the cycle 2 loading pattern "su_c2_lay.mcyc" file
- C.6 PARCS input for the HFP cycle 2 "c2_depl_s.inp" file
- C.7 PARCS input for the HZP cycle 3 fuel shuffling "c2_c3_shuf_s.inp" file
- C.8 PARCS input for the HFP cycle 3 "c3_depl_s.inp" file

Table 3.7 provides the PARCS input and output files. The PARCS calculations were performed with two types of radial reflector cross sections: (1) the explicit model, which utilizes direction–dependent radial reflector cross sections and incorporates ADFs generated for each reflector location at the core/reflector interface, and (2) the 'simple' model is the non–sided radial reflector cross section.

3.2 BENCHMARK RESULTS

3.2.1 HFP Results

The EPRI report [1] provides the uncorrected and corrected critical boron concentrations as a function of burnup. The uncorrected critical boron concentrations are the measured values at the operating conditions with actual thermal power, inlet temperature, and control bank insertion. The corrected critical boron concentrations are the corrected values at 100% power, all control bank out, and nominal inlet temperature. Figures 3.2 and 3.5 provide the corrected/measured and calculated critical boron concentrations for the SU1 cycles 1 and 2. Typically, the measured boron concentrations include some uncertainties as observed in Figures 3.2 and 3.5, with nonsmooth shapes. The measured boron concentrations were fitted with polynomial expansion and then were converted into the smooth–measured boron concentrations. The smooth–measured boron concentrations are provided in Tables 3.8 and 3.9 for cycles 1 and 2, respectively. The fifth column lists the fitted measured data with polynomial expansion, and the sixth column lists the differences between the corrected and polynomial–expanded critical boron concentrations. The root mean square (RMS) errors were obtained to be 16.1 ppm and 12.9 ppm for cycles 1 and 2, respectively, using the differences from which the measurement uncertainty can be obtained.

As noted in Section 3.1.3, two types of radial reflector models, *explicit* and *simple*, were used in the PARCS calculations. Figures 3.3 and 3.6 compare the critical boron concentrations between the uncorrected/measured and calculated at the operating conditions. Figures 3.4 and 3.7 provide comparisons of the corrected/measured boron concentrations with the simulated boron concentrations at the nominal reactor conditions. The PARCS results with the simple reflector model are more consistent with the measured data. There remains ambiguity regarding the best practices for generating radial reflector cross sections within the Polaris–PARCS code package. Proper reflector modeling with Polaris–PARCS is an active area of development, and further investigation is needed to stabilize the procedures for preparing reflector cross sections in this framework. Tables 3.8 and 3.9 provide the measured and calculated critical boron concentrations and the average and RMS errors for the SU1 cycles 1 and 2, respectively. The uncorrected/measured critical boron concentrations in SU1 cycle 1 (red in Table 3.8) were not included in obtaining the average and RMS error because they are very different from the simulated values. Figure 3.8 provides the calculated HFP critical boron concentrations as a function of burnup for cycle 3 for which the measured critical boron concentrations are not available. Figure 3.9 illustrates the soluble boron worths as a function of burnup for the SU1 cycles 1 and 2 which are used in converting the differences of critical boron concentrations between measurement and simulation.

The enthalpy rise hot channel factors ($F_{\Delta H}^{N}$s) for SU1 cycles 1 and 2 are provided in Figures 3.10 and 3.11. The PARCS results with the simple reflector models provide smaller $F_{\Delta H}^{N}$s, regardless of the correction of reactor conditions. The $F_{\Delta H}^{N}$s with the explicit reflector models do not meet the $F_{\Delta H}^{N}$ limit of 1.435 with 8% uncertainty. Because the Polaris pin power form factors do not include gamma powers, more detailed investigation is required for reflector cross sections, gamma–smeared powers, and the violation of $F_{\Delta H}^{N}$ limit.

Figure 3.12 and Table 3.10 provide comparisons of the calculated power maps with the measured power maps for the 3D axially integrated 2D radial and radially integrated 1D axial distributions. The total 3D, 2D, and 1D RMS errors for the SU1 are 7.69%, 5.34%, and 3.79% with the simple reflector models, respectively.

Figure 3.13 compares the 1D axial power maps at burnups 1.88 and 13.31 MWd/kgU for SU1 cycle 1. There is a significant difference in the comparison of the 13.31 MWd/kgU results for which core power is 59.4%, whereas other power maps were measured at >90% powers. This suggests that further investigation of the PARCS simulations for significant power changes is required. Figure 3.14 provides comparisons of the 1D axial power maps between the measured and calculated results at burnups 0.115 and 6.55 MWd/kgU for SU1 cycle 2 showing very good consistency between the measured data and the calculated results.

Appendix D provides the utility program used to compare the calculated flux map results with the measured data.

- D.1 program source
- D.2 Cycle–1 input
- D.3 Cycle–2 input
- D.4 Cycle–1 power map measured data
- D.5 Cycle–2 power map measured data

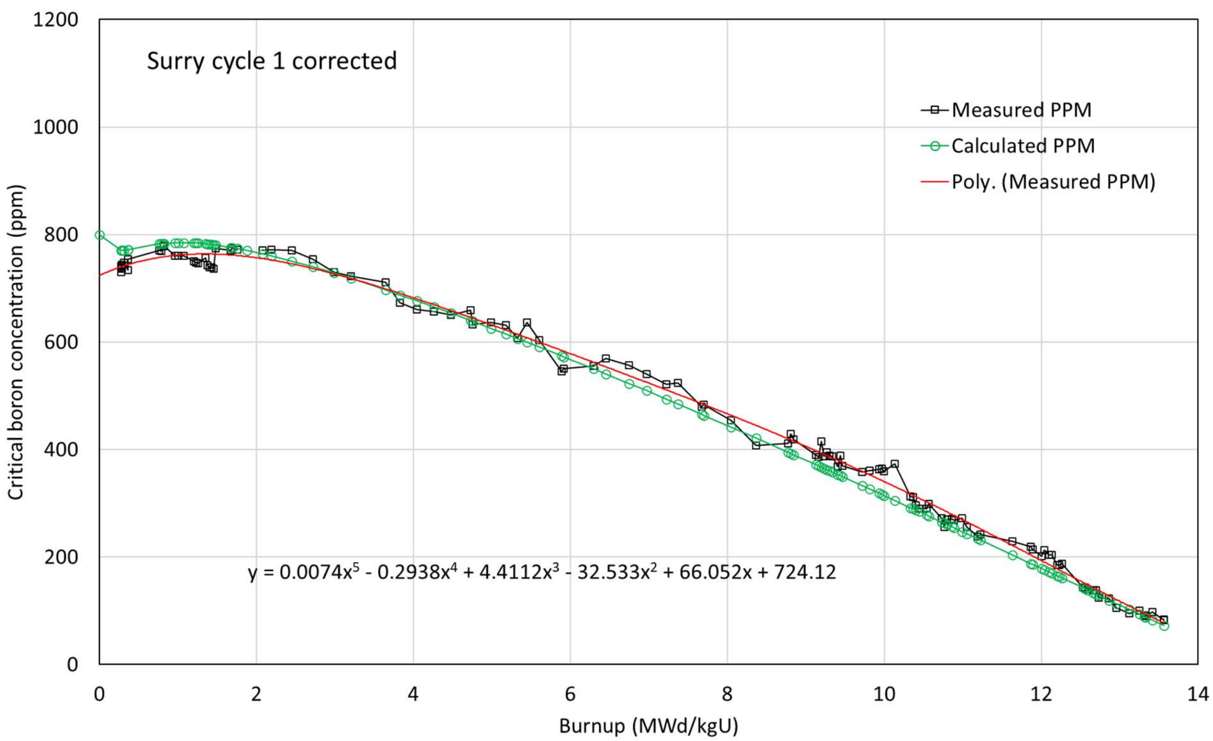


Figure 3.2. SU1 cycle 1 HFP corrected boron letdown comparison for measured uncertainty.

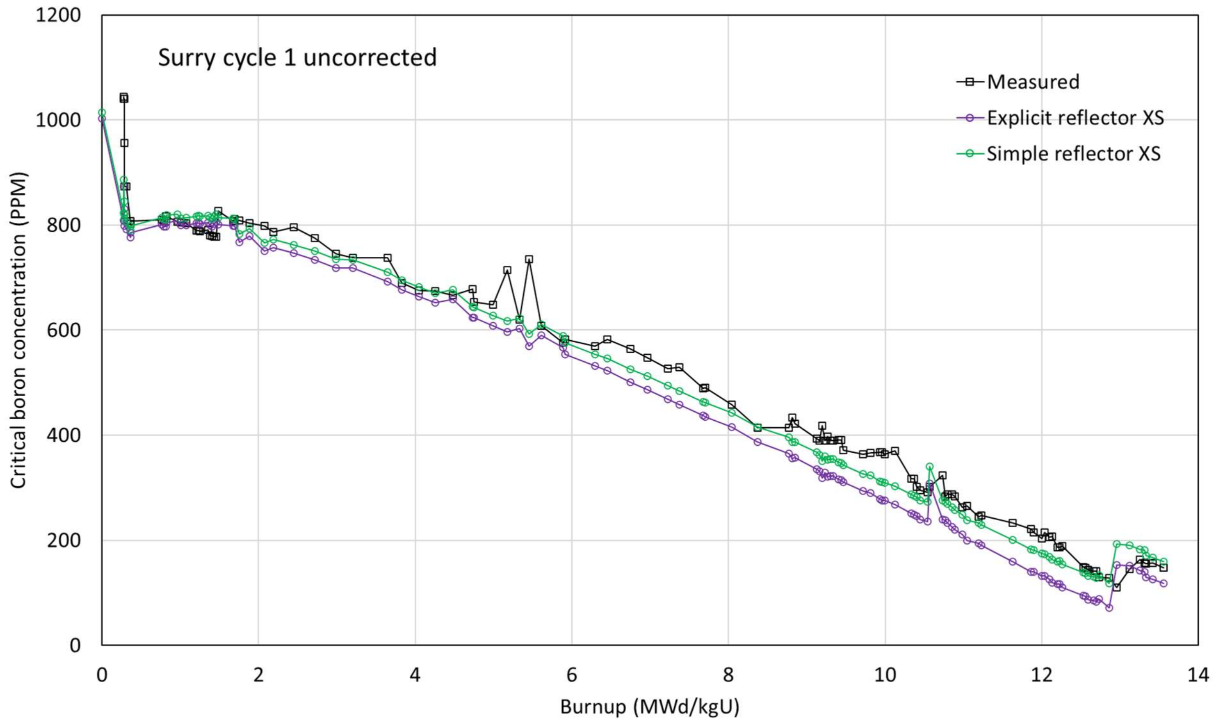


Figure 3.3. SU1 cycle 1 HFP uncorrected boron letdown comparison.

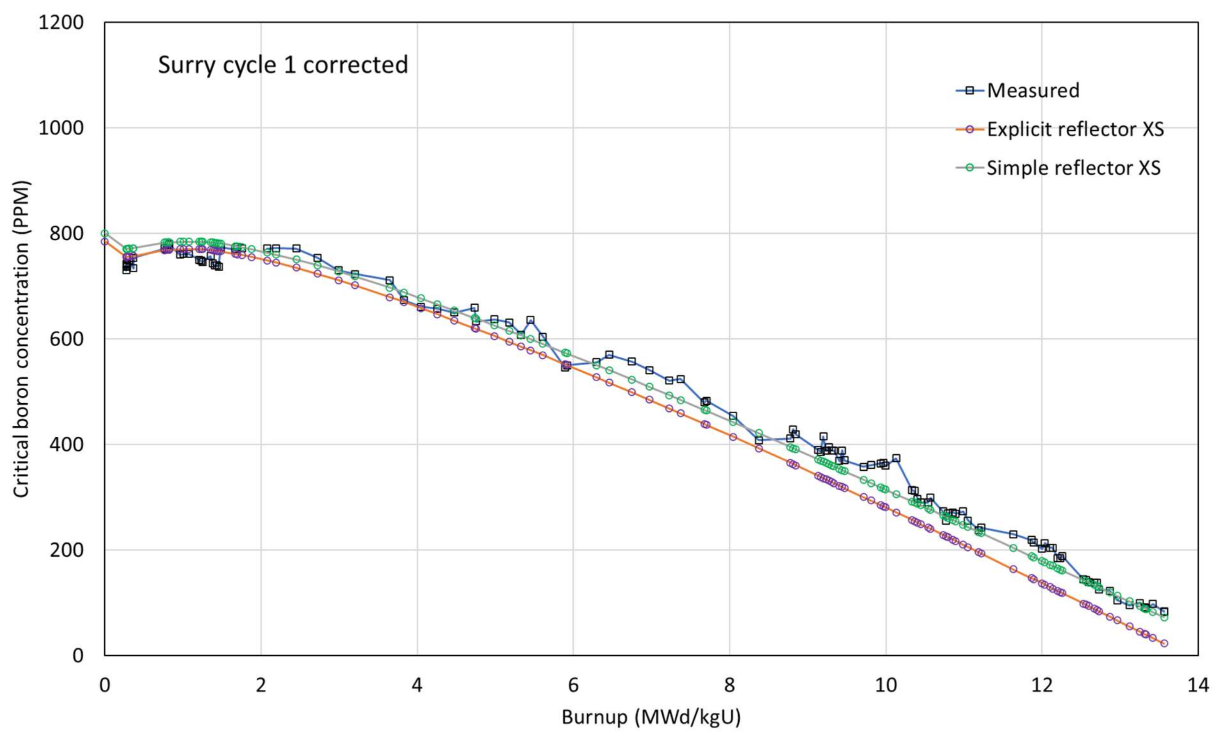


Figure 3.4. SU1 cycle 1 HFP corrected boron letdown comparison.

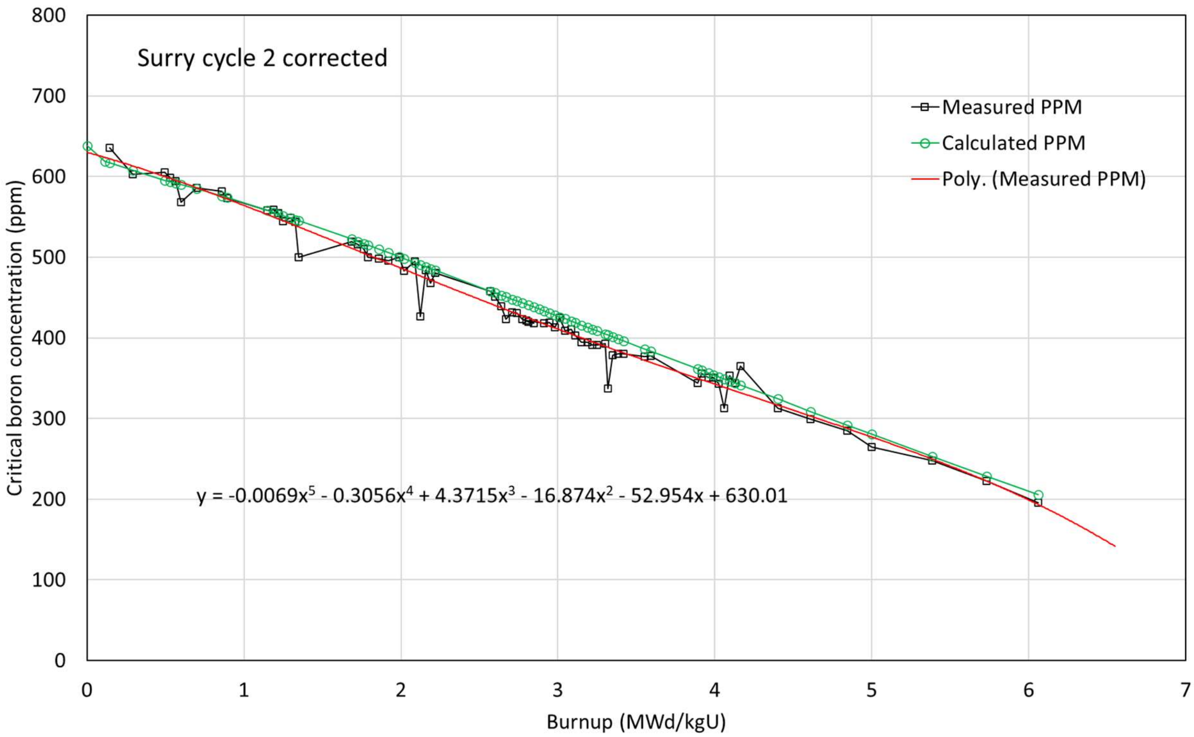


Figure 3.5. SU1 cycle 2 HFP corrected boron letdown comparison for measured uncertainty.

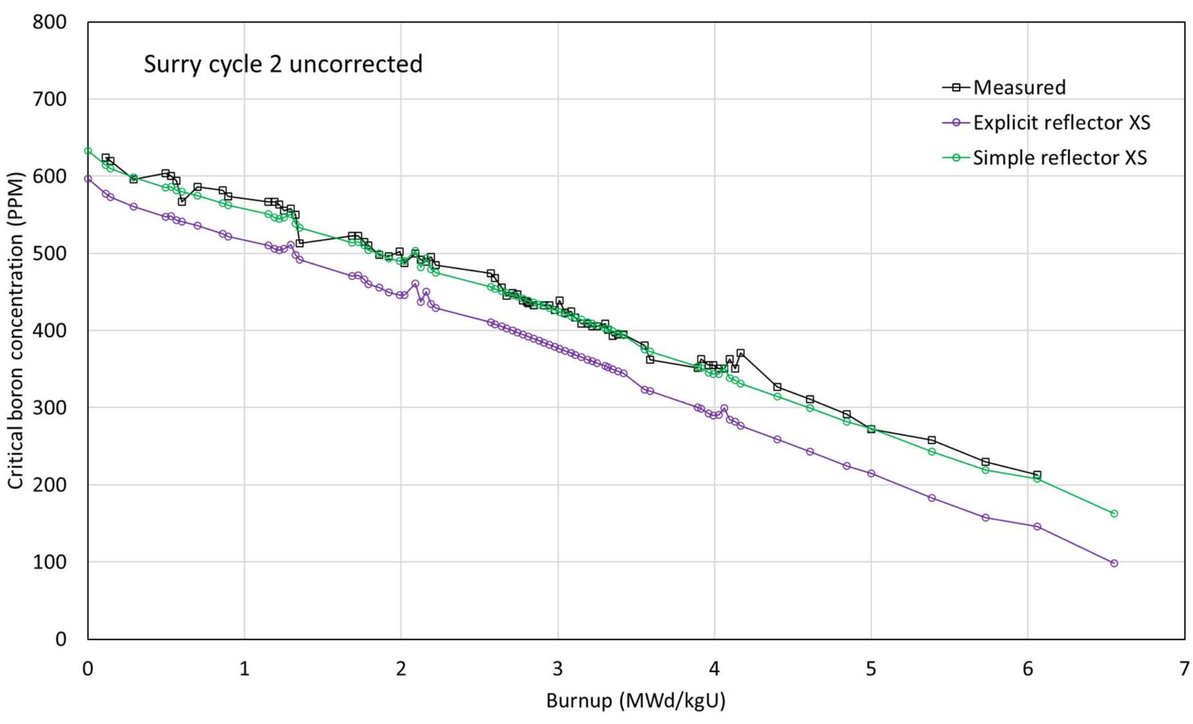


Figure 3.6. SU1 cycle 2 HFP uncorrected boron letdown comparison.

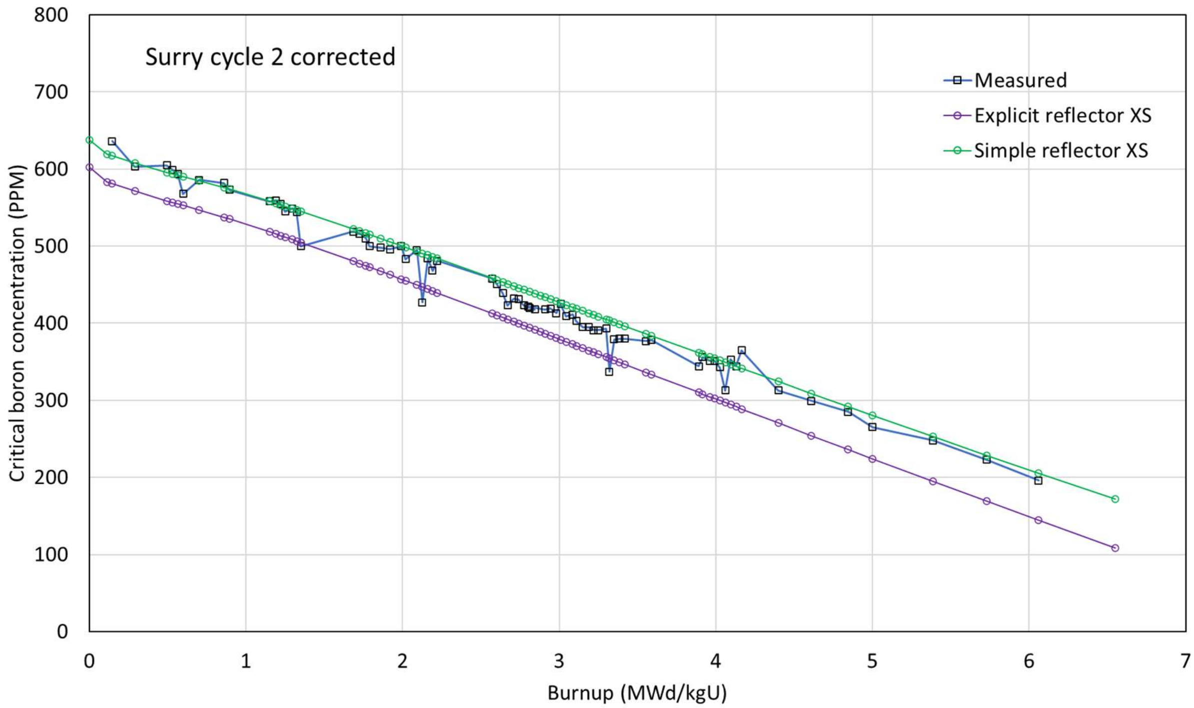


Figure 3.7. SU1 cycle 2 HFP corrected boron letdown comparison.

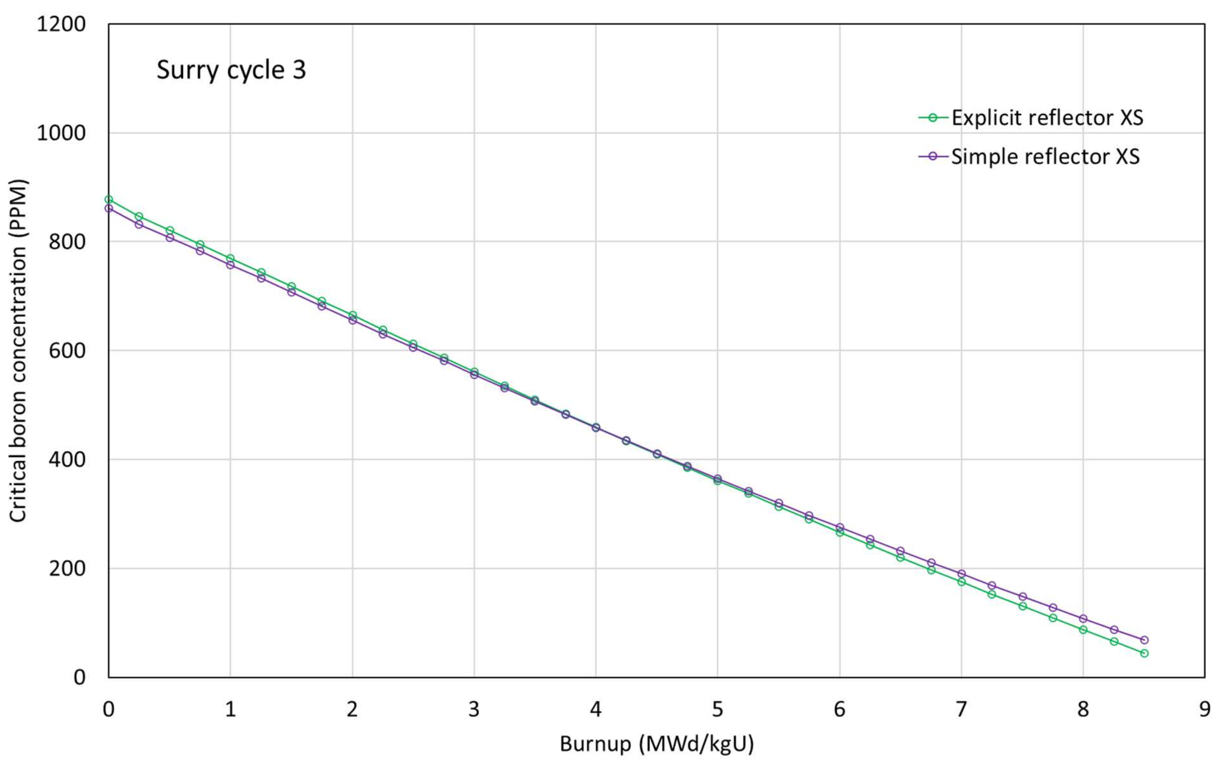


Figure 3.8. SU1 cycle 3 HFP boron letdown.

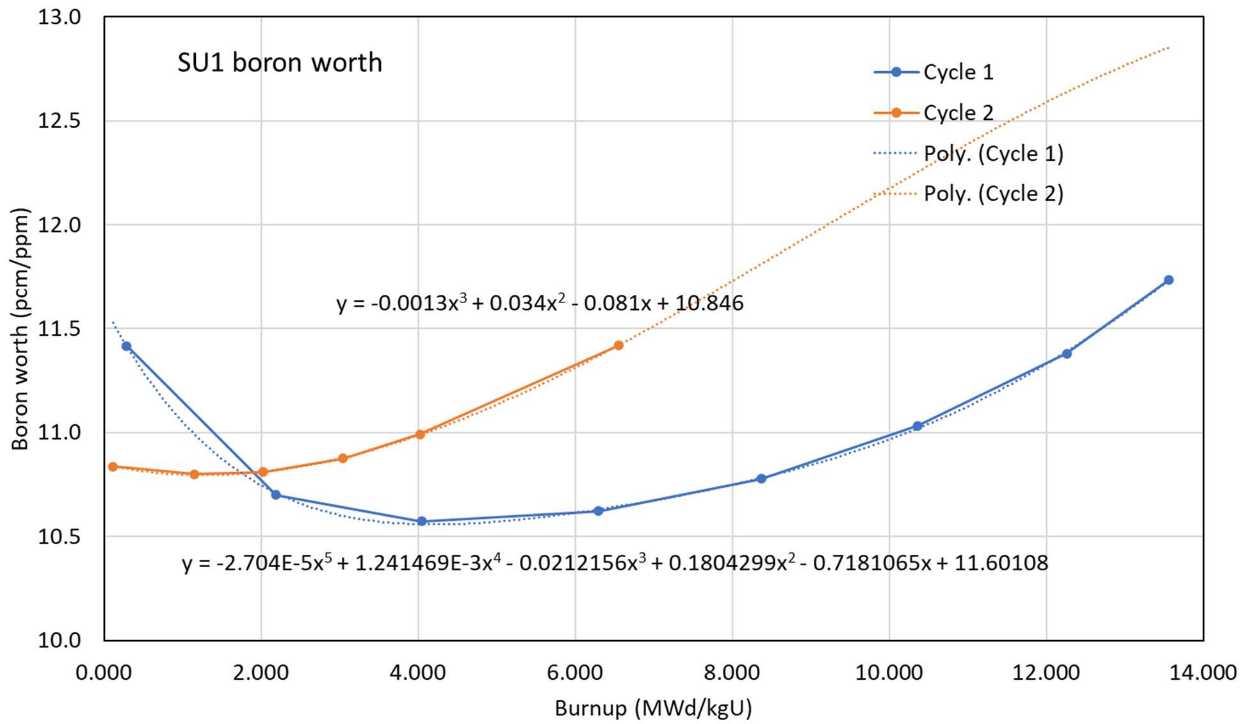


Figure 3.9. Boron worths as function of burnup for SU1.

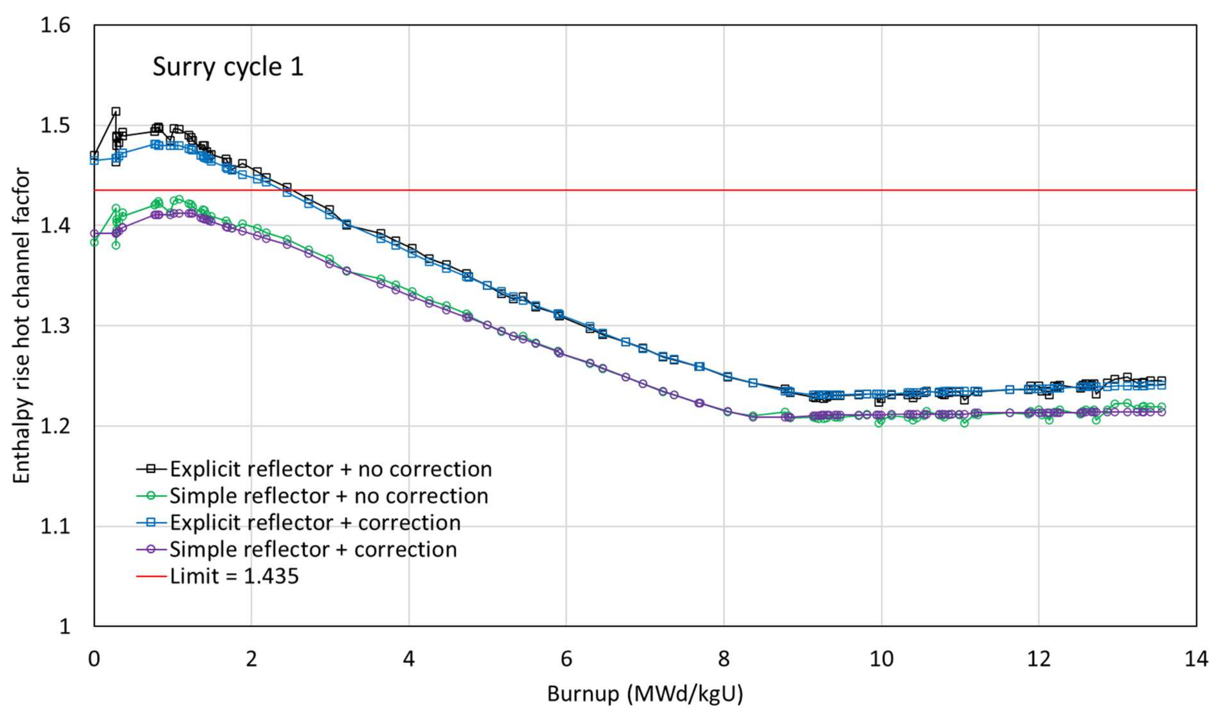


Figure 3.10. Enthalpy rise hot channel factors for the SU1 cycle 1.

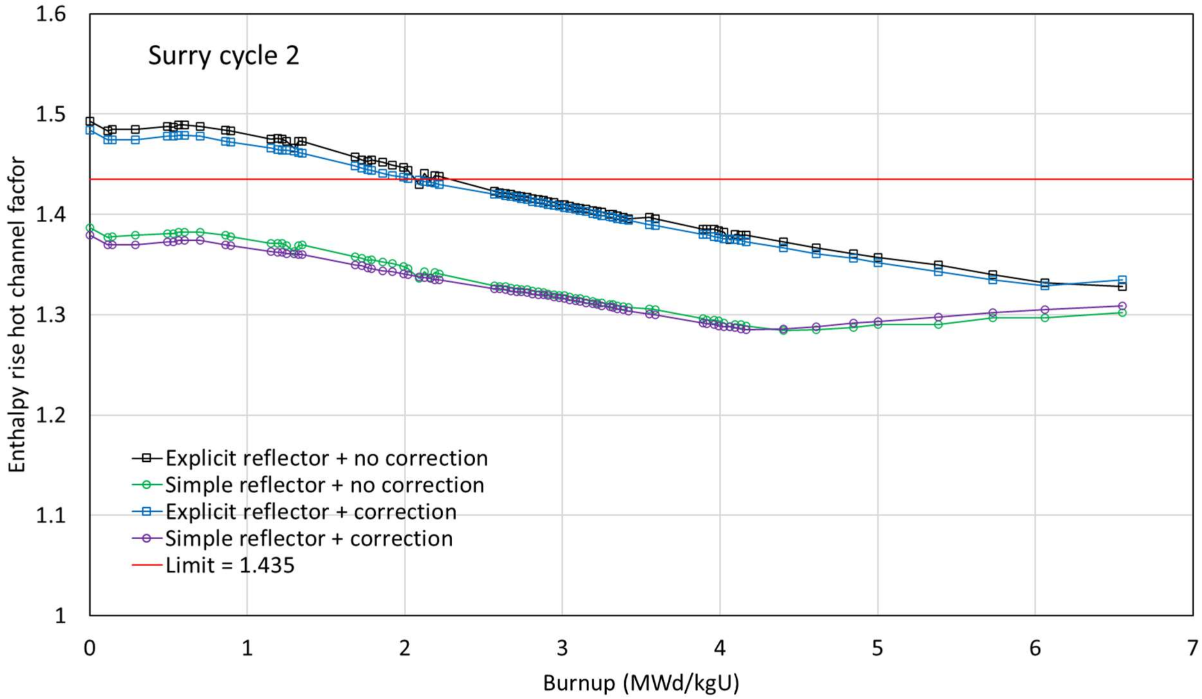


Figure 3.11. Enthalpy rise hot channel factors for the SU1 cycle 2.

Table 3.8. Comparison of the critical boron concentrations for the SU1 cycle 1

No.	Burnup (MWd/kgU)	Measured critical boron (ppm)				PARCS critical boron (ppm)				Difference			
		Uncorrected [1]	Corrected [2]	Polynomial [3]	Difference [2–3]	Uncorrected		Corrected		ppm		pcm	
						Explicit	Simple [4]	Explicit	Simple [5]	[4–1]	[5–2]	[4–1]	[5–2]
1	0.274	1044	730	740	–10	809	824	756	771	–220	41	–2512	468
2	0.274	1040	742	740	2	874	886	756	771	–154	29	–1758	331
3	0.283	1040	744	740	4	808	821	756	771	–219	27	–2499	308
4	0.284	956.5	739	740	–1	832	845	756	771	–112	32	–1278	365
5	0.288	873	737	741	–4	799	812	756	771	–61	34	–696	388
6	0.313	873	748	742	6	793	807	756	771	–66	23	–752	262
7	0.364	803	734	744	–10	776	790	757	772	–13	38	–148	432
8	0.365	808	754	744	10	785	799	757	772	–9	18	–102	205
9	0.764	810	771	757	14	801	814	768	783	4	12	45	134
10	0.790	808	769	758	11	798	811	769	783	3	14	33	156
11	0.815	816	778	759	19	797	810	769	783	–6	5	–67	56
12	0.826	816	779	759	20	805	819	769	783	3	4	33	44
13	0.963	806	760	761	–1	808	821	770	784	15	24	166	265
14	1.009	805	761	762	–1	800	813	770	784	8	23	88	254
15	1.077	804	761	763	–2	800	813	770	784	9	23	99	253
16	1.207	790	750	764	–14	803	817	770	784	27	34	296	373
17	1.232	789	748	764	–16	804	817	770	784	28	36	307	394
18	1.252	788	746	764	–18	803	816	770	784	28	38	306	416
19	1.353	791	757	764	–7	805	818	769	783	27	26	295	284
20	1.379	781	743	764	–21	800	814	768	783	33	40	360	436
21	1.405	779	739	764	–25	798	812	768	782	33	43	360	468
22	1.431	778	739	764	–25	803	816	767	782	38	43	414	468
23	1.456	778	737	764	–27	807	820	767	781	42	44	457	479
24	1.485	827	774	764	10	801	815	766	781	–13	7	–141	76
25	1.671	807	770	762	8	799	813	761	776	6	6	65	65
26	1.693	811	774	762	12	798	812	761	776	1	2	11	22
27	1.755	809	772	761	11	768	782	759	774	–27	2	–291	22
28	1.880	803.5	—	759	—	779	793	755	770	–10	—	–108	—
29	2.075	798	771	755	16	750	766	749	764	–32	–7	–343	–75
30	2.190	787	772	753	19	757	772	745	760	–15	–12	–160	–128
31	2.449	796	771	746	25	747	762	735	751	–34	–20	–362	–213
32	2.720	775	754	737	17	734	751	724	740	–24	–14	–255	–149
33	2.990	746	730	727	3	719	735	712	728	–11	–2	–117	–21
34	3.204	738	723	718	5	718	734	701	719	–4	–5	–42	–53
35	3.646	738	711	699	12	693	710	679	697	–28	–14	–296	–148
36	3.830	690	673	691	–18	676	695	670	688	5	15	53	158
37	4.043	676	661	680	–19	664	683	658	677	7	16	74	169
38	4.257	674	657	670	–13	652	671	647	666	–3	9	–32	95
39	4.476	666	650	659	–9	659	677	635	654	11	4	116	42
40	4.732	678	659	646	13	624	644	620	640	–34	–19	–359	–201
41	4.753	654	633	645	–12	624	644	619	639	–10	6	–106	63
42	4.990	649	637	632	5	608	628	606	626	–21	–11	–222	–116
43	5.176	715	631	623	8	597	618	595	615	–97	–16	–1025	–169
44	5.328	620	608	615	–7	603	623	586	607	3	–1	32	–11
45	5.450	735	636	608	28	570	593	579	600	–143	–36	–1513	–381
46	5.608	608	604	600	4	590	611	569	591	3	–13	32	–138
47	5.890	576	546	585	–39	567	589	552	574	13	28	138	297
48	5.915	582	550	583	–33	554	576	551	573	–6	23	–64	244
49	6.296	569	556	563	–7	532	555	527	550	–14	–6	–149	–64
50	6.456	582	570	554	16	522	546	517	541	–36	–29	–383	–308
51	6.750	565	557	538	19	501	525	499	523	–40	–34	–426	–362
52	6.968	548	541	526	15	487	512	485	510	–36	–31	–384	–331
53	7.227	527	521	512	9	469	495	468	494	–32	–28	–342	–299
54	7.370	530	524	504	20	459	485	459	485	–45	–40	–481	–428
55	7.676	489	480	487	–7	437	464	439	466	–25	–15	–268	–161
56	7.700	491	483	485	–2	435	462	437	464	–29	–19	–311	–204
57	8.045	458	454	465	–11	415	443	415	442	–15	–12	–161	–129
58	8.370	414	408	446	–38	387	416	393	421	2	13	22	140
59	8.775	414	411	422	–11	366	396	365	395	–18	–16	–195	–173
60	8.810	434	429	420	9	357	387	363	393	–47	–36	–508	–389

- Highlighted cells indicate statepoints with differences exceeding 1,000 pcm.

Table 3.8. Comparison of the critical boron concentrations for the SU1 cycle 1 (continued)

No.	Burnup (MWd/kgU)	Measured critical boron (ppm)				PARCS critical boron (ppm)				Difference			
		Uncorrected	Corrected	Polynomial	Difference	Uncorrected		Corrected		ppm		pcm	
		[1]	[2]	[3]	[2–3]	Explicit	Simple [4]	Explicit	Simple [5]	[4–1]	[5–2]	[4–1]	[5–2]
61	8.845	422	419	418	1	357	388	361	391	–34	–28	–368	–303
62	9.130	394	390	400	–10	336	368	341	372	–27	–18	–293	–195
63	9.165	390	386	398	–12	331	363	338	370	–27	–17	–293	–185
64	9.200	418	415	396	19	318	351	336	367	–67	–48	–727	–521
65	9.235	390	388	394	–6	329	361	334	365	–29	–23	–315	–250
66	9.270	398	395	392	3	321	353	331	363	–45	–32	–489	–348
67	9.305	390	389	390	–1	323	355	329	360	–35	–29	–380	–315
68	9.333	390	388	388	0	323	355	327	358	–36	–30	–391	–326
69	9.405	391	369	383	–14	317	349	322	354	–42	–15	–457	–163
70	9.438	391	389	381	8	315	347	320	352	–44	–38	–479	–414
71	9.470	372	370	379	–9	311	344	317	349	–28	–21	–305	–229
72	9.715	364	358	363	–5	294	327	300	333	–37	–25	–404	–273
73	9.810	366	361	357	4	290	324	294	327	–42	–34	–459	–372
74	9.935	368	364	349	15	278	312	285	319	–56	–45	–613	–493
75	9.965	368	365	347	18	276	311	283	317	–58	–48	–635	–526
76	9.995	364	360	345	15	276	310	281	315	–54	–45	–592	–493
77	10.130	370	374	336	38	268	303	271	306	–68	–68	–746	–746
78	10.335	317	313	322	–9	252	288	257	292	–29	–21	–319	–231
79	10.365	317	312	320	–8	249	285	255	290	–32	–22	–352	–242
80	10.405	302	297	317	–20	246	282	252	287	–20	–10	–220	–110
81	10.445	295	290	314	–24	240	276	249	285	–19	–5	–209	–55
82	10.540	292	290	308	–18	236	273	242	278	–19	–12	–210	–132
83	10.570	302	299	306	–7	309	340	240	276	38	–23	420	–254
84	10.732	324	273	295	–22	240	276	229	265	–48	–8	–531	–89
85	10.765	284	256	292	–36	238	274	226	263	–10	7	–111	78
86	10.796	288	270	290	–20	233	270	224	261	–18	–9	–199	–100
87	10.859	288	271	286	–15	226	263	219	257	–26	–14	–288	–155
88	10.891	284	269	283	–14	221	258	217	254	–26	–15	–289	–166
89	10.990	263	273	276	–3	211	249	210	248	–14	–25	–156	–278
90	11.050	265	256	272	–16	199	238	206	244	–27	–12	–300	–134
91	11.190	245	238	262	–24	195	234	196	234	–11	–4	–123	–45
92	11.225	248	242	260	–18	190	229	193	232	–19	–10	–212	–112
93	11.630	233	230	231	–1	160	200	164	204	–33	–26	–371	–292
94	11.865	222	219	213	6	141	183	147	188	–39	–31	–440	–350
95	11.895	215	214	211	3	140	182	145	186	–33	–28	–373	–316
96	12.000	204	202	204	–2	133	175	137	179	–29	–23	–328	–260
97	12.035	215	213	201	12	132	174	134	177	–41	–37	–464	–419
98	12.100	206	204	196	8	126	169	130	172	–37	–32	–420	–363
99	12.135	207	204	194	10	120	163	127	170	–44	–34	–499	–386
100	12.200	187	185	189	–4	116	160	122	165	–27	–20	–307	–227
101	12.230	187	185	187	–2	117	160	120	163	–27	–22	–307	–250
102	12.260	189	188	185	3	110	154	118	161	–35	–27	–398	–307
103	12.530	149	144	165	–21	94	139	98	143	–10	–1	–114	–11
104	12.560	148	143	163	–20	93	138	96	141	–10	–2	–115	–23
105	12.595	144	139	161	–22	87	133	94	138	–11	–1	–126	–11
106	12.665	141	138	156	–18	85	131	89	134	–10	–4	–115	–46
107	12.700	141	138	153	–15	83	129	86	131	–12	–7	–138	–80
108	12.730	130	125	151	–26	88	133	84	129	3	4	34	46
109	12.865	128	123	142	–19	72	118	74	120	–10	–3	–115	–35
110	12.960	110	105	135	–30	154	194	67	114	84	9	971	104
111	13.120	145	95	124	–29	151	191	55	103	46	8	533	93
112	13.250	164	100	116	–16	143	183	46	94	19	–6	221	–70
113	13.310	157	92	112	–20	141	181	41	90	24	–2	280	–23
114	13.330	156	90	110	–20	129	171	40	88	15	–2	175	–23
115	13.420	157	98	105	–7	126	168	33	82	11	–16	128	–187
116	13.560	148	83	96	–13	118	160	23	73	12	–10	141	–117
				RMS	16.1					31.2	24.4	339	268
				Average	–4.1					–15.6	–6.2	–161	–67
				# of cases	116					110	115	110	115

Table 3.9. Comparison of the critical boron concentrations for the SU1 cycle 2

No.	Burnup (MWd/kgU)	Measured critical boron (ppm)				PARCS critical boron (ppm)				Difference			
		Uncorrected	Corrected	Polynomial	Difference	Uncorrected		Corrected		ppm		pcm	
		[1]	[2]	[3]	[2–3]	Explicit	Simple [4]	Explicit	Simple [5]	[4–1]	[5–2]	[4–1]	[5–2]
1	0.115	624	—	—	—	579	615	585	620	–9	—	–98	—
2	0.145	620	636	622	14	574	611	582	618	–9	–18	–98	–195
3	0.290	596	603	613	–10	562	599	573	609	3	6	32	65
4	0.495	604	605	600	5	548	586	560	597	–18	–8	–195	–87
5	0.530	600	599	598	1	549	587	558	595	–13	–4	–141	–43
6	0.565	594	594	595	–1	544	583	556	593	–12	–1	–130	–11
7	0.600	567	568	593	–25	542	581	554	591	14	23	151	249
8	0.700	586	586	586	0	537	576	548	586	–10	0	–108	0
9	0.860	582	582	575	7	527	566	539	577	–16	–5	–173	–54
10	0.895	574	573	572	1	523	563	536	575	–11	2	–119	22
11	1.150	567	558	553	5	511	552	520	559	–15	1	–162	11
12	1.190	567	559	550	9	507	548	517	557	–19	–3	–205	–32
13	1.220	563	555	548	7	506	546	515	555	–17	0	–184	0
14	1.250	555	545	545	0	508	548	513	553	–7	8	–76	86
15	1.295	558	549	542	7	512	552	510	550	–6	1	–65	11
16	1.325	550	544	539	5	499	540	508	548	–10	4	–108	43
17	1.350	513	500	537	–37	493	535	506	546	22	46	237	497
18	1.685	523	519	511	8	472	515	482	524	–8	5	–86	54
19	1.725	523	516	508	8	473	516	479	521	–7	5	–76	54
20	1.765	515	510	505	5	468	511	476	518	–4	8	–43	86
21	1.790	510	500	503	–3	462	505	474	516	–5	16	–54	173
22	1.860	498	498	497	1	457	501	469	511	3	13	32	140
23	1.920	496	496	493	3	451	495	464	507	–1	11	–11	119
24	1.990	502	500	487	13	447	492	459	502	–10	2	–108	22
25	2.020	487	483	485	–2	447	491	456	500	4	17	43	184
26	2.090	500	495	479	16	462	505	451	495	5	0	54	0
27	2.125	492	427	477	–50	438	483	448	492	–9	65	–97	703
28	2.160	489	484	474	10	452	495	446	489	6	5	65	54
29	2.190	495	468	472	–4	436	481	443	487	–14	19	–151	206
30	2.220	485	481	469	12	431	476	441	485	–9	4	–97	43
31	2.570	474	458	443	15	412	458	414	460	–17	2	–184	22
32	2.600	468	451	440	11	410	455	412	457	–13	6	–141	65
33	2.640	456	439	437	2	407	452	409	454	–4	15	–43	163
34	2.670	445	423	435	–12	404	450	406	452	5	29	54	315
35	2.710	449	432	432	0	401	447	403	449	–2	17	–22	184
36	2.740	447	431	430	1	399	445	401	447	–2	16	–22	174
37	2.775	439	423	427	–4	396	443	398	445	4	22	43	239
38	2.810	435	420	425	–5	393	440	396	442	5	22	54	239
39	2.845	433	418	422	–4	391	438	393	440	5	22	54	239
40	2.800	437	422	425	–3	388	435	390	437	–2	15	–22	163
41	2.910	433	418	417	1	386	433	388	435	0	17	0	185
42	2.945	433	419	415	4	383	430	385	432	–3	13	–33	141
43	2.980	427	413	412	1	380	428	382	430	1	17	11	185
44	3.010	439	425	410	15	378	426	380	428	–13	3	–141	33
45	3.045	423	409	408	1	375	423	377	425	0	16	0	174
46	3.085	425	411	405	6	372	420	374	422	–5	11	–54	120
47	3.110	417	403	403	0	370	418	372	420	1	17	11	185
48	3.150	409	395	400	–5	367	415	369	417	6	22	65	240
49	3.190	409	395	397	–2	364	413	366	414	4	19	44	207
50	3.220	405	391	395	–4	362	410	364	412	5	21	54	229
51	3.250	405	391	393	–2	359	408	361	410	3	19	33	207
52	3.300	409	393	390	3	355	404	357	406	–5	13	–55	142
53	3.320	401	337	388	–51	354	403	356	405	2	68	22	741
54	3.350	393	379	386	–7	352	401	354	403	8	24	87	262
55	3.385	395	380	384	–4	349	398	351	400	3	20	33	218
56	3.420	395	380	381	–1	346	396	348	398	1	18	11	196
57	3.552	381	377	372	5	325	377	338	388	–4	11	–44	120
58	3.590	362	378	370	8	323	374	335	385	12	7	131	77
59	3.890	352	344	350	–6	302	355	312	363	3	19	33	208
60	3.915	363	356	348	8	300	353	310	361	–10	5	–110	55

Table 3.9. Comparison of the critical boron concentrations for the SU1 cycle 2 (continued)

No.	Burnup (MWd/kgU)	Measured critical boron (ppm)				PARCS critical boron (ppm)				Difference			
		Uncorrected	Corrected	Polynomial	Difference	Uncorrected		Corrected		ppm		pcm	
		[1]	[2]	[3]	[2–3]	Explicit	Simple [4]	Explicit	Simple [5]	[4–1]	[5–2]	[4–1]	[5–2]
61	3.960	355	351	345	6	294	347	306	358	–8	7	–88	77
62	3.990	355	351	343	8	291	345	304	356	–10	5	–110	55
63	4.025	351	343	341	2	292	345	301	353	–6	10	–66	110
64	4.060	351	313	339	–26	301	353	298	351	2	38	22	418
65	4.095	363	353	337	16	286	340	296	348	–24	–5	–264	–55
66	4.130	351	344	334	10	283	337	293	345	–14	1	–154	11
67	4.165	371	365	332	33	279	333	290	343	–38	–22	–418	–242
68	4.400	327	313	317	–4	261	316	272	326	–11	13	–121	143
69	4.610	311	299	303	–4	245	301	256	310	–10	11	–111	122
70	4.845	292	285	288	–3	227	284	238	293	–8	8	–89	89
71	5.000	272	265	277	–12	217	274	226	282	2	17	22	189
72	5.385	258	248	250	–2	184	244	197	255	–14	7	–157	78
73	5.730	230	223	223	0	160	221	171	230	–9	7	–101	79
74	6.060	213	196	194	2	148	209	146	207	–4	11	–45	124
				RMS	12.9					10.3	18.3	113	201
				Average	0.0					–4.6	11.7	–51	128
				# of cases	73					74	73	74	73

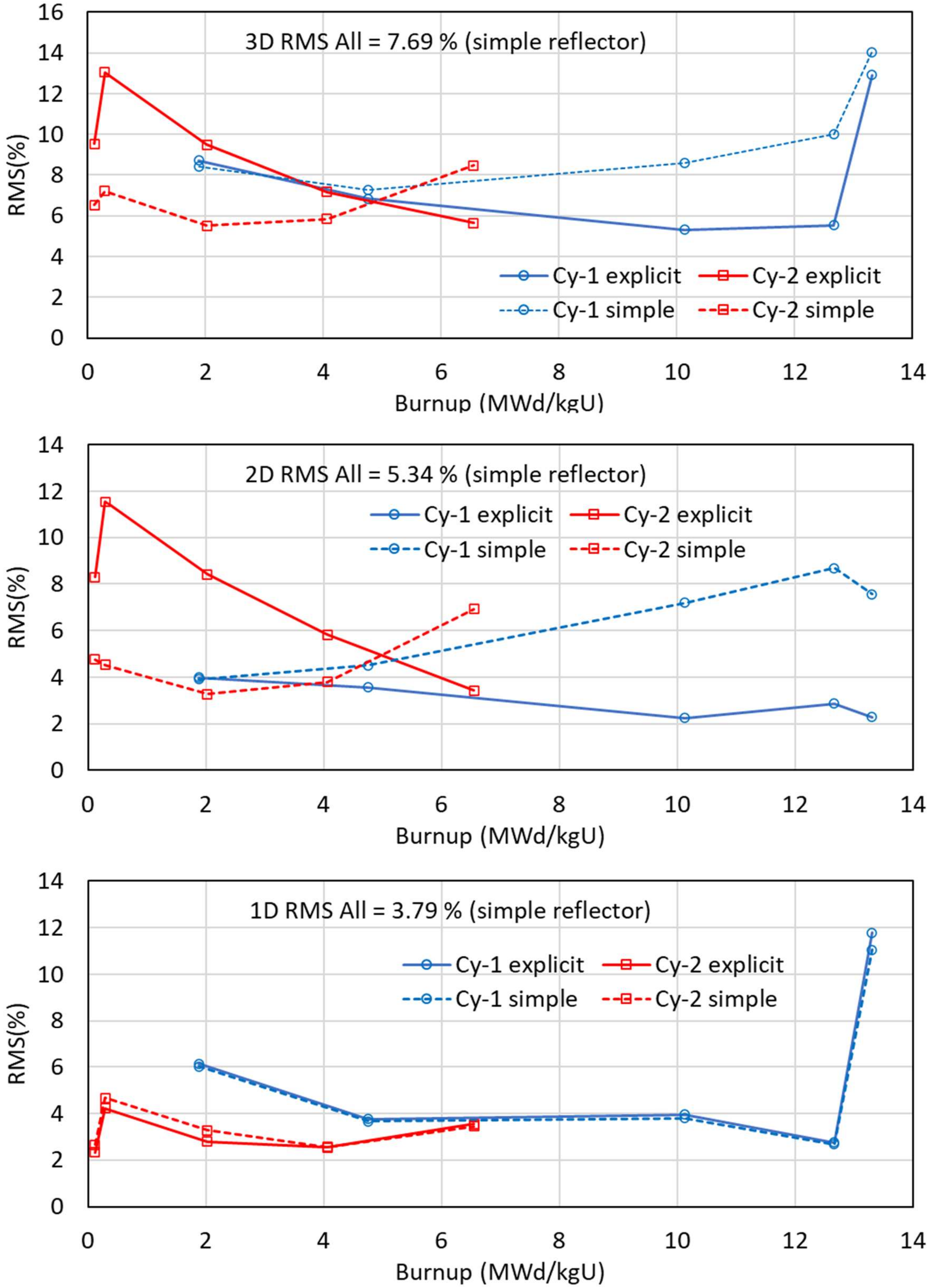


Figure 3.12. Comparison of the HFP power maps for SU1.

Table 3.10. Comparison of the power maps for SU1

Reflector	cycle	Map	Burnup (MWd/kgU)	PARCS point	3D RMS (%)	3D cases	2D radial RMS (%)	2D radial cases	1D axial RMS (%)	1D axial cases
Explicit model	1	43	1.880	29	8.71	1,209	3.98	31	6.13	39
		53	4.753	42	6.84	1,170	3.57	30	3.77	39
		68	10.130	78	5.31	468	2.25	12	3.96	39
		71	12.665	107	5.54	663	2.86	17	2.76	39
		73	13.310	114	12.92	507	2.28	13	11.78	39
	2	9	0.115	2	9.54	741	8.30	19	2.33	39
		10	0.290	4	13.04	585	11.55	15	4.23	39
		13	2.020	26	9.50	546	8.42	14	2.79	39
		17	4.060	65	7.17	663	5.81	17	2.54	39
		20	6.550	76	5.65	585	3.42	15	3.54	39
	All				8.23	6,630	6.00	170	3.73	351
Simple model	1	43	1.880	29	8.71	1,209	3.98	31	6.13	39
		53	4.753	42	6.84	1,170	3.57	30	3.77	39
		68	10.130	78	5.31	468	2.25	12	3.96	39
		71	12.665	107	5.54	663	2.86	17	2.76	39
		73	13.310	114	12.92	507	2.28	13	11.78	39
	2	9	0.115	2	9.54	741	8.30	19	2.33	39
		10	0.290	4	13.04	585	11.55	15	4.23	39
		13	2.020	26	9.50	546	8.42	14	2.79	39
		17	4.060	65	7.17	663	5.81	17	2.54	39
		20	6.550	76	5.65	585	3.42	15	3.54	39
	All				7.69	6,630	5.34	170	3.79	351

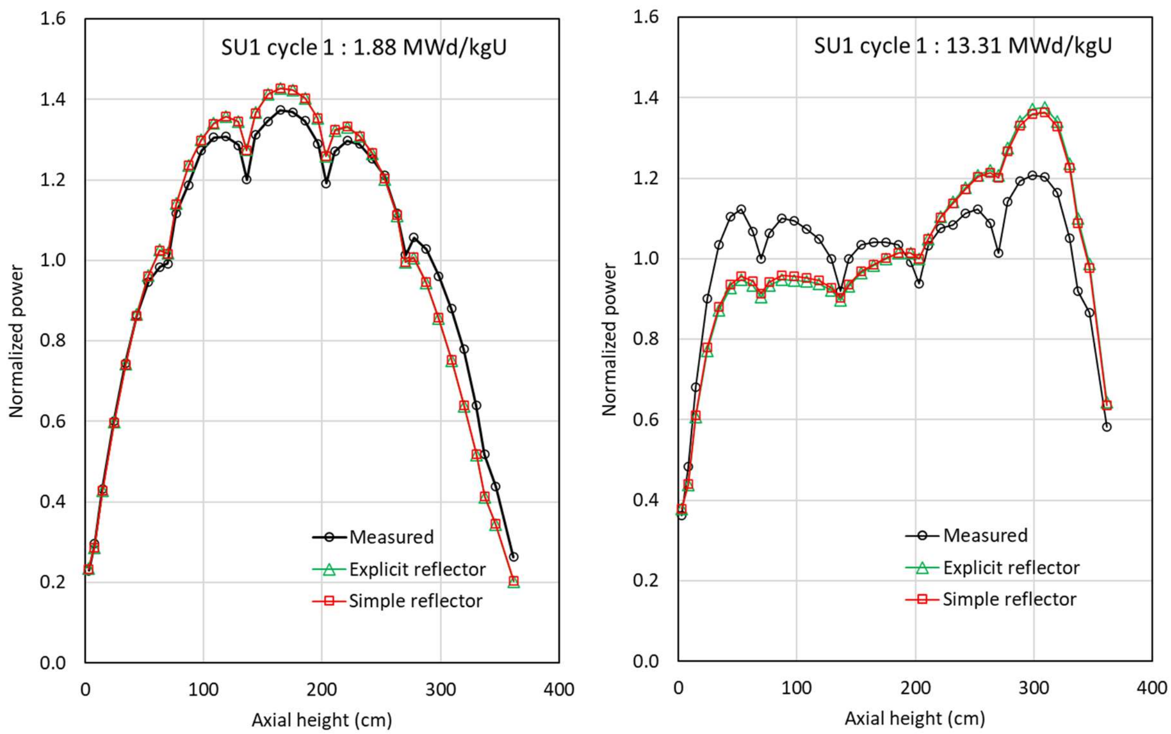


Figure 3.13. Axial 1D flux map comparison for the SU1 cycle 1.

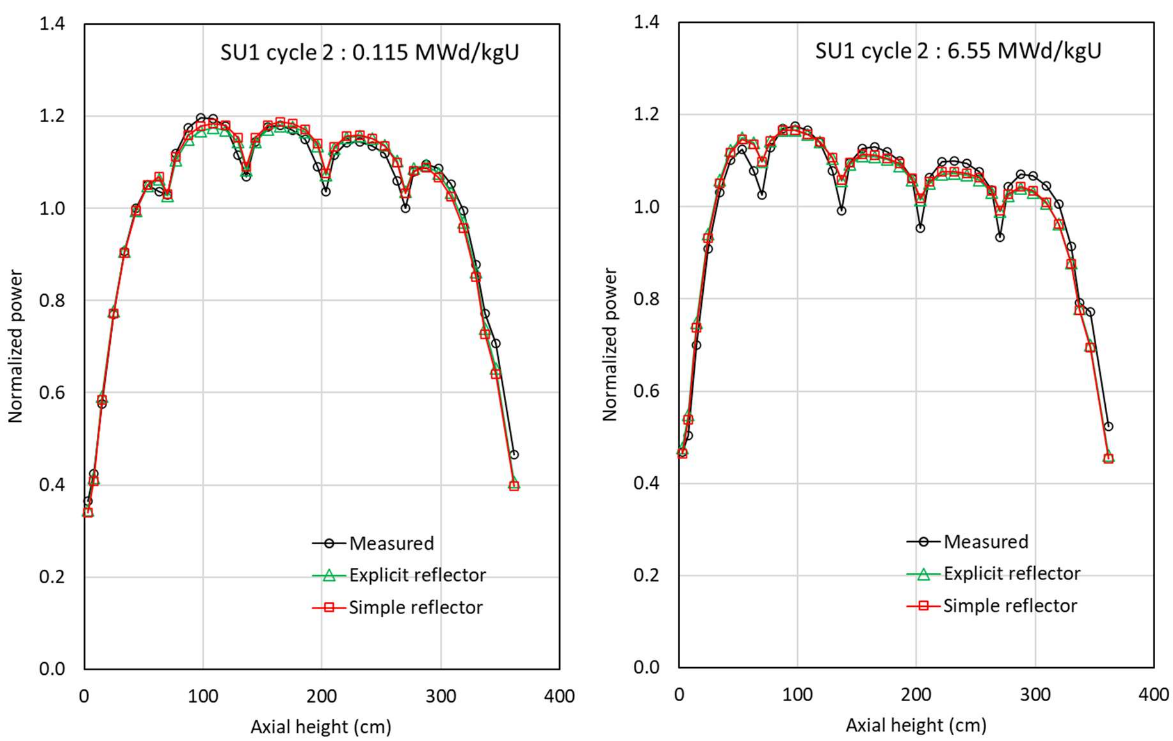


Figure 3.14. Axial 1D flux map comparison for the SU1 cycle 2.

4. CONCLUSION

The SU1 benchmark calculations were performed, and the benchmark results were compared with the measured data for the HFP critical boron concentrations and in–core detector power maps. The investigation outlines the discrepancies and uncertainties in measured boron concentrations, systematically addressed through polynomial expansion, yielding smoother, more consistent data sets. The calculated boron concentrations show good agreement with the fitted measured data, with RMS error of 16.1 ppm for cycle 1 and 12.9 ppm for cycle 2. The overall RMS errors for SU1 power maps are 7.69% for 3D, 5.34% for 2D, and 3.79% for 1D when employing the simple reflector models. However, it's worth noting that when utilizing the explicit reflector model, higher errors are observed. Moreover, the investigation of the enthalpy rise hot channel factors for the SU1 cycles 1 and 2 reveals smaller enthalpy rise hot channel factors with the simple reflector models. This, alongside the violation of the enthalpy rise hot channel factors limit by the explicit reflector models, necessitates that further investigation is required to enhance the stability of the procedure for preparing reflector cross–sections when using the Polaris–PARCS code package. Furthermore, it is crucial to note the identification of errors in the fuel assembly loading patterns within the EPRI report [1]. Corrections were inevitable to avoid unrealistic differences in critical boron concentrations and flux maps, thereby ensuring the introduction of more reasonable and accurate benchmark results. The simulated radial and axial flux shapes can be improved by enhancing effective axial and radial reflector cross sections. In addition, SCALE 6.3.0/Polaris does not currently support gamma–smeared power distributions. Improving and implementing the mentioned capabilities are expected to help Polaris–GenPMAXS–PARCS procedure show better agreement with benchmark results.

The primary objective of these benchmark calculations is to validate the SCALE/Polaris–GenPMAXS–PARCS code package, leveraging the ENDF/B–VII.1 AMPX 56–group libraries, by assessing uncertainties for pivotal nuclear parameters, including reactivity, temperature reactivity coefficients, control rod worth, and pin and assembly power peaking factors [13]. The benchmark calculations for SU1, utilizing the SCALE 6.3/Polaris–GenPMAXS–PARCS v3.4.2 code package, have been finalized. The resultant data will facilitate the validation of this code package for light–water reactor physics by determining statistical uncertainties for key nuclear parameters.

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APPENDIX A. SAMPLE OF POLARIS INPUT FILES

A.1 Polaris Input for the Fuel Assembly type A 1.868_bp00

```
=polaris
%-------------------------------------------------------
%    general options
%-------------------------------------------------------
title "SURRY 1.868 w/o 00 BP ASSM 1"
lib "broad_lwr"
opt KEFF RaySpacing=0.04
opt PRINT XFile16=true
system PWR
%-------------------------------------------------------
%    geometry (thermal expansions are considered)
% pin pitch = 1.43527cm
% lattice pitch = 21.52906318 cm
% assembly width = 21.60912 cm
% gap = 0.04003 cm
%-------------------------------------------------------
geom assembly: ASSM 15 1.43527 SE
hgap 0.04003
%-------------------------------------------------------
%    compositions and materials
%-------------------------------------------------------
% materials and compositions
comp f_1   : UOX  enr=1.868 refdens=9.89508
comp f_2   : UOX  enr=2.573 refdens=9.831095
comp f_3   : UOX  enr=3.117 refdens=9.725765
comp f_4a  : UOX  enr=1.86  refdens=9.979738
comp f_4b  : UOX  enr=2.61  refdens=10.01124
comp f_4c  : UOX  enr=3.33  refdens=9.990566
comp f_4x  : UOX  enr=1.86  refdens=9.980722

comp air : CONC refdens=0.000616
 6012 = 6.7565e-09
 6013 = 7.3076e-11
 8016 = 5.2864e-06
 8017 = 2.0137e-09
 8018 = 1.0863e-08
 7014 = 1.9681e-05
 7015 = 7.1900e-08
18036 = 7.9414e-10
18038 = 1.4915e-10
18040 = 2.3506e-07

mat FUEL.1  : f_1
mat FUEL.2  : f_2
mat FUEL.3  : f_3
mat FUEL.4  : f_4a
mat FUEL.5  : f_4b
mat FUEL.6  : f_4c
mat FUEL.7  : f_4x
mat CLAD.1  : ZIRC4     dens=6.526634012
mat COOL.1  : WATER     temp=615.0 dens=0.608316 : boron=500
mat AIR.1   : air
mat CNTL.1  : AIC
mat BP.1    : B4C
mat CRS.1   : SS304
mat MI.1    : AL2O3
mat GRID.1  : INC718

% add rings according to ORNL recommendations
mesh FUEL.1 nr=4

deplete ALL=false FUEL=true
shield ALL=N FUEL=P CNTL=P BP=P

% fuel rod
pin 1 : 0.46714   0.47502   0.53685
      : FUEL.1   GAP.1    CLAD.1
%pin 3 : 0.4634   0.4742   0.5359
%      : FUEL.3   GAP.1    CLAD.1
%pin X : 0.4096   0.4178   0.4750
%      : FUEL.7   GAP.1    CLAD.1
% guide tube
pin G : 0.61496  0.69129
      : COOL.1  CLAD.1
% instrument tube
```

```
pin I : 0.61496  0.69129
      : COOL.1   CLAD.1

% ------------------------------------------------
%    detector
% ------------------------------------------------
comp c_u235 : CONC 92235=1.0e-15
mat DET.1 : c_u235
pin P : 0.4 : COOL.2
det d_u235 : pin.P at=pin.I : R(n,FIS) COOL.2 DET.1
opt FG DetectorEdit=d_u235

pinmap
 I
 1 1
 1 1 1
 1 1 1 G
 G 1 1 1 1
 1 1 G 1 1 G
 1 1 1 1 1 1 1
 1 1 1 1 1 1 1 1

% define the RCCA

% AIC Full
PIN D : 0.3575   0.5582   0.61496   0.69129
      : CNTL.1   CRS.1    COOL.1   CLAD.1
% AIC Part
pin E : 0.5099   0.5582   0.61496   0.69129
      : CNTL.1   CRS.1    COOL.1   CLAD.1
% AIC Upper Part
pin F : 0.3575   0.5582   0.61496   0.69129
      : MI.1     CRS.1    COOL.1   CLAD.1

control  BankA : RODLET
 _
 _ _
 _ _ _
 _ _ _ D
 D _ _ _ _
 _ _ D _ _ D
 _ _ _ _ _ _ _
 _ _ _ _ _ _ _ _

control  BankB : RODLET
 _
 _ _
 _ _ _
 _ _ _ E
 E _ _ _ _
 _ _ E _ _ E
 _ _ _ _ _ _ _
 _ _ _ _ _ _ _ _

control  BankC : RODLET
 _
 _ _
 _ _ _
 _ _ _ F
 F _ _ _ _
 _ _ F _ _ F
 _ _ _ _ _ _ _
 _ _ _ _ _ _ _ _

% begin burnup and branch cases
power 34.8938
bu 0 0.1 0.5 1 2 4 6 8 10 12.5 15 17.5 20 25 30 35 40 45 50

% Set base temperature field to core average, use
% history and branching variables to perturb to appropriate
% value for calculations

state ALL    : temp=615.0
      FUEL   : temp=800.0
      COOL   : boron=500  dens=0.608316
      BankA  : in=false
      BankB  : in=false
      BankC  : in=false

% reference history internal burnup steps through 50 GWD/MTU
```

```
read branch
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 0.1  FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 500  FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 1500 FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 0.1  FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 500  FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 1500 FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 0.1  FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 500  FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 1500 FUEL : temp= 560.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
% add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 0.1  FUEL : temp= 1600.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 500  FUEL : temp= 1600.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 1500 FUEL : temp= 1600.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 0.1  FUEL : temp= 1600.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 500  FUEL : temp= 1600.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 1500 FUEL : temp= 1600.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 0.1  FUEL : temp= 1600.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 500  FUEL : temp= 1600.0
 add  BankA : in= false BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 1500 FUEL : temp= 1600.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= true  BankB : in= false BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
```

```
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= true  BankC : in= false ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 615.0 COOL.1 : dens= 0.608316 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 585.0 COOL.1 : dens= 0.700809 COOL.1 :
boron= 1500 FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 0.1  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 500  FUEL : temp= 800.0
 add  BankA : in= false BankB : in= false BankC : in= true  ALL : temp= 550.0 COOL.1 : dens= 0.769987 COOL.1 :
boron= 1500 FUEL : temp= 800.0
end branch

end
```

A.2 Polaris Input for Radial Reflector

```
=polaris
% -----------------------------------------------
%    general options
% -----------------------------------------------
title "WEC 15x15 lattice"
lib   "broad_lwr"
opt   PRINT XFile16=true
system PWR
% -----------------------------------------------
%    compositions and materials
% -----------------------------------------------
comp c_uox : UOX 2.573
mat FUEL.1 : c_uox 9.831095
% -----------------------------------------------
%    geometry
% -----------------------------------------------
geom W15 : ASSM 15 1.43527
hgap 0.04
pin F : 0.46714   0.47502   0.53685
      : FUEL.1 GAP   CLAD
pin I : 0.61496  0.69129
      : COOL.1 TUBE  COOL.1
pin G : 0.61496  0.69129
      : COOL.1 TUBE  COOL.1
mesh GAP  : ns=1
mesh FUEL : nr=4
shield ALL=N FUEL=P
pinmap
   I
   F F
   F F F
   F F F G
   G F F F F
   F F G F F G
   F F F F F F F
   F F F F F F F F
geom rad_ref : REFL 21.5
slab rad_ref : 0.1524   2.54   18.8076
             : COOL.1 STRUCT COOL.1
             : 1      4      25
             : 34     34     34
% -----------------------------------------------
%    states
% -----------------------------------------------
```

```
state ALL : temp=550 FUEL : temp=800 COOL : dens=0.76971 boron=600 rad_ref : in=yes
read branch
  add COOL : boron=0
  add COOL : boron=1800
  add ALL : temp=585 FUEL : temp=800 COOL : boron=600 dens=0.70045
end branch

end
```

A.3 Polaris Input for Axial Top Reflector

```
=polaris
% ------------------------------------------------
%    general options
% ------------------------------------------------
title "Top reflector"
lib   "broad_lwr"
opt   PRINT XFile16=true
system PWR
% ------------------------------------------------
%    geometry
% ------------------------------------------------
geom W15 : ASSM 15 1.43527 FULL
hgap 0.04
% ------------------------------------------------
%    compositions and materials
% ------------------------------------------------
comp c_uox : UOX 2.573
mat FUEL.1 : c_uox 9.831095
% ------------------------------------------------
%    pins definitions
% ------------------------------------------------
pin F : 0.46714   0.47502   0.53685
      : FUEL.1 GAP   CLAD
pin I : 0.61496  0.69129
      : COOL.1 TUBE  COOL.1
pin G : 0.61496  0.69129
      : COOL.1 TUBE  COOL.1
mesh GAP  : ns=1
mesh FUEL : nr=4
shield ALL=N FUEL=P
% ------------------------------------------------
%    maps
% ------------------------------------------------
pinmap
   I
   F F
   F F F
   F F F G
   G F F F F
   F F G F F G
   F F F F F F F
   F F F F F F F F
% ------------------------------------------------
%    reflector
% ------------------------------------------------
geom top_refl_lpc : REFL 36.226
geom top_refl_mpc : REFL 36.226
geom top_refl_hpc : REFL 36.226
geom top_refl_mdc : REFL 36.226
slab  top_refl_lpc : 8.556  3.866      3.578 1.67   2.129     8.827     7.6
                   : PLE.1  PLE_GRID.1 PLE.1 PLUG.1 NOZ_GAP.1 TOP_NOZ.1 TOP_CP.1
                   : 14     6          6     3      3         14        12
                   : 34     34         34    34     34        34        34
slab  top_refl_mpc : 8.556  3.866      3.578 1.67   2.129     8.827     7.6
                   : PLE.2  PLE_GRID.2 PLE.2 PLUG.2 NOZ_GAP.2 TOP_NOZ.2 TOP_CP.2
                   : 14     6          6     3      3         14        12
                   : 34     34         34    34     34        34        34
slab  top_refl_hpc : 8.556  3.866      3.578 1.67   2.129     8.827     7.6
                   : PLE.3  PLE_GRID.3 PLE.3 PLUG.3 NOZ_GAP.3 TOP_NOZ.3 TOP_CP.3
                   : 14     6          6     3      3         14        12
                   : 34     34         34    34     34        34        34
slab  top_refl_mdc : 8.556  3.866      3.578 1.67   2.129     8.827     7.6
                   : PLE.4  PLE_GRID.4 PLE.4 PLUG.4 NOZ_GAP.4 TOP_NOZ.4 TOP_CP.4
                   : 14     6          6     3      3         14        12
                   : 34     34         34    34     34        34        34
mat PLE.1 : c_ple_lpc 2.25
mat PLE_GRID.1 : c_ple_grid_lpc 2.78
mat PLUG.1 : c_plug_lpc 3.07
mat NOZ_GAP.1 : c_noz_gap_lpc 0.66
```

```
mat TOP_NOZ.1 : c_top_noz_lpc 2.02
mat TOP_CP.1 : c_top_cp_lpc 4.27

mat PLE.2 : c_ple_mpc 2.25
mat PLE_GRID.2 : c_ple_grid_mpc 2.78
mat PLUG.2 : c_plug_mpc 3.07
mat NOZ_GAP.2 : c_noz_gap_mpc 0.66
mat TOP_NOZ.2 : c_top_noz_mpc 2.02
mat TOP_CP.2 : c_top_cp_mpc 4.27

mat PLE.3 : c_ple_hpc 2.25
mat PLE_GRID.3 : c_ple_grid_hpc 2.78
mat PLUG.3 : c_plug_hpc 3.07
mat NOZ_GAP.3 : c_noz_gap_hpc 0.66
mat TOP_NOZ.3 : c_top_noz_hpc 2.02
mat TOP_CP.3 : c_top_cp_hpc 4.27

mat PLE.4 : c_ple_mdc 2.31
mat PLE_GRID.4 : c_ple_grid_mdc 2.83
mat PLUG.4 : c_plug_mdc 3.12
mat NOZ_GAP.4 : c_noz_gap_mdc 0.75
mat TOP_NOZ.4 : c_top_noz_mdc 2.10
mat TOP_CP.4 : c_top_cp_mdc 4.32

comp c_cool_lpc : LW 0
comp c_ple_lpc : WT ZIRC4=29 SS304=55 c_cool_lpc=-100
comp c_ple_grid_lpc : WT ZIRC4=23 SS304=45 INC718=20 c_cool_lpc=-100
comp c_plug_lpc : WT ZIRC4=88 c_cool_lpc=-100
comp c_noz_gap_lpc : WT ZIRC4=8 c_cool_lpc=-100
comp c_top_noz_lpc : WT SS304=76 c_cool_lpc=-100
comp c_top_cp_lpc : WT SS304=93 c_cool_lpc=-100

comp c_cool_mpc : LW 600
comp c_ple_mpc : WT ZIRC4=29 SS304=55 c_cool_mpc=-100
comp c_ple_grid_mpc : WT ZIRC4=23 SS304=45 INC718=20 c_cool_mpc=-100
comp c_plug_mpc : WT ZIRC4=88 c_cool_mpc=-100
comp c_noz_gap_mpc : WT ZIRC4=8 c_cool_mpc=-100
comp c_top_noz_mpc : WT SS304=76 c_cool_mpc=-100
comp c_top_cp_mpc : WT SS304=93 c_cool_mpc=-100

comp c_cool_hpc : LW 1800
comp c_ple_hpc : WT ZIRC4=29 SS304=55 c_cool_hpc=-100
comp c_ple_grid_hpc : WT ZIRC4=23 SS304=45 INC718=20 c_cool_hpc=-100
comp c_plug_hpc : WT ZIRC4=88 c_cool_hpc=-100
comp c_noz_gap_hpc : WT ZIRC4=8 c_cool_hpc=-100
comp c_top_noz_hpc : WT SS304=76 c_cool_hpc=-100
comp c_top_cp_hpc : WT SS304=93 c_cool_hpc=-100

comp c_cool_mdc : LW 600
comp c_ple_mdc : WT ZIRC4=28 SS304=54 c_cool_mdc=-100
comp c_ple_grid_mdc : WT ZIRC4=23 SS304=44 INC718=20 c_cool_mdc=-100
comp c_plug_mdc : WT ZIRC4=87 c_cool_mdc=-100
comp c_noz_gap_mdc : WT ZIRC4=7 c_cool_mdc=-100
comp c_top_noz_mdc : WT SS304=73 c_cool_mdc=-100
comp c_top_cp_mdc : WT SS304=92 c_cool_mdc=-100

opt ESSM RaySpacing=0.0425
opt KEFF RaySpacing=0.046
% ------------------------------------------------
%    states
% ------------------------------------------------
state ALL : temp=615
     FUEL : temp=800
     COOL : dens=0.60811 boron=600
     top_refl_mpc : in=yes
     top_refl_lpc : in=no
     top_refl_hpc : in=no
     top_refl_mdc : in=no
read branch
  add        COOL : boron=0
     top_refl_mpc : in=no
     top_refl_lpc : in=yes
     top_refl_hpc : in=no
     top_refl_mdc : in=no

  add        COOL : boron=1800
     top_refl_mpc : in=no
     top_refl_lpc : in=no
     top_refl_hpc : in=yes
     top_refl_mdc : in=no
```

```
  add         ALL : temp=585
             FUEL : temp=800
             COOL : boron=600 dens=0.70045
     top_refl_mpc : in=no
     top_refl_lpc : in=no
     top_refl_hpc : in=no
     top_refl_mdc : in=yes
end branch
end
```

A.4 Polaris Input for Axial Bottom Reflector

```
=polaris
% ------------------------------------------------
%    general options
% ------------------------------------------------
title "Bottom reflector"
lib   "broad_lwr"
opt   PRINT XFile16=true
system PWR
% ------------------------------------------------
%    geometry
% ------------------------------------------------
geom W15 : ASSM 15 1.43527 FULL
hgap 0.04003
% ------------------------------------------------
%    compositions and materials
% ------------------------------------------------
comp c_uox : UOX 2.573
mat FUEL.1 : c_uox 9.831095
% ------------------------------------------------
%    pins definitions
% ------------------------------------------------
pin F : 0.46714   0.47502   0.53685
      : FUEL.1 GAP   CLAD
pin I : 0.61496  0.69129
      : COOL.1 TUBE  COOL.1
pin G : 0.61496  0.69129
      : COOL.1 TUBE  COOL.1
mesh GAP  : ns=1
mesh FUEL : nr=4
shield ALL=N FUEL=P
% ------------------------------------------------
%    maps
% ------------------------------------------------
pinmap
   I
   F F
   F F F
   F F F G
   G F F F F
   F F G F F G
   F F F F F F F
   F F F F F F F F
% ------------------------------------------------
%    reflector
% ------------------------------------------------
geom bot_refl_lpc : REFL 16.951
geom bot_refl_mpc : REFL 16.951
geom bot_refl_hpc : REFL 16.951
geom bot_refl_mdc : REFL 16.951
slab  bot_refl_lpc : 5.898     6.053     5.000
                   : BOT_GAP.1 BOT_NOZ.1 BOT_CP.1
                   : 9         9         8
                   : 34        34        34
slab  bot_refl_mpc : 5.898     6.053     5.000
                   : BOT_GAP.2 BOT_NOZ.2 BOT_CP.2
                   : 9         9         8
                   : 34        34        34
slab  bot_refl_hpc : 5.898     6.053     5.000
                   : BOT_GAP.3 BOT_NOZ.3 BOT_CP.3
                   : 9         9         8
                   : 34        34        34
slab  bot_refl_mdc : 5.898     6.053     5.000
                   : BOT_GAP.4 BOT_NOZ.4 BOT_CP.4
                   : 9         9         8
                   : 34        34        34
mat BOT_GAP.1 : c_bot_gap_lpc 1.82
mat BOT_NOZ.1 : c_bot_noz_lpc 2.79
mat BOT_CP.1 : c_bot_cp_lpc 4.35
```

```
mat BOT_GAP.2 : c_bot_gap_mpc 1.82
mat BOT_NOZ.2 : c_bot_noz_mpc 2.79
mat BOT_CP.2 : c_bot_cp_mpc 4.35

mat BOT_GAP.3 : c_bot_gap_hpc 1.82
mat BOT_NOZ.3 : c_bot_noz_hpc 2.79
mat BOT_CP.3 : c_bot_cp_hpc 4.35

mat BOT_GAP.4 : c_bot_gap_mdc 1.76
mat BOT_NOZ.4 : c_bot_noz_mdc 2.74
mat BOT_CP.4 : c_bot_cp_mdc 4.32

comp c_cool_lpc : LW 0
comp c_bot_gap_lpc : WT ZIRC4=44 INC718=21 c_cool_lpc=-100
comp c_bot_noz_lpc : WT SS304=80 c_cool_lpc=-100
comp c_bot_cp_lpc : WT SS304=91 c_cool_lpc=-100

comp c_cool_mpc : LW 600
comp c_bot_gap_mpc : WT ZIRC4=44 INC718=21 c_cool_mpc=-100
comp c_bot_noz_mpc : WT SS304=80 c_cool_mpc=-100
comp c_bot_cp_mpc : WT SS304=91 c_cool_mpc=-100

comp c_cool_hpc : LW 1800
comp c_bot_gap_hpc : WT ZIRC4=44 INC718=21 c_cool_hpc=-100
comp c_bot_noz_hpc : WT SS304=80 c_cool_hpc=-100
comp c_bot_cp_hpc : WT SS304=91 c_cool_hpc=-100

comp c_cool_mdc : LW 600
comp c_bot_gap_mdc : WT ZIRC4=46 INC718=21 c_cool_mdc=-100
comp c_bot_noz_mdc : WT SS304=82 c_cool_mdc=-100
comp c_bot_cp_mdc : WT SS304=92 c_cool_mdc=-100

opt ESSM RaySpacing=0.045
opt KEFF RaySpacing=.066
% -----------------------------------------------
%    states
% -----------------------------------------------
state ALL : temp=550
     FUEL : temp=800
     COOL : dens=0.76971 boron=600
     bot_refl_mpc : in=yes
     bot_refl_lpc : in=no
     bot_refl_hpc : in=no
     bot_refl_mdc : in=no
read branch
  add        COOL : boron=0
     bot_refl_mpc : in=no
     bot_refl_lpc : in=yes
     bot_refl_hpc : in=no
     bot_refl_mdc : in=no

  add        COOL : boron=1800
     bot_refl_mpc : in=no
     bot_refl_lpc : in=no
     bot_refl_hpc : in=yes
     bot_refl_mdc : in=no

  add         ALL : temp=585
             FUEL : temp=800
             COOL : boron=600 dens=0.70045
     bot_refl_mpc : in=no
     bot_refl_lpc : in=no
     bot_refl_hpc : in=no
     bot_refl_mdc : in=yes
end branch
end
```

APPENDIX B. SAMPLE OF GENPMAXS INPUT FILES

B.1 GenPMAXS Input for the Fuel Assembly 1.868_bp00

```
%JOB_TIT
 'b1_1.878_bp00.PMAX'  T  3.0
%JOB_OPT
   T  T  F  F  F  F  T  T  T  F  T  T  T  F
 !ad,xe,de,j1,ch,Xd,iv,dt,yl,cd,gf,be,lb,dc
%DAT_SRC
  8   8   1
%STA_VAR
  4
  CR DC PC TF
%HISTORY
  8   4
  HIST01    0.00000     0.60832      500.0    800.0
  HIST02    0.00000     0.70081        0.0    800.0
  HIST03    0.00000     0.70081      500.0    560.0
  HIST04    0.00000     0.70081      500.0    800.0
  HIST05    0.00000     0.70081      500.0   1600.0
  HIST06    0.00000     0.70081     1500.0    800.0
  HIST07    0.00000     0.76999      500.0    800.0
  HIST08    1.00000     0.70081      500.0    800.0
%BRANCH
  54  14
  BLCK01    0.00000     0.60832        0.5    560.0
  BLCK02    0.00000     0.60832      500.0    560.0
  BLCK03    0.00000     0.60832     1500.0    560.0
  BLCK04    0.00000     0.70081        0.5    560.0
  BLCK05    0.00000     0.70081      500.0    560.0
  BLCK06    0.00000     0.70081     1500.0    560.0
  BLCK07    0.00000     0.76999        0.5    560.0
  BLCK08    0.00000     0.76999      500.0    560.0
  BLCK09    0.00000     0.76999     1500.0    560.0
  BLCK10    0.00000     0.60832        0.5    800.0
  BLCK11    0.00000     0.60832      500.0    800.0
  BLCK12    0.00000     0.60832     1500.0    800.0
  BLCK13    0.00000     0.70081        0.5    800.0
  BLCK14    0.00000     0.70081      500.0    800.0
  BLCK15    0.00000     0.70081     1500.0    800.0
  BLCK16    0.00000     0.76999        0.5    800.0
  BLCK17    0.00000     0.76999      500.0    800.0
  BLCK18    0.00000     0.76999     1500.0    800.0
  BLCK19    0.00000     0.60832        0.5   1600.0
  BLCK20    0.00000     0.60832      500.0   1600.0
  BLCK21    0.00000     0.60832     1500.0   1600.0
  BLCK22    0.00000     0.70081        0.5   1600.0
  BLCK23    0.00000     0.70081      500.0   1600.0
  BLCK24    0.00000     0.70081     1500.0   1600.0
  BLCK25    0.00000     0.76999        0.5   1600.0
  BLCK26    0.00000     0.76999      500.0   1600.0
  BLCK27    0.00000     0.76999     1500.0   1600.0
  BLCK28    1.00000     0.60832        0.5    800.0
  BLCK29    1.00000     0.60832      500.0    800.0
  BLCK30    1.00000     0.60832     1500.0    800.0
  BLCK31    1.00000     0.70081        0.5    800.0
  BLCK32    1.00000     0.70081      500.0    800.0
  BLCK33    1.00000     0.70081     1500.0    800.0
  BLCK34    1.00000     0.76999        0.5    800.0
  BLCK35    1.00000     0.76999      500.0    800.0
  BLCK36    1.00000     0.76999     1500.0    800.0
  BLCK37    2.00000     0.60832        0.5    800.0
  BLCK38    2.00000     0.60832      500.0    800.0
  BLCK39    2.00000     0.60832     1500.0    800.0
  BLCK40    2.00000     0.70081        0.5    800.0
  BLCK41    2.00000     0.70081      500.0    800.0
  BLCK42    2.00000     0.70081     1500.0    800.0
  BLCK43    2.00000     0.76999        0.5    800.0
  BLCK44    2.00000     0.76999      500.0    800.0
  BLCK45    2.00000     0.76999     1500.0    800.0
  BLCK46    3.00000     0.60832        0.5    800.0
  BLCK47    3.00000     0.60832      500.0    800.0
  BLCK48    3.00000     0.60832     1500.0    800.0
  BLCK49    3.00000     0.70081        0.5    800.0
  BLCK50    3.00000     0.70081      500.0    800.0
  BLCK51    3.00000     0.70081     1500.0    800.0
  BLCK52    3.00000     0.76999        0.5    800.0
  BLCK53    3.00000     0.76999      500.0    800.0
```

```
  BLCK54    3.00000     0.76999     1500.0    800.0
%BURNUP
  1
  BS1  19
         0.000   0.100   0.500   1.000   2.000
         4.000   6.000   8.000  10.000  12.500
        15.000  17.500  20.000  25.000  30.000
        35.000  40.000  45.000  50.000
  HIST01 54*1
  HIST02 54*1
  HIST03 54*1
  HIST04 54*1
  HIST05 54*1
  HIST06 54*1
  HIST07 54*1
  HIST08 54*1
%USERINP
  1
  PIN  1.43243 0.06131 0.06131  0
%FIL_CNT
  1  '../../Polaris/bare/b1_1.8_00bp/b1_1.868_bp00_cr0_dc60_p0500_tf0800.t16' 54 1
       1  1 11  1  19  !
       2  1  1  1  19  !
       3  1  2  1  19  !
       4  1  3  1  19  !
       5  1  4  1  19  !
       6  1  5  1  19  !
       7  1  6  1  19  !
       8  1  7  1  19  !
       9  1  8  1  19  !
      10  1  9  1  19  !
      11  1 10  1  19  !
      12  1 12  1  19  !
      13  1 13  1  19  !
      14  1 14  1  19  !
      15  1 15  1  19  !
      16  1 16  1  19  !
      17  1 17  1  19  !
      18  1 18  1  19  !
      19  1 19  1  19  !
      20  1 20  1  19  !
      21  1 21  1  19  !
      22  1 22  1  19  !
      23  1 23  1  19  !
      24  1 24  1  19  !
      25  1 25  1  19  !
      26  1 26  1  19  !
      27  1 27  1  19  !
      28  1 28  1  19  !
      29  1 29  1  19  !
      30  1 30  1  19  !
      31  1 31  1  19  !
      32  1 32  1  19  !
      33  1 33  1  19  !
      34  1 34  1  19  !
      35  1 35  1  19  !
      36  1 36  1  19  !
      37  1 37  1  19  !
      38  1 38  1  19  !
      39  1 39  1  19  !
      40  1 40  1  19  !
      41  1 41  1  19  !
      42  1 42  1  19  !
      43  1 43  1  19  !
      44  1 44  1  19  !
      45  1 45  1  19  !
      46  1 46  1  19  !
      47  1 47  1  19  !
      48  1 48  1  19  !
      49  1 49  1  19  !
      50  1 50  1  19  !
      51  1 51  1  19  !
      52  1 52  1  19  !
      53  1 53  1  19  !
      54  1 54  1  19  !
  2  '../../Polaris/bare/b1_1.8_00bp/b1_1.868_bp00_cr0_dc70_p0000_tf0800.t16' 54 1
       1  2 13  1  19  !
       2  2  1  1  19  !
       3  2  2  1  19  !
       4  2  3  1  19  !
       5  2  4  1  19  !
```

```
      6  2  5  1  19  !
      7  2  6  1  19  !
      8  2  7  1  19  !
      9  2  8  1  19  !
     10  2  9  1  19  !
     11  2 10  1  19  !
     12  2 11  1  19  !
     13  2 12  1  19  !
     14  2 14  1  19  !
     15  2 15  1  19  !
     16  2 16  1  19  !
     17  2 17  1  19  !
     18  2 18  1  19  !
     19  2 19  1  19  !
     20  2 20  1  19  !
     21  2 21  1  19  !
     22  2 22  1  19  !
     23  2 23  1  19  !
     24  2 24  1  19  !
     25  2 25  1  19  !
     26  2 26  1  19  !
     27  2 27  1  19  !
     28  2 28  1  19  !
     29  2 29  1  19  !
     30  2 30  1  19  !
     31  2 31  1  19  !
     32  2 32  1  19  !
     33  2 33  1  19  !
     34  2 34  1  19  !
     35  2 35  1  19  !
     36  2 36  1  19  !
     37  2 37  1  19  !
     38  2 38  1  19  !
     39  2 39  1  19  !
     40  2 40  1  19  !
     41  2 41  1  19  !
     42  2 42  1  19  !
     43  2 43  1  19  !
     44  2 44  1  19  !
     45  2 45  1  19  !
     46  2 46  1  19  !
     47  2 47  1  19  !
     48  2 48  1  19  !
     49  2 49  1  19  !
     50  2 50  1  19  !
     51  2 51  1  19  !
     52  2 52  1  19  !
     53  2 53  1  19  !
     54  2 54  1  19  !
3  '../../Polaris/bare/b1_1.8_00bp/b1_1.868_bp00_cr0_dc70_p0500_tf0560.t16' 54 1
      1  3  5  1  19  !
      2  3  1  1  19  !
      3  3  2  1  19  !
      4  3  3  1  19  !
      5  3  4  1  19  !
      6  3  6  1  19  !
      7  3  7  1  19  !
      8  3  8  1  19  !
      9  3  9  1  19  !
     10  3 10  1  19  !
     11  3 11  1  19  !
     12  3 12  1  19  !
     13  3 13  1  19  !
     14  3 14  1  19  !
     15  3 15  1  19  !
     16  3 16  1  19  !
     17  3 17  1  19  !
     18  3 18  1  19  !
     19  3 19  1  19  !
     20  3 20  1  19  !
     21  3 21  1  19  !
     22  3 22  1  19  !
     23  3 23  1  19  !
     24  3 24  1  19  !
     25  3 25  1  19  !
     26  3 26  1  19  !
     27  3 27  1  19  !
     28  3 28  1  19  !
     29  3 29  1  19  !
     30  3 30  1  19  !
     31  3 31  1  19  !
```

```
    32  3 32  1  19  !
    33  3 33  1  19  !
    34  3 34  1  19  !
    35  3 35  1  19  !
    36  3 36  1  19  !
    37  3 37  1  19  !
    38  3 38  1  19  !
    39  3 39  1  19  !
    40  3 40  1  19  !
    41  3 41  1  19  !
    42  3 42  1  19  !
    43  3 43  1  19  !
    44  3 44  1  19  !
    45  3 45  1  19  !
    46  3 46  1  19  !
    47  3 47  1  19  !
    48  3 48  1  19  !
    49  3 49  1  19  !
    50  3 50  1  19  !
    51  3 51  1  19  !
    52  3 52  1  19  !
    53  3 53  1  19  !
    54  3 54  1  19  !
4  '../../Polaris/bare/b1_1.8_00bp/b1_1.868_bp00_cr0_dc70_p0500_tf0800.t16' 54 1
     1  4 14  1  19  !
     2  4  1  1  19  !
     3  4  2  1  19  !
     4  4  3  1  19  !
     5  4  4  1  19  !
     6  4  5  1  19  !
     7  4  6  1  19  !
     8  4  7  1  19  !
     9  4  8  1  19  !
    10  4  9  1  19  !
    11  4 10  1  19  !
    12  4 11  1  19  !
    13  4 12  1  19  !
    14  4 13  1  19  !
    15  4 15  1  19  !
    16  4 16  1  19  !
    17  4 17  1  19  !
    18  4 18  1  19  !
    19  4 19  1  19  !
    20  4 20  1  19  !
    21  4 21  1  19  !
    22  4 22  1  19  !
    23  4 23  1  19  !
    24  4 24  1  19  !
    25  4 25  1  19  !
    26  4 26  1  19  !
    27  4 27  1  19  !
    28  4 28  1  19  !
    29  4 29  1  19  !
    30  4 30  1  19  !
    31  4 31  1  19  !
    32  4 32  1  19  !
    33  4 33  1  19  !
    34  4 34  1  19  !
    35  4 35  1  19  !
    36  4 36  1  19  !
    37  4 37  1  19  !
    38  4 38  1  19  !
    39  4 39  1  19  !
    40  4 40  1  19  !
    41  4 41  1  19  !
    42  4 42  1  19  !
    43  4 43  1  19  !
    44  4 44  1  19  !
    45  4 45  1  19  !
    46  4 46  1  19  !
    47  4 47  1  19  !
    48  4 48  1  19  !
    49  4 49  1  19  !
    50  4 50  1  19  !
    51  4 51  1  19  !
    52  4 52  1  19  !
    53  4 53  1  19  !
    54  4 54  1  19  !
5  '../../Polaris/bare/b1_1.8_00bp/b1_1.868_bp00_cr0_dc70_p0500_tf1600.t16' 54 1
     1  5 23  1  19  !
     2  5  1  1  19  !
```

```
      3   5   2   1   19   !
      4   5   3   1   19   !
      5   5   4   1   19   !
      6   5   5   1   19   !
      7   5   6   1   19   !
      8   5   7   1   19   !
      9   5   8   1   19   !
     10   5   9   1   19   !
     11   5  10   1   19   !
     12   5  11   1   19   !
     13   5  12   1   19   !
     14   5  13   1   19   !
     15   5  14   1   19   !
     16   5  15   1   19   !
     17   5  16   1   19   !
     18   5  17   1   19   !
     19   5  18   1   19   !
     20   5  19   1   19   !
     21   5  20   1   19   !
     22   5  21   1   19   !
     23   5  22   1   19   !
     24   5  24   1   19   !
     25   5  25   1   19   !
     26   5  26   1   19   !
     27   5  27   1   19   !
     28   5  28   1   19   !
     29   5  29   1   19   !
     30   5  30   1   19   !
     31   5  31   1   19   !
     32   5  32   1   19   !
     33   5  33   1   19   !
     34   5  34   1   19   !
     35   5  35   1   19   !
     36   5  36   1   19   !
     37   5  37   1   19   !
     38   5  38   1   19   !
     39   5  39   1   19   !
     40   5  40   1   19   !
     41   5  41   1   19   !
     42   5  42   1   19   !
     43   5  43   1   19   !
     44   5  44   1   19   !
     45   5  45   1   19   !
     46   5  46   1   19   !
     47   5  47   1   19   !
     48   5  48   1   19   !
     49   5  49   1   19   !
     50   5  50   1   19   !
     51   5  51   1   19   !
     52   5  52   1   19   !
     53   5  53   1   19   !
     54   5  54   1   19   !
6  '../../Polaris/bare/b1_1.8_00bp/b1_1.868_bp00_cr0_dc70_p1500_tf0800.t16' 54 1
      1   6  15   1   19   !
      2   6   1   1   19   !
      3   6   2   1   19   !
      4   6   3   1   19   !
      5   6   4   1   19   !
      6   6   5   1   19   !
      7   6   6   1   19   !
      8   6   7   1   19   !
      9   6   8   1   19   !
     10   6   9   1   19   !
     11   6  10   1   19   !
     12   6  11   1   19   !
     13   6  12   1   19   !
     14   6  13   1   19   !
     15   6  14   1   19   !
     16   6  16   1   19   !
     17   6  17   1   19   !
     18   6  18   1   19   !
     19   6  19   1   19   !
     20   6  20   1   19   !
     21   6  21   1   19   !
     22   6  22   1   19   !
     23   6  23   1   19   !
     24   6  24   1   19   !
     25   6  25   1   19   !
     26   6  26   1   19   !
     27   6  27   1   19   !
     28   6  28   1   19   !
```

```
      29   6 29   1   19   !
      30   6 30   1   19   !
      31   6 31   1   19   !
      32   6 32   1   19   !
      33   6 33   1   19   !
      34   6 34   1   19   !
      35   6 35   1   19   !
      36   6 36   1   19   !
      37   6 37   1   19   !
      38   6 38   1   19   !
      39   6 39   1   19   !
      40   6 40   1   19   !
      41   6 41   1   19   !
      42   6 42   1   19   !
      43   6 43   1   19   !
      44   6 44   1   19   !
      45   6 45   1   19   !
      46   6 46   1   19   !
      47   6 47   1   19   !
      48   6 48   1   19   !
      49   6 49   1   19   !
      50   6 50   1   19   !
      51   6 51   1   19   !
      52   6 52   1   19   !
      53   6 53   1   19   !
      54   6 54   1   19   !
 7  '../../Polaris/bare/b1_1.8_00bp/b1_1.868_bp00_cr0_dc77_p0500_tf0800.t16' 54 1
       1   7 17   1   19   !
       2   7  1   1   19   !
       3   7  2   1   19   !
       4   7  3   1   19   !
       5   7  4   1   19   !
       6   7  5   1   19   !
       7   7  6   1   19   !
       8   7  7   1   19   !
       9   7  8   1   19   !
      10   7  9   1   19   !
      11   7 10   1   19   !
      12   7 11   1   19   !
      13   7 12   1   19   !
      14   7 13   1   19   !
      15   7 14   1   19   !
      16   7 15   1   19   !
      17   7 16   1   19   !
      18   7 18   1   19   !
      19   7 19   1   19   !
      20   7 20   1   19   !
      21   7 21   1   19   !
      22   7 22   1   19   !
      23   7 23   1   19   !
      24   7 24   1   19   !
      25   7 25   1   19   !
      26   7 26   1   19   !
      27   7 27   1   19   !
      28   7 28   1   19   !
      29   7 29   1   19   !
      30   7 30   1   19   !
      31   7 31   1   19   !
      32   7 32   1   19   !
      33   7 33   1   19   !
      34   7 34   1   19   !
      35   7 35   1   19   !
      36   7 36   1   19   !
      37   7 37   1   19   !
      38   7 38   1   19   !
      39   7 39   1   19   !
      40   7 40   1   19   !
      41   7 41   1   19   !
      42   7 42   1   19   !
      43   7 43   1   19   !
      44   7 44   1   19   !
      45   7 45   1   19   !
      46   7 46   1   19   !
      47   7 47   1   19   !
      48   7 48   1   19   !
      49   7 49   1   19   !
      50   7 50   1   19   !
      51   7 51   1   19   !
      52   7 52   1   19   !
      53   7 53   1   19   !
      54   7 54   1   19   !
```

```
  8  '../../Polaris/bare/b1_1.8_00bp/b1_1.868_bp00_cr1_dc70_p0500_tf0800.t16' 54 1
       1  8 32  1  19  !
       2  8  1  1  19  !
       3  8  2  1  19  !
       4  8  3  1  19  !
       5  8  4  1  19  !
       6  8  5  1  19  !
       7  8  6  1  19  !
       8  8  7  1  19  !
       9  8  8  1  19  !
      10  8  9  1  19  !
      11  8 10  1  19  !
      12  8 11  1  19  !
      13  8 12  1  19  !
      14  8 13  1  19  !
      15  8 14  1  19  !
      16  8 15  1  19  !
      17  8 16  1  19  !
      18  8 17  1  19  !
      19  8 18  1  19  !
      20  8 19  1  19  !
      21  8 20  1  19  !
      22  8 21  1  19  !
      23  8 22  1  19  !
      24  8 23  1  19  !
      25  8 24  1  19  !
      26  8 25  1  19  !
      27  8 26  1  19  !
      28  8 27  1  19  !
      29  8 28  1  19  !
      30  8 29  1  19  !
      31  8 30  1  19  !
      32  8 31  1  19  !
      33  8 33  1  19  !
      34  8 34  1  19  !
      35  8 35  1  19  !
      36  8 36  1  19  !
      37  8 37  1  19  !
      38  8 38  1  19  !
      39  8 39  1  19  !
      40  8 40  1  19  !
      41  8 41  1  19  !
      42  8 42  1  19  !
      43  8 43  1  19  !
      44  8 44  1  19  !
      45  8 45  1  19  !
      46  8 46  1  19  !
      47  8 47  1  19  !
      48  8 48  1  19  !
      49  8 49  1  19  !
      50  8 50  1  19  !
      51  8 51  1  19  !
      52  8 52  1  19  !
      53  8 53  1  19  !
      54  8 54  1  19  !
%JOB_END
```

B.2 GenPMAXS Input for Radial Edge Reflector

```
%JOB_TIT
 'refl_rad_edge.PMAX' T 3.0
%JOB_OPT
  F   F   F   F   F   F   F   F   F   F   F   F   F   F   F
 !adf,xes,ded,j1f,chi,chd,inv,det,yld,cdf,gff,bet,lam,dec,zdf
%DAT_SRC
  8  1  0
%STA_VAR
  3
  CR DC PC
%HISTORY
  1  1
  'CR0-HDC-MPC' 0 0.769987  500
%BRANCH
  4  1
  'CR0-HDC-MPC' 0 0.769987  500
  'CR0-HDC-LPC' 0 0.769987    0
  'CR0-HDC-HPC' 0 0.769987 1500
  'CR0-MDC-MPC' 0 0.700809  500
%BURNUP
  1
  'NOBP'  1
          0
  'CR0-MDC-MPC' 4*1
%FIL_CNT
  1 '../../Polaris/reflector/polaris_rad.t16'  4 0
   1  1  1  1  1
   2  1  2  1  1
   3  1  3  1  1
   4  1  4  1  1
%JOB_END
```

B.3 GenPMAXS Input for Axial Top Reflector

```
%JOB_TIT
 'refl_top.PMAX'  T  3.0
%JOB_OPT
  F   F   F   F   F   F   T   F   F   F   F   F   F   F   F
 !adf,xes,ded,j1f,chi,chd,inv,det,yld,cdf,gff,bet,lam,dec,zdf
%DAT_SRC
  8  1  0
%STA_VAR
  3
  CR DC PC
%HISTORY
  1   1
  'CR0-LDC-MPC' 0 0.608316  500
%BRANCH
  4  1
  'CR0-LDC-MPC' 0 0.608316  500
  'CR0-LDC-LPC' 0 0.608316    0
  'CR0-LDC-HPC' 0 0.608316 1500
  'CR0-MDC-MPC' 0 0.700809  500
%BURNUP
  1
  'NOBP'  1
          0
  'CR0-LDC-MPC' 4*1
%FIL_CNT
  1 '../../Polaris/reflector/polaris_top.t16'  4 0
   1  1  1  1  1
   2  1  2  1  1
   3  1  3  1  1
   4  1  4  1  1
%JOB_END
```

B.4 GenPMAXS Input for Axial Bottom Reflector

```
%JOB_TIT
 'refl_bot.PMAX'  T  3.0
%JOB_OPT
  F   F   F   F   F   F   T   F   F   F   F   F   F   F   F
 !adf,xes,ded,j1f,chi,chd,inv,det,yld,cdf,gff,bet,lam,dec,zdf
%DAT_SRC
  8  1  0
%STA_VAR
  3
  CR DC PC
%HISTORY
  1  1
  'CR0-HDC-MPC' 0 0.769987 500
%BRANCH
  4  1
  'CR0-HDC-MPC' 0 0.769987  500
  'CR0-HDC-LPC' 0 0.769987    0
  'CR0-HDC-HPC' 0 0.769987 1500
  'CR0-MDC-MPC' 0 0.700809  500
%BURNUP
  1
  'NOBP'  1
          0
  'CR0-MDC-MPC' 4*1
%FIL_CNT
  1 '../../Polaris/reflector/polaris_bot.t16'  4 0
   1  1  1  1  1
   2  1  2  1  1
   3  1  3  1  1
   4  1  4  1  1
%JOB_END
```

APPENDIX C. PARCS INPUT FILES

C.1 PARCS Input for the In–Core Detector Map "depl_detect_full.geom" File

```
DET_XY_LOC  157
                        0   0   0   0   0
                0   0   0   1   2   3   0   0   0
            0   0   4   5   6   7   8   9  10   0   0
        0   0  11  12  13  14  15  16  17  18  19   0   0
    0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
    0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
    0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
    0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
        0   0 139 140 141 142 143 144 145 146 147   0   0
            0   0 148 149 150 151 152 153 154   0   0
                0   0   0 155 156 157   0   0   0
                        0   0   0   0   0

DET_Z_LOC      39  1
                2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

DET_Z_WEI       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1

DET_NAME
1   D001
2   D002
3   D003
4   D004
5   D005
6   D006
7   D007
8   D008
9   D009
10  D010
11  D011
12  D012
13  D013
14  D014
15  D015
16  D016
17  D017
18  D018
19  D019
20  D020
21  D021
22  D022
23  D023
24  D024
25  D025
26  D026
27  D027
28  D028
29  D029
30  D030
31  D031
32  D032
33  D033
34  D034
35  D035
36  D036
37  D037
38  D038
39  D039
40  D040
41  D041
42  D042
43  D043
44  D044
45  D045
46  D046
47  D047
48  D048
49  D049
50  D050
51  D051
52  D052
53  D053
54  D054
55  D055
56  D056
```

57	D057
58	D058
59	D059
60	D060
61	D061
62	D062
63	D063
64	D064
65	D065
66	D066
67	D067
68	D068
69	D069
70	D070
71	D071
72	D072
73	D073
74	D074
75	D075
76	D076
77	D077
78	D078
79	D079
80	D080
81	D081
82	D082
83	D083
84	D084
85	D085
86	D086
87	D087
88	D088
89	D089
90	D090
91	D091
92	D092
93	D093
94	D094
95	D095
96	D096
97	D097
98	D098
99	D099
100	D100
101	D101
102	D102
103	D103
104	D104
105	D105
106	D106
107	D107
108	D108
109	D109
110	D110
111	D111
112	D112
113	D113
114	D114
115	D115
116	D116
117	D117
118	D118
119	D119
120	D120
121	D121
122	D122
123	D123
124	D124
125	D125
126	D126
127	D127
128	D128
129	D129
130	D130
131	D131
132	D132
133	D133
134	D134
135	D135
136	D136
137	D137
138	D138
139	D139
140	D140
141	D141
142	D142
143	D143
144	D144

```
145  D145
146  D146
147  D147
148  D148
149  D149
150  D150
151  D151
152  D152
153  D153
154  D154
155  D155
156  D156
157  D157
```

C.2 PARCS Input for the Cycle 1 Loading Pattern "su_c1_lay.mcyc" File

```
                                    0     0     0     0     0
                        0     0     0     C-30  C-27  C-16  0     0     0
                  0     0     C-31  C-28  C-51  A-35  C-2   C-3   C-20  0     0
            0     0     C-47  C-21  B-10  A-9   B-35  A-52  B-18  C-13  C-6   0     0
      0     0     C-43  A-18  B-28  A-22  B-19  A-8   B-25  A-21  B-31  A-2   C-32  0     0
      0     C-46  C-7   B-50  A-46  B-52  A-6   B-17  A-39  B-3   A-25  B-23  C-40  C-33  0
0     0     C-26  B-47  A-20  B-2   A-11  B-7   A-49  B-34  A-30  B-11  A-41  B-24  C-15  0     0
0     C-34  C-8   A-17  B-6   A-16  B-8   A-1   B-36  A-3   B-33  A-37  B-15  A-24  C-44  C-39  0
0     C-38  A-38  B-27  A-48  B-45  A-51  B-26  A-32  B-42  A-31  B-21  A-19  B-1   A-40  C-49  0
0     C-35  C-25  A-50  B-9   A-53  B-44  A-10  B-14  A-7   B-29  A-23  B-30  A-43  C-36  C-29  0
0     0     C-1   B-16  A-13  B-46  A-42  B-20  A-12  B-39  A-15  B-37  A-34  B-40  C-10  0     0
      0     C-45  C-18  B-4   A-14  B-13  A-44  B-49  A-47  B-5   A-33  B-43  C-19  C-23  0
      0     0     C-24  A-45  B-32  A-27  B-48  A-5   B-22  A-4   B-12  A-28  C-4   0     0
            0     0     C-12  C-11  B-51  A-26  B-41  A-36  B-38  C-17  C-9   0     0
                  0     0     C-22  C-14  C-50  A-29  C-52  C-48  C-37  0     0
                        0     0     0     C-41  C-42  C-5   0     0     0
                                    0     0     0     0     0
```

C.3 PARCS Input for the HFP Cycle 1 "c1_depl_s.inp" File

```
!*******************************************************************************
CASEID depl-cycl-s              Surry Unit 1 - Cycle 1
!*******************************************************************************
CNTL
      core_type        pwr
      core_power       4.96  ! 2441 MW
!
      search          ppm
!                        D   BP
      bank_pos         62.5  0.0
!
      depletion        T  1.0E-5 T
!                         NSET     LADF LXES LJ1F LDED LCHI LCHD LINV LDET LYLD LCDF LGFF LBET LAMB LDEC
      tree_xs          T     38      T    T    F    F    F    F    F    T    T    F    T    F    F    F
      int_th           T   -1
      xe_sm            1   1
      mult_cyc         T
      detector         T  1.0  1
      pin_power        T
!
!*******************************************************************************
!XSEC
!      group_spec     2  1
!*******************************************************************************
PARAM
      n_iters_ss     5  200
      nlupd_ss       3  3  1
      conv_ss        1.0e-6 1.0e-5 5.0e-5
      cnv_th_ss      0.001
!      wielandt       5.0  10.0  1.0
      cmfd           2
      decusp         2
!*******************************************************************************
GEOM
      geo_dim        17 17 41  1  1   !nasyx,nasyy,nz
      rad_conf
       0  0  0  0  0  0 90  4  4  4 90  0  0  0  0  0  0
       0  0  0  0 99  4  5 30 30 30  8  4 99  0  0  0  0
       0  0  0 99  5 30 30 32 10 32 30 30  8 99  0  0  0
       0  0 99  5 30 32 22 10 22 10 22 32 30  8 99  0  0
       0 99  5 30 10 22 10 22 10 22 10 22 10 30  8 99  0
       0  1 30 32 22 10 22 10 22 10 22 10 22 32 30  3  0
      90  5 30 22 10 22 10 22 10 22 10 22 10 22 30  8 90
       1 30 32 10 22 10 22 10 22 10 22 10 22 10 32 30  3
```

```
 1 30 10 22 10 22 10 22 10 22 10 22 10 22 10 30  3
 1 30 32 10 22 10 22 10 22 10 22 10 22 10 32 30  3
90  6 30 22 10 22 10 22 10 22 10 22 10 22 30  7 90
 0  1 30 32 22 10 22 10 22 10 22 10 22 32 30  3  0
 0 99  6 30 10 22 10 22 10 22 10 22 10 30  7 99  0
 0  0 99  6 30 32 22 10 22 10 22 32 30  7 99  0  0
 0  0  0 99  6 30 30 32 10 32 30 30  7 99  0  0  0
 0  0  0  0 99  2  6 30 30 30  7  2 99  0  0  0  0
 0  0  0  0  0  0 90  2  2  2 90  0  0  0  0  0  0

assy_type      1  1*1  39*3  1*2  REFL  ! W          39*3
assy_type      2  1*1  39*4  1*2  REFL  ! S          39*4
assy_type      3  1*1  39*5  1*2  REFL  ! E          39*5
assy_type      4  1*1  39*6  1*2  REFL  ! N          39*6
assy_type      5  1*1  39*7  1*2  REFL  ! NW         39*7
assy_type      6  1*1  39*8  1*2  REFL  ! SW         39*8
assy_type      7  1*1  39*9  1*2  REFL  ! SE         39*9
assy_type      8  1*1  39*10 1*2  REFL  ! NE         39*10
assy_type     90  1*1  39*11 1*2  REFL  ! no adf     39*11
assy_type     99  1*1  39*12 1*2  REFL  ! corner     39*12

assy_type     10  1*1  1*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 2*13 1*2  FUEL  ! 1.87   A, also Plug
assy_type     20  1*1  1*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 2*15 1*2  FUEL  ! 2.57   B, also Plug
assy_type     22  1*1  1*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 2*17 1*2  FUEL  ! 2.57   B, BP-12
assy_type     30  1*1  1*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 2*19 1*2  FUEL  ! 3.12   C, also Plug
assy_type     32  1*1  1*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 2*21 1*2  FUEL  ! 3.12   C, BP-12
assy_type     40  1*1  1*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 2*23 1*2  FUEL  ! 3.33  4A, also Plug
assy_type     42  1*1  1*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 2*25 1*2  FUEL  ! 3.33  4A, BP-12
assy_type     43  1*1  1*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 2*27 1*2  FUEL  ! 3.33  4A, BP-20
assy_type     51  1*1  1*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 2*29 1*2  FUEL  ! 2.61  4B, BP-08
assy_type     54  1*1  1*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 2*31 1*2  FUEL  ! 2.61  4B, BPR-12
assy_type     60  1*1  1*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 2*33 1*2  FUEL  ! 1.86  4C, also Plug
assy_type     70  1*1  1*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 2*35 1*2  FUEL  ! 1.86  4X, 17x17 Plug
assy_type     80  1*1  1*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 2*37 1*2  FUEL  ! 2.10   5, also Plug

grid_x         17*21.60912
neutmesh_x     17*1
grid_y         17*21.60912
neutmesh_y     17*1
grid_z         1*15.24 1*12.923 1*3.81 6*9.642 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 2*11.522 1*14.098

boun_cond      2 2 2 2 2 2       !ibcw,ibce,ibcn,ibcs,ibcb,ibct

PINCAL_LOC
                         0   0   0   0   0
                 0   0   0   1   2   3   0   0   0
             0   0   4   5   6   7   8   9  10   0   0
         0   0  11  12  13  14  15  16  17  18  19   0   0
     0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
     0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
 0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
 0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
 0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
 0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
 0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
     0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
     0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
         0   0 139 140 141 142 143 144 145 146 147   0   0
             0   0 148 149 150 151 152 153 154   0   0
                 0   0   0 155 156 157   0   0   0
                         0   0   0   0   0

cr_axinfo      15.24 2.561271
bank_conf
                 0  0  0  0  0
           0  0  0  0  0  0  0  0  0
        0  0  0  0  2  1  2  0  0  0  0
     0  0  0  2  2  0  2  0  2  2  0  0  0
  0  0  0  0  2  0  2  0  2  0  2  0  0  0  0
  0  0  2  2  0  2  0  2  0  2  0  2  2  0  0
0  0  0  2  0  2  1  2  0  2  1  2  0  2  0  0  0
0  0  2  0  2  0  2  0  2  0  2  0  2  0  2  0  0
0  0  1  2  0  2  0  2  0  2  0  2  0  2  1  0  0
0  0  2  0  2  0  2  0  2  0  2  0  2  0  2  0  0
0  0  0  2  0  2  1  2  0  2  1  2  0  2  0  0  0
  0  0  2  2  0  2  0  2  0  2  0  2  2  0  0
  0  0  0  0  2  0  2  0  2  0  2  0  0  0  0
     0  0  0  2  2  0  2  0  2  2  0  0  0
        0  0  0  0  2  1  2  0  0  0  0
           0  0  0  0  0  0  0  0  0
                 0  0  0  0  0
```

```
     crb_def       2
                   1 0   1 0 1.27     361.95   500.0  ! Cd/In/Ag Abso
                   2 0   1 0 1.27     362.41   500.0  ! Burnable Poison as CR

     crb_type      1  2
!                  D  BP

     file  './depl_detect_full.geom'

!******************************************************************************
FDBK
     fa_powpit     15.548   21.60912         !assembly power(Mw) and pitch(cm)
     gamma_frac    0.019                     !direc heating fraction
!******************************************************************************
TH
     unif_th       0.74300 600.0 293.33      ! cool den, ftemp(C), ctemp(C)
     n_pingt       204 21                    !nfuelpin,ngt
     pin_dim       4.677 5.368 0.618 6.945   !pin radii, rs,rw,tw, and rgt in mm
     flow_cond     289.74 80.976             !tin,cmfrfa(Kg/sec)
     hgap          15000.0                   !hgap(w/M^2-C)                   Need estimate!!
     n_ring        10                        !number of meshes in pellet
!******************************************************************************
DEPL
     hst_opt       T T F F F
     out_opt       T T F F F
!*********************************************************************
    PMAXS_F  1   '../GenPMAXS/reflector/refl_bot.PMAX'           1  ! Bottom
    PMAXS_F  2   '../GenPMAXS/reflector/refl_top.PMAX'           2  ! Top
    PMAXS_F  3   '../GenPMAXS/reflector/refl_rad_W.PMAX'         3  ! W
    PMAXS_F  4   '../GenPMAXS/reflector/refl_rad_S.PMAX'         4  ! S
    PMAXS_F  5   '../GenPMAXS/reflector/refl_rad_E.PMAX'         5  ! E
    PMAXS_F  6   '../GenPMAXS/reflector/refl_rad_N.PMAX'         6  ! N
    PMAXS_F  7   '../GenPMAXS/reflector/refl_rad_NW.PMAX'        7  ! NW
    PMAXS_F  8   '../GenPMAXS/reflector/refl_rad_SW.PMAX'        8  ! SW
    PMAXS_F  9   '../GenPMAXS/reflector/refl_rad_SE.PMAX'        9  ! SE
    PMAXS_F  10  '../GenPMAXS/reflector/refl_rad_NE.PMAX'        10 ! NE
    PMAXS_F  11  '../GenPMAXS/reflector/refl_rad.PMAX'           11 ! no adf
    PMAXS_F  12  '../GenPMAXS/reflector/refl_rad_diag.PMAX'      12 ! corner
!*********************************************************************
    PMAXS_F  13  '../GenPMAXS/fuel/b1_1.878_bp00.PMAX'           13
    PMAXS_F  14  '../GenPMAXS/fuel_spacer/b1_1.878_bp00.PMAX'    14
    PMAXS_F  15  '../GenPMAXS/fuel/b2_2.573_bp00.PMAX'           15
    PMAXS_F  16  '../GenPMAXS/fuel_spacer/b2_2.573_bp00.PMAX'    16
    PMAXS_F  17  '../GenPMAXS/fuel/b2_2.573_bp12.PMAX'           17
    PMAXS_F  18  '../GenPMAXS/fuel_spacer/b2_2.573_bp12.PMAX'    18
    PMAXS_F  19  '../GenPMAXS/fuel/b3_3.117_bp00.PMAX'           19
    PMAXS_F  20  '../GenPMAXS/fuel_spacer/b3_3.117_bp00.PMAX'    20
    PMAXS_F  21  '../GenPMAXS/fuel/b3_3.117_bp12.PMAX'           21
    PMAXS_F  22  '../GenPMAXS/fuel_spacer/b3_3.117_bp12.PMAX'    22
    PMAXS_F  23  '../GenPMAXS/fuel/b4a_3.330_bp00.PMAX'          23
    PMAXS_F  24  '../GenPMAXS/fuel_spacer/b4a_3.330_bp00.PMAX'   24
    PMAXS_F  25  '../GenPMAXS/fuel/b4a_3.330_bp12.PMAX'          25
    PMAXS_F  26  '../GenPMAXS/fuel_spacer/b4a_3.330_bp12.PMAX'   26
    PMAXS_F  27  '../GenPMAXS/fuel/b4a_3.330_bp20.PMAX'          27
    PMAXS_F  28  '../GenPMAXS/fuel_spacer/b4a_3.330_bp20.PMAX'   28
    PMAXS_F  29  '../GenPMAXS/fuel/b4b_2.610_bp08.PMAX'          29
    PMAXS_F  30  '../GenPMAXS/fuel_spacer/b4b_2.610_bp08.PMAX'   30
    PMAXS_F  31  '../GenPMAXS/fuel/b4b_2.610_bp12.PMAX'          31
    PMAXS_F  32  '../GenPMAXS/fuel_spacer/b4b_2.610_bp12.PMAX'   32
    PMAXS_F  33  '../GenPMAXS/fuel/b4c_1.860_bp00.PMAX'          33
    PMAXS_F  34  '../GenPMAXS/fuel_spacer/b4c_1.860_bp00.PMAX'   34
    PMAXS_F  35  '../GenPMAXS/fuel/b4x_1.860_bp00.PMAX'          35
    PMAXS_F  36  '../GenPMAXS/fuel_spacer/b4x_1.860_bp00.PMAX'   36
    PMAXS_F  37  '../GenPMAXS/fuel/b5_2.100_bp00.PMAX'           37
    PMAXS_F  38  '../GenPMAXS/fuel_spacer/b5_2.100_bp00.PMAX'    38
!******************************************************************************
MCYCLE
     bank_def    1   62.5     0.0
     bank_def    2   37.3     0.0
     bank_def    3   99.0     0.0
     bank_def    4   77.7     0.0
     bank_def    5   89.7     0.0
     bank_def    6   97.9     0.0
     bank_def    7  122.5     0.0
     bank_def    8  101.1     0.0
     bank_def    9  114.9     0.0
     bank_def   10  117.5     0.0
     bank_def   11  114.9     0.0
     bank_def   12  115.6     0.0
     bank_def   13  118.1     0.0
```

bank_def	14	116.6	0.0
bank_def	15	117.5	0.0
bank_def	16	114.9	0.0
bank_def	17	123.8	0.0
bank_def	18	125.1	0.0
bank_def	19	122.5	0.0
bank_def	20	120.6	0.0
bank_def	21	125.1	0.0
bank_def	22	125.1	0.0
bank_def	23	123.2	0.0
bank_def	24	142.1	0.0
bank_def	25	125.1	0.0
bank_def	26	126.3	0.0
bank_def	27	125.1	0.0
bank_def	28	128.2	0.0
bank_def	29	118.1	0.0
bank_def	30	123.2	0.0
bank_def	31	126.3	0.0
bank_def	32	128.8	0.0
bank_def	33	129.5	0.0
bank_def	34	125.7	0.0
bank_def	35	126.9	0.0
bank_def	36	126.9	0.0
bank_def	37	126.9	0.0
bank_def	38	123.2	0.0
bank_def	39	127.6	0.0
bank_def	40	126.3	0.0
bank_def	41	126.3	0.0
bank_def	42	123.8	0.0
bank_def	43	127.6	0.0
bank_def	44	135.8	0.0
bank_def	45	135.8	0.0
bank_def	46	129.5	0.0
bank_def	47	133.9	0.0
bank_def	48	133.9	0.0
bank_def	49	136.4	0.0
bank_def	50	133.9	0.0
bank_def	51	135.2	0.0
bank_def	52	132.6	0.0
bank_def	53	133.9	0.0
bank_def	54	134.5	0.0
bank_def	55	135.2	0.0
bank_def	56	134.5	0.0
bank_def	57	133.3	0.0
bank_def	58	132.0	0.0
bank_def	59	139.6	0.0
bank_def	60	144.0	0.0
bank_def	61	139.6	0.0
bank_def	62	135.8	0.0
bank_def	63	136.4	0.0
bank_def	64	135.2	0.0
bank_def	65	137.1	0.0
bank_def	66	137.7	0.0
bank_def	67	134.5	0.0
bank_def	68	135.2	0.0
bank_def	69	137.1	0.0
bank_def	70	136.4	0.0
bank_def	71	136.4	0.0
bank_def	72	136.4	0.0
bank_def	73	137.1	0.0
bank_def	74	138.3	0.0
bank_def	75	137.7	0.0
bank_def	76	130.7	0.0
bank_def	77	133.3	0.0
bank_def	78	136.4	0.0
bank_def	79	135.8	0.0
bank_def	80	138.3	0.0
bank_def	81	133.3	0.0
bank_def	82	135.8	0.0
bank_def	83	137.1	0.0
bank_def	84	125.1	0.0
bank_def	85	136.4	0.0
bank_def	86	135.2	0.0
bank_def	87	134.5	0.0
bank_def	88	136.4	0.0
bank_def	89	137.7	0.0
bank_def	90	137.1	0.0
bank_def	91	130.3	0.0
bank_def	92	137.7	0.0
bank_def	93	136.4	0.0
bank_def	94	138.3	0.0

```
      bank_def   95  137.7     0.0
      bank_def   96  142.1     0.0
      bank_def   97  142.7     0.0
      bank_def   98  136.4     0.0
      bank_def   99  136.4     0.0
      bank_def  100  132.6     0.0
      bank_def  101  140.8     0.0
      bank_def  102  140.2     0.0
      bank_def  103  143.4     0.0
      bank_def  104  138.3     0.0
      bank_def  105  141.5     0.0
      bank_def  106  143.4     0.0
      bank_def  107  141.5     0.0
      bank_def  108  142.1     0.0
      bank_def  109  129.5     0.0
      bank_def  110  143.4     0.0
      bank_def  111  128.2     0.0
      bank_def  112  128.8     0.0
      bank_def  113  133.9     0.0
      bank_def  114  135.2     0.0
      bank_def  115  137.1     0.0
      bank_def  116  132.0     0.0
      bank_def  117  132.6     0.0


      cycle_def     1
      depl_step   -0.274 -0.00001 -0.009 -0.001 -0.004 -0.025 -0.051 -0.001 -0.399 -0.026 -0.025 -0.011 -0.137 -0.046 -0.068 -0.13 -0.025 -0.02 -
0.101 -0.026 -0.026 -0.026 -0.025 -0.029 -0.186 -0.022 -0.062 -0.125 -0.195 -0.115 -0.259 -0.271 -0.27 -0.214 -0.442 -0.184 -0.213 -0.214 -0.219 -
0.256 -0.021 -0.237 -0.186 -0.152 -0.122 -0.158 -0.282 -0.025 -0.381 -0.16 -0.294 -0.218 -0.259 -0.143 -0.306 -0.024 -0.345 -0.325 -0.405 -0.035 -
0.035 -0.285 -0.035 -0.035 -0.035 -0.035 -0.035 -0.028 -0.072 -0.033 -0.032 -0.245 -0.095 -0.125 -0.03 -0.03 -0.135 -0.205 -0.03 -0.04 -0.04 -
0.095 -0.03 -0.162 -0.033 -0.031 -0.063 -0.032 -0.099 -0.06 -0.14 -0.035 -0.405 -0.235 -0.03 -0.105 -0.035 -0.065 -0.035 -0.065 -0.03 -0.03 -0.27
-0.03 -0.035 -0.07 -0.035 -0.03 -0.135 -0.095 -0.16 -0.13 -0.06 -0.02 -0.09 -0.14
      bank_seq    1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34
35  36  37  38  39  40  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71
72  73  74  75  76  77  78  79  80  81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99  100  101  102  103  104  105  106
107  108  109  110  111  112  113  114  115  116  117
      power_lev   4.96  29.29  31.42  50.00  44.08  61.49  72.72  75.26  75.42  74.19  74.52  74.52  71.36  74.56  74.56  73.86  74.03  74.19
75.01  74.23  75.34  76.16  74.85  74.89  75.71  73.90  74.85  91.97  78.98  90.82  87.55  87.96  88.41  89.02  89.51  86.11  89.14  88.82  91.11
81.85  90.95  90.91  93.81  95.66  89.55  94.72  86.77  88.28  94.59  94.22  94.39  94.02  94.02  96.35  96.11  96.76  95.94  95.86  98.69  97.46
98.93  97.79  98.57  99.34  99.14  98.85  99.39  98.81  98.57  98.85  98.57  99.30  99.67  99.51  99.84  98.65  98.73  98.07  98.44  99.43  99.10
99.75  99.75  67.92  93.53  93.16  93.36  95.00  95.90  96.27  96.97  98.07  98.61  99.67  99.26  99.47  99.34  98.57  99.06  98.07  99.92  98.65
99.80  98.53  98.81  99.22  97.71  98.77  92.34  98.61  60.63  58.99  59.40  59.81  61.45  60.18  59.40
      inlet_ent   -561.71        -564.15    -564.26    -564.26    -565.15    -568.54    -569.98    -569.26    -569.71    -568.93    -569.54
           -570.59    -569.93    -564.26    -570.21    -569.82    -570.32    -570.21    -568.87    -566.93    -569.82    -570.15    -567.54
           -567.87    -567.54    -568.15    -566.76    -566.76    -568.15    -570.04    -568.48    -569.04    -569.32    -569.43    -564.87
           -569.09    -569.48    -569.04    -568.54    -567.98    -568.76    -567.59    -567.59    -567.82    -566.93    -570.87    -567.26
           -568.32    -568.26    -567.87    -567.71    -568.43    -568.59    -567.59    -568.15    -568.15    -568.71    -567.59    -568.71
           -568.15    -568.71    -568.15    -568.15    -568.15    -570.93    -568.15    -568.71    -568.15    -568.15    -568.15    -568.15
           -568.15    -568.15    -567.59    -568.15    -567.59    -567.59    -568.15    -568.15    -568.15    -567.59    -568.37    -567.87
           -565.43    -567.04    -567.04    -567.32    -567.48    -567.82    -567.98    -568.15    -567.59    -567.59    -567.59    -568.15
           -568.15    -568.15    -567.59    -567.59    -568.15    -568.15    -568.15    -568.71    -568.15    -568.15    -568.71    -568.71
           -568.15    -568.15    -568.15    -567.59    -566.48    -567.04    -566.48    -568.15    -567.04    -567.04
      flow_rate   117*80.9758

      LOCATION
                          0   0   0   0   0
                  0   0   0   1   2   3   0   0   0
              0   0   4   5   6   7   8   9  10   0   0
          0   0  11  12  13  14  15  16  17  18  19   0   0
      0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
      0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
  0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
  0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
  0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
  0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
  0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
      0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
      0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
          0   0 139 140 141 142 143 144 145 146 147   0   0
              0   0 148 149 150 151 152 153 154   0   0
                  0   0   0 155 156 157   0   0   0
                          0   0   0   0   0

      SHUF_MAP   1   1
                          0   0   0   0   0
                  0   0   0   1   2   3   0   0   0
              0   0   4   5   6   7   8   9  10   0   0
          0   0  11  12  13  14  15  16  17  18  19   0   0
      0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
      0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
  0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
```

```
     0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
     0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
     0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
     0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
         0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
         0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
             0   0 139 140 141 142 143 144 145 146 147   0   0
                 0   0 148 149 150 151 152 153 154   0   0
                         0   0   0 155 156 157   0   0   0
                             0   0   0   0   0

     CYCLE_IND    1   0   1
!
     CONV_EC    0.1   1      ! convergence criterion (GWD/T), max number of iteration
!****************************************************************************************
.
```

C.4 PARCS Input for the HZP Cycle 2 Fuel Shuffling "c1_c2_shuf_s.inp" File

```
!********************************************************************************
CASEID cyc2_BOC-s                Surry Unit 1 - Cycle 1-2 Shuffle
!********************************************************************************
CNTL
     core_type       pwr
     core_power      0.0001  ! 2441 MW zero power during shuffling
!                    D      BP1    BP2
     bank_pos        144.0  144.0  0.0
!
     depletion       T  1.0E-5 F
!                         NSET    IADF IXES LJ1F LDED LCHI LCHD LINV LDET LYLD LCDF LGFF LBET LAMB LDEC
     tree_xs         T     38      T    T    F    F    F    F    F    T    T    F    T    F    F    F
     int_th          F   -1
     xe_sm           0   0
     mult_cyc        T
!
!********************************************************************************
!XSEC
!     group_spec     2  1
!********************************************************************************
PARAM
     n_iters_ss     5  200
     nlupd_ss       3  3  1
     conv_ss        1.0e-6 1.0e-5 5.0e-5
     cnv_th_ss      0.001
     cmfd           2
     decusp         2
!********************************************************************************
GEOM
     geo_dim        17 17 41  1  1   !nasyx,nasyy,nz
     rad_conf
      0  0  0  0  0  0 90  4  4  4 90  0  0  0  0  0  0
      0  0  0  0 99  4  5 40 40 40  8  4 99  0  0  0  0
      0  0  0 99  5 40 40 43 10 43 40 40  8 99  0  0  0
      0  0 99  5 40 42 10 22 54 22 10 42 40  8 99  0  0
      0 99  5 40 60 22 22 22 20 22 22 22 60 40  8 99  0
      0  1 40 42 22 22 70 22 51 22 60 22 22 42 40  3  0
     90  5 40 10 22 60 10 60 10 60 10 60 22 10 40  8 90
      1 40 43 22 22 22 60 22 51 22 60 22 22 22 43 40  3
      1 40 10 54 22 51 10 51 10 51 10 51 22 54 10 40  3
      1 40 43 22 22 22 60 22 51 22 60 22 22 22 43 40  3
     90  6 40 10 22 60 10 60 10 60 10 60 22 10 40  7 90
      0  1 40 42 22 22 60 22 51 22 70 22 22 42 40  3  0
      0 99  6 40 60 22 22 22 20 22 22 22 60 40  7 99  0
      0  0 99  6 40 42 10 22 54 22 10 42 40  7 99  0  0
      0  0  0 99  6 40 40 43 10 43 40 40  7 99  0  0  0
      0  0  0  0 99  2  6 40 40 40  7  2 99  0  0  0  0
      0  0  0  0  0  0 90  2  2  2 90  0  0  0  0  0  0

!       0  0  0  0  0  0 90  4  4  4 90  0  0  0  0  0  0
!       0  0  0  0 99  4  5 30 30 30  8  4 99  0  0  0  0
!       0  0  0 99  5 30 30 32 10 32 30 30  8 99  0  0  0
!       0  0 99  5 30 32 22 10 22 10 22 32 30  8 99  0  0
!       0 99  5 30 10 22 10 22 10 22 10 22 10 30  8 99  0
!       0  1 30 32 22 10 22 10 22 10 22 10 22 32 30  3  0
!      90  5 30 22 10 22 10 22 10 22 10 22 10 22 30  8 90
!       1 30 32 10 22 10 22 10 22 10 22 10 22 10 32 30  3
!       1 30 10 22 10 22 10 22 10 22 10 22 10 22 10 30  3
!       1 30 32 10 22 10 22 10 22 10 22 10 22 10 32 30  3
!      90  6 30 22 10 22 10 22 10 22 10 22 10 22 30  7 90
```

```
!       0  1 30 32 22 10 22 10 22 10 22 10 22 32 30  3  0
!       0 99  6 30 10 22 10 22 10 22 10 22 10 30  7 99  0
!       0  0 99  6 30 32 22 10 22 10 22 32 30  7 99  0  0
!       0  0  0 99  6 30 30 32 10 32 30 30  7 99  0  0  0
!       0  0  0  0 99  2  6 30 30 30  7  2 99  0  0  0  0
!       0  0  0  0  0  0 90  2  2  2 90  0  0  0  0  0  0

     assy_type      1  1*1  39*3  1*2  REFL  ! W          36*3
     assy_type      2  1*1  39*4  1*2  REFL  ! S          36*4
     assy_type      3  1*1  39*5  1*2  REFL  ! E          36*5
     assy_type      4  1*1  39*6  1*2  REFL  ! N          36*6
     assy_type      5  1*1  39*7  1*2  REFL  ! NW         36*7
     assy_type      6  1*1  39*8  1*2  REFL  ! SW         36*8
     assy_type      7  1*1  39*9  1*2  REFL  ! SE         36*9
     assy_type      8  1*1  39*10 1*2  REFL  ! NE         36*10
     assy_type     90  1*1  39*11 1*2  REFL  ! no adf     36*11
     assy_type     99  1*1  39*12 1*2  REFL  ! corner     36*12

     assy_type     10  1*1  1*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 2*13 1*2  FUEL  ! 1.87   A, also Plug
     assy_type     20  1*1  1*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 2*15 1*2  FUEL  ! 2.57   B, also Plug
     assy_type     22  1*1  1*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 2*17 1*2  FUEL  ! 2.57   B, BP-12
     assy_type     30  1*1  1*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 2*19 1*2  FUEL  ! 3.12   C, also Plug
     assy_type     32  1*1  1*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 2*21 1*2  FUEL  ! 3.12   C, BP-12
     assy_type     40  1*1  1*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 2*23 1*2  FUEL  ! 3.33  4A, also Plug
     assy_type     42  1*1  1*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 2*25 1*2  FUEL  ! 3.33  4A, BP-12
     assy_type     43  1*1  1*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 2*27 1*2  FUEL  ! 3.33  4A, BP-20
     assy_type     51  1*1  1*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 2*29 1*2  FUEL  ! 2.61  4B, BP-08
     assy_type     54  1*1  1*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 2*31 1*2  FUEL  ! 2.61  4B, BPR-12
     assy_type     60  1*1  1*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 2*33 1*2  FUEL  ! 1.86  4C, also Plug
     assy_type     70  1*1  1*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 2*35 1*2  FUEL  ! 1.86  4X, 17x17 Plug
     assy_type     80  1*1  1*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 2*37 1*2  FUEL  ! 2.10   5, also Plug

     grid_x        17*21.60912
     neutmesh_x    17*1
     grid_y        17*21.60912
     neutmesh_y    17*1
     grid_z        1*15.24 1*12.923 1*3.81 6*9.642 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 2*11.522 1*14.098

     boun_cond      2 2 2 2 2 2       !ibcw,ibce,ibcn,ibcs,ibcb,ibct

     cr_axinfo      15.24 2.561271
     bank_conf
! cycle 2  (Bank D + Cycle-1 BP + Cycle-2 BP)
                          0  0  0  0  0
                    0  0  0  0  0  0  0  0  0
                 0  0  0  0  3  1  3  0  0  0  0
              0  0  0  3  0  2  3  2  0  3  0  0  0
           0  0  0  0  2  2  2  0  2  2  2  2  0  0  0
           0  0  3  2  2  0  2  3  2  0  2  2  3  0  0
        0  0  0  0  2  0  1  0  0  0  1  0  2  0  0  0  0
        0  0  3  2  2  2  0  2  3  2  0  2  2  2  3  0  0
        0  0  1  3  2  3  0  3  0  3  0  3  2  3  1  0  0
        0  0  3  2  2  2  0  2  3  2  0  2  2  2  3  0  0
        0  0  0  0  2  0  1  0  0  0  1  0  2  0  0  0  0
           0  0  3  2  2  0  2  3  2  0  2  2  3  0  0
           0  0  0  0  2  2  2  0  2  2  2  2  0  0  0
              0  0  0  3  0  2  3  2  0  3  0  0  0
                 0  0  0  0  3  1  3  0  0  0  0
                    0  0  0  0  0  0  0  0  0
                          0  0  0  0  0

     crb_def        3
                    1 0   1 0 1.27      361.95   2.54  ! Cd/In/Ag Abso
                    2 0   1 0 1.27      362.41   2.08  ! Burnable Poison as CR
                    3 0   1 0 1.27      362.41   2.08  ! Burnable Poison as CR

     crb_type      1    2    3
!                  D  BP1  BP2
!     crb_type      1 1 1 1 2 1  3
!                   A B C D R S BP
!    crb_def is used to specify type of crb for each bank
!*****************************************************************************
FDBK
     fa_powpit      15.548   21.60912          !assembly power(Mw) and pitch(cm)
     gamma_frac     0.019                      !direc heating fraction
!*****************************************************************************
TH
     unif_th        0.74300 600.0 293.33       ! cool den, ftemp(C), ctemp(C)
     n_pingt        225 21                     !npin,ngt
     pin_dim        4.647 5.359 0.617 6.901    !pin radii, rs,rw,tw, and rgt in mm
     flow_cond      289.74 80.976              !tin,cmfrfa(Kg/sec)
```

```
     hgap           15000.0                    !hgap(w/M^2-C)                        Need estimate!!
     n_ring         10                         !number of meshes in pellet
!******************************************************************************
DEPL
     inp_hst        'depl-cyc1-s.parcs_cyc-01' 1 117
     inp_opt        F F F F
     hst_opt        T T F F F
     out_opt        T T F F F
!*****************************************************************
    PMAXS_F  1    '../GenPMAXS/reflector/refl_bot.PMAX'            1  ! Bottom
    PMAXS_F  2    '../GenPMAXS/reflector/refl_top.PMAX'            2  ! Top
    PMAXS_F  3    '../GenPMAXS/reflector/refl_rad_W.PMAX'          3  ! W
    PMAXS_F  4    '../GenPMAXS/reflector/refl_rad_S.PMAX'          4  ! S
    PMAXS_F  5    '../GenPMAXS/reflector/refl_rad_E.PMAX'          5  ! E
    PMAXS_F  6    '../GenPMAXS/reflector/refl_rad_N.PMAX'          6  ! N
    PMAXS_F  7    '../GenPMAXS/reflector/refl_rad_NW.PMAX'         7  ! NW
    PMAXS_F  8    '../GenPMAXS/reflector/refl_rad_SW.PMAX'         8  ! SW
    PMAXS_F  9    '../GenPMAXS/reflector/refl_rad_SE.PMAX'         9  ! SE
    PMAXS_F  10   '../GenPMAXS/reflector/refl_rad_NE.PMAX'         10 ! NE
    PMAXS_F  11   '../GenPMAXS/reflector/refl_rad.PMAX'            11 ! no adf
    PMAXS_F  12   '../GenPMAXS/reflector/refl_rad_diag.PMAX'       12 ! corner
!*****************************************************************
    PMAXS_F  13   '../GenPMAXS/fuel/b1_1.878_bp00.PMAX'            13
    PMAXS_F  14   '../GenPMAXS/fuel_spacer/b1_1.878_bp00.PMAX'     14
    PMAXS_F  15   '../GenPMAXS/fuel/b2_2.573_bp00.PMAX'            15
    PMAXS_F  16   '../GenPMAXS/fuel_spacer/b2_2.573_bp00.PMAX'     16
    PMAXS_F  17   '../GenPMAXS/fuel/b2_2.573_bp12.PMAX'            17
    PMAXS_F  18   '../GenPMAXS/fuel_spacer/b2_2.573_bp12.PMAX'     18
    PMAXS_F  19   '../GenPMAXS/fuel/b3_3.117_bp00.PMAX'            19
    PMAXS_F  20   '../GenPMAXS/fuel_spacer/b3_3.117_bp00.PMAX'     20
    PMAXS_F  21   '../GenPMAXS/fuel/b3_3.117_bp12.PMAX'            21
    PMAXS_F  22   '../GenPMAXS/fuel_spacer/b3_3.117_bp12.PMAX'     22
    PMAXS_F  23   '../GenPMAXS/fuel/b4a_3.330_bp00.PMAX'           23
    PMAXS_F  24   '../GenPMAXS/fuel_spacer/b4a_3.330_bp00.PMAX'    24
    PMAXS_F  25   '../GenPMAXS/fuel/b4a_3.330_bp12.PMAX'           25
    PMAXS_F  26   '../GenPMAXS/fuel_spacer/b4a_3.330_bp12.PMAX'    26
    PMAXS_F  27   '../GenPMAXS/fuel/b4a_3.330_bp20.PMAX'           27
    PMAXS_F  28   '../GenPMAXS/fuel_spacer/b4a_3.330_bp20.PMAX'    28
    PMAXS_F  29   '../GenPMAXS/fuel/b4b_2.610_bp08.PMAX'           29
    PMAXS_F  30   '../GenPMAXS/fuel_spacer/b4b_2.610_bp08.PMAX'    30
    PMAXS_F  31   '../GenPMAXS/fuel/b4b_2.610_bp12.PMAX'           31
    PMAXS_F  32   '../GenPMAXS/fuel_spacer/b4b_2.610_bp12.PMAX'    32
    PMAXS_F  33   '../GenPMAXS/fuel/b4c_1.860_bp00.PMAX'           33
    PMAXS_F  34   '../GenPMAXS/fuel_spacer/b4c_1.860_bp00.PMAX'    34
    PMAXS_F  35   '../GenPMAXS/fuel/b4x_1.860_bp00.PMAX'           35
    PMAXS_F  36   '../GenPMAXS/fuel_spacer/b4x_1.860_bp00.PMAX'    36
    PMAXS_F  37   '../GenPMAXS/fuel/b5_2.100_bp00.PMAX'            37
    PMAXS_F  38   '../GenPMAXS/fuel_spacer/b5_2.100_bp00.PMAX'     38
!******************************************************************************
MCYCLE
     bank_def    1  144.0  144.0  0.0

     cycle_def   1
     depl_step   0.0001
     bank_seq    2*1
     power_lev   2*0.001

     cycle_def   2
     depl_step   0.0001
     bank_seq    2*1
     power_lev   2*0.001

     LOCATION 0
                                    0     0     0     0     0
                        0     0     0     C-30  C-27  C-16  0     0     0
                  0     0     C-31  C-28  C-51  A-35  C-2   C-3   C-20  0     0
            0     0     C-47  C-21  B-10  A-9   B-35  A-52  B-18  C-13  C-6   0     0
      0     0     C-43  A-18  B-28  A-22  B-19  A-8   B-25  A-21  B-31  A-2   C-32  0     0
      0     C-46  C-7   B-50  A-46  B-52  A-6   B-17  A-39  B-3   A-25  B-23  C-40  C-33  0
0     0     C-26  B-47  A-20  B-2   A-11  B-7   A-49  B-34  A-30  B-11  A-41  B-24  C-15  0     0
0     C-34  C-8   A-17  B-6   A-16  B-8   A-1   B-36  A-3   B-33  A-37  B-15  A-24  C-44  C-39  0
0     C-38  A-38  B-27  A-48  B-45  A-51  B-26  A-32  B-42  A-31  B-21  A-19  B-1   A-40  C-49  0
0     C-35  C-25  A-50  B-9   A-53  B-44  A-10  B-14  A-7   B-29  A-23  B-30  A-43  C-36  C-29  0
0     0     C-1   B-16  A-13  B-46  A-42  B-20  A-12  B-39  A-15  B-37  A-34  B-40  C-10  0     0
      0     C-45  C-18  B-4   A-14  B-13  A-44  B-49  A-47  B-5   A-33  B-43  C-19  C-23  0
      0     0     C-24  A-45  B-32  A-27  B-48  A-5   B-22  A-4   B-12  A-28  C-4   0     0
            0     0     C-12  C-11  B-51  A-26  B-41  A-36  B-38  C-17  C-9   0     0
                  0     0     C-22  C-14  C-50  A-29  C-52  C-48  C-37  0     0
                        0     0     0     C-41  C-42  C-5   0     0     0
                                    0     0     0     0     0
```

```
     SHUF_MAP   1   1
! no BP re-insertion
                                    0     0     0     0     0
                        0     0     0     -40   -40   -40   0     0     0
                  0     0     -40   -40   -43   A-8   -43   -40   -40   0     0
            0     0     -40   -42   A-22  B-28  -54   B-31  A-21  -42   -40   0     0
      0     0     -40   -60   B-7   B-19  B-52  B-35  B-3   B-25  B-34  -60   -40   0     0
      0     -40   -42   B-8   B-36  -70   B-10  -51   B-18  -60   B-42  B-33  -42   -40   0
0     0     -40   A-20  B-6   -60   A-18  -60   A-35  -60   A-2   -60   B-15  A-41  -40   0     0
0     -40   -43   B-50  B-2   B-47  -60   B-17  -51   B-21  -60   B-24  B-11  B-23  -43   -40   0
0     -40   A-48  -54   B-27  -51   A-38  -51   A-32  -51   A-40  -51   B-1   -54   A-19  -40   0
0     -40   -43   B-4   B-46  B-16  -60   B-45  -51   B-49  -60   B-40  B-37  B-43  -43   -40   0
0     0     -40   A-13  B-9   -60   A-45  -60   A-29  -60   A-28  -60   B-30  A-34  -40   0     0
      0     -40   -42   B-44  B-26  -60   B-51  -51   B-38  -70   B-14  B-29  -42   -40   0
      0     0     -40   -60   B-20  B-48  B-13  B-41  B-5   B-22  B-39  -60   -40   0     0
            0     0     -40   -42   A-27  B-32  -54   B-12  A-4   -42   -40   0     0
                  0     0     -40   -40   -43   A-5   -43   -40   -40   0     0
                        0     0     0     -40   -40   -40   0     0     0
                                    0     0     0     0     0
!
     CYCLE_IND    1   0   1
     CYCLE_IND    2   1   2
!
     CONV_EC    0.1   2      ! convergence criterion (GWD/T), max number of iteration
!*****************************************************************************************
.
```

C.5 PARCS Input for the Cycle 2 Loading Pattern "su_c2_lay.mcyc" File

```
                                    0     0     0     0     0
                        0     0     0     4A-32 4A-22 4A-5  0     0     0
                  0     0     4A-13 4A-36 4A-40 A-8   4A-52 4A-7  4A-48 0     0
            0     0     4A-30 4A-15 A-22  B-28  4B-3  B-31  A-21  4A-47 4A-23 0     0
      0     0     4A-20 4C-4  B-7   B-19  B-52  B-35  B-3   B-25  B-34  4C-5  4A-38 0     0
      0     4A-27 4A-9  B-8   B-36  4X-1  B-10  4B-10 B-18  4C-8  B-42  B-33  4A-18 4A-51 0
0     0     4A-45 A-20  B-6   4C-17 A-18  4C-1  A-35  4C-18 A-2   4C-10 B-15  A-41  4A-17 0     0
0     4A-43 4A-4  B-50  B-2   B-47  4C-6  B-17  4B-4  B-21  4C-14 B-24  B-11  B-23  4A-6  4A-28 0
0     4A-39 A-48  4B-5  B-27  4B-9  A-38  4B-7  A-32  4B-12 A-40  4B-8  B-1   4B-11 A-19  4A-41 0
0     4A-14 4A-26 B-4   B-46  B-16  4C-9  B-45  4B-6  B-49  4C-7  B-40  B-37  B-43  4A-50 4A-49 0
0     0     4A-21 A-13  B-9   4C-3  A-45  4C-15 A-29  4C-16 A-28  4C-12 B-30  A-34  4A-2  0     0
      0     4A-42 4A-16 B-44  B-26  4C-11 B-51  4B-2  B-38  4X-2  B-14  B-29  4A-34 4A-12 0
      0     0     4A-37 4C-2  B-20  B-48  B-13  B-41  B-5   B-22  B-39  4C-13 4A-24 0     0
            0     0     4A-29 4A-35 A-27  B-32  4B-1  B-12  A-4   4A-1  4A-11 0     0
                  0     0     4A-44 4A-8  4A-46 A-5   4A-33 4A-19 4A-10 0     0
                        0     0     0     4A-3  4A-31 4A-25 0     0     0
                                    0     0     0     0     0
```

C.6 PARCS Input for the HFP Cycle 2 "c2_depl_s.inp" File

```
!******************************************************************************
CASEID depl-cyc2-s              Surry Unit 1 - Cycle 2
!******************************************************************************
CNTL
     core_type        pwr
     core_power       98.44  ! 2441 MW
!
     search          ppm
!                        D    BP1    BP2
     bank_pos         137.7  144.0    0.0
!
     depletion        T  1.0E-5 T
!                         NSET    LADF LXES LJ1F LDED LCHI LCHD LINV LDET LYLD LCDF LGFF LBET LAMB LDEC
     tree_xs          T     38      T    T    F    F    F    F    F    T    T    F    T    F    F    F
     int_th           T   -1
     xe_sm            1   1
     mult_cyc         T
     detector         T  250.0  2
     pin_power        T
!
!******************************************************************************
!XSEC
!     group_spec     2  1
!******************************************************************************
PARAM
     n_iters_ss     5  200
     nlupd_ss       3  3  1
     conv_ss        1.0e-6 1.0e-5 5.0e-5
```

```
     cnv_th_ss      0.001
     cmfd           2
     decusp         2
!******************************************************************************
GEOM
     geo_dim        17 17 41  1  1   !nasyx,nasyy,nz
     rad_conf

      0  0  0  0  0  0 90  4  4  4 90  0  0  0  0  0  0
      0  0  0  0 99  4  5 40 40 40  8  4 99  0  0  0  0
      0  0  0 99  5 40 40 43 10 43 40 40  8 99  0  0  0
      0  0 99  5 40 42 10 22 54 22 10 42 40  8 99  0  0
      0 99  5 40 60 22 22 22 22 22 22 22 60 40  8 99  0
      0  1 40 42 22 22 70 22 51 22 60 22 22 42 40  3  0
     90  5 40 10 22 60 10 60 10 60 10 60 22 10 40  8 90
      1 40 43 22 22 22 60 22 51 22 60 22 22 22 43 40  3
      1 40 10 54 22 51 10 51 10 51 10 51 22 54 10 40  3
      1 40 43 22 22 22 60 22 51 22 60 22 22 22 43 40  3
     90  6 40 10 22 60 10 60 10 60 10 60 22 10 40  7 90
      0  1 40 42 22 22 60 22 51 22 70 22 22 42 40  3  0
      0 99  6 40 60 22 22 22 22 22 22 22 60 40  7 99  0
      0  0 99  6 40 42 10 22 54 22 10 42 40  7 99  0  0
      0  0  0 99  6 40 40 43 10 43 40 40  7 99  0  0  0
      0  0  0  0 99  2  6 40 40 40  7  2 99  0  0  0  0
      0  0  0  0  0  0 90  2  2  2 90  0  0  0  0  0  0

     assy_type      1  1*1  39*3  1*2  REFL  ! W         36*3
     assy_type      2  1*1  39*4  1*2  REFL  ! S         36*4
     assy_type      3  1*1  39*5  1*2  REFL  ! E         36*5
     assy_type      4  1*1  39*6  1*2  REFL  ! N         36*6
     assy_type      5  1*1  39*7  1*2  REFL  ! NW        36*7
     assy_type      6  1*1  39*8  1*2  REFL  ! SW        36*8
     assy_type      7  1*1  39*9  1*2  REFL  ! SE        36*9
     assy_type      8  1*1  39*10 1*2  REFL  ! NE        36*10
     assy_type     90  1*1  39*11 1*2  REFL  ! no adf    36*11
     assy_type     99  1*1  39*12 1*2  REFL  ! corner    36*12

     assy_type     10  1*1  1*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 2*13 1*2  FUEL  ! 1.87   A, also Plug
     assy_type     20  1*1  1*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 2*15 1*2  FUEL  ! 2.57   B, also Plug
     assy_type     22  1*1  1*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 2*17 1*2  FUEL  ! 2.57   B, BP-12
     assy_type     30  1*1  1*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 2*19 1*2  FUEL  ! 3.12   C, also Plug
     assy_type     32  1*1  1*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 2*21 1*2  FUEL  ! 3.12   C, BP-12
     assy_type     40  1*1  1*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 2*23 1*2  FUEL  ! 3.33  4A, also Plug
     assy_type     42  1*1  1*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 2*25 1*2  FUEL  ! 3.33  4A, BP-12
     assy_type     43  1*1  1*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 2*27 1*2  FUEL  ! 3.33  4A, BP-20
     assy_type     51  1*1  1*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 2*29 1*2  FUEL  ! 2.61  4B, BP-08
     assy_type     54  1*1  1*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 2*31 1*2  FUEL  ! 2.61  4B, BPR-12
     assy_type     60  1*1  1*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 2*33 1*2  FUEL  ! 1.86  4C, also Plug
     assy_type     70  1*1  1*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 2*35 1*2  FUEL  ! 1.86  4X, 17x17 Plug
     assy_type     80  1*1  1*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 2*37 1*2  FUEL  ! 2.10   5, also Plug

     grid_x        17*21.60912
     neutmesh_x    17*1
     grid_y        17*21.60912
     neutmesh_y    17*1
     grid_z        1*15.24 1*12.923 1*3.81 6*9.642 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 2*11.522 1*14.098

     boun_cond      2 2 2 2 2 2      !ibcw,ibce,ibcn,ibcs,ibcb,ibct

     PINCAL_LOC
                          0   0   0   0   0
                  0   0   0   1   2   3   0   0   0
              0   0   4   5   6   7   8   9  10   0   0
          0   0  11  12  13  14  15  16  17  18  19   0   0
      0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
      0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
  0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
  0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
  0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
  0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
  0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
      0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
      0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
          0   0 139 140 141 142 143 144 145 146 147   0   0
              0   0 148 149 150 151 152 153 154   0   0
                  0   0   0 155 156 157   0   0   0
                          0   0   0   0   0

     cr_axinfo      15.24 2.561271
     bank_conf
! cycle 2  (Bank D + Cycle-1 BP + Cycle-2 BP)
```

```
                    0  0  0  0  0
                0  0  0  0  0  0  0  0  0
             0  0  0  0  3  1  3  0  0  0  0
          0  0  0  3  0  2  3  2  0  3  0  0  0
       0  0  0  0  2  2  2  2  2  2  2  0  0  0  0
       0  0  3  2  2  0  2  3  2  0  2  2  3  0  0
    0  0  0  0  2  0  1  0  0  0  1  0  2  0  0  0  0
    0  0  3  2  2  2  0  2  3  2  0  2  2  2  3  0  0
    0  0  1  3  2  3  0  3  0  3  0  3  2  3  1  0  0
    0  0  3  2  2  2  0  2  3  2  0  2  2  2  3  0  0
    0  0  0  0  2  0  1  0  0  0  1  0  2  0  0  0  0
       0  0  3  2  2  0  2  3  2  0  2  2  3  0  0
       0  0  0  0  2  2  2  2  2  2  2  0  0  0  0
          0  0  0  3  0  2  3  2  0  3  0  0  0
             0  0  0  0  3  1  3  0  0  0  0
                0  0  0  0  0  0  0  0  0
                    0  0  0  0  0

     crb_def        3
                    1 0   1 0 1.27     361.95   2.54  ! Cd/In/Ag Abso
                    2 0   1 0 1.27     362.41   2.08  ! Burnable Poison as CR
                    3 0   1 0 1.27     362.41   2.08  ! Burnable Poison as CR

     crb_type       1    2    3
!                   D  BP1  BP2
!     crb_type      1 1 1 1 2 1  3
!                   A B C D R S BP
!    crb_def is used to specify type of crb for each bank

     file  './depl_detect_full.geom'

!******************************************************************************
FDBK
     fa_powpit      15.548   21.60912          !assembly power(Mw) and pitch(cm)
     gamma_frac     0.019                      !direc heating fraction
!******************************************************************************
TH
     unif_th        0.74300 600.0 293.33       ! cool den, ftemp(C), ctemp(C)
     n_pingt        225 21                     !npin,ngt
     pin_dim        4.647 5.359 0.617 6.901    !pin radii, rs,rw,tw, and rgt in mm
     flow_cond      289.74 80.976              !tin,cmfrfa(Kg/sec)
     hgap           15000.0                    !hgap(w/M^2-C)                        Need estimate!!
     n_ring         10                         !number of meshes in pellet
!******************************************************************************
DEPL
     inp_hst        'cyc2_BOC-s.parcs_cyc-02' 1 2
     inp_opt        F  F  F  F
     hst_opt        T T F F F
     out_opt        T T F F F
!*******************************************************************
    PMAXS_F   1    '../GenPMAXS/reflector/refl_bot.PMAX'            1  ! Bottom
    PMAXS_F   2    '../GenPMAXS/reflector/refl_top.PMAX'            2  ! Top
    PMAXS_F   3    '../GenPMAXS/reflector/refl_rad_W.PMAX'          3  ! W
    PMAXS_F   4    '../GenPMAXS/reflector/refl_rad_S.PMAX'          4  ! S
    PMAXS_F   5    '../GenPMAXS/reflector/refl_rad_E.PMAX'          5  ! E
    PMAXS_F   6    '../GenPMAXS/reflector/refl_rad_N.PMAX'          6  ! N
    PMAXS_F   7    '../GenPMAXS/reflector/refl_rad_NW.PMAX'         7  ! NW
    PMAXS_F   8    '../GenPMAXS/reflector/refl_rad_SW.PMAX'         8  ! SW
    PMAXS_F   9    '../GenPMAXS/reflector/refl_rad_SE.PMAX'         9  ! SE
    PMAXS_F  10    '../GenPMAXS/reflector/refl_rad_NE.PMAX'         10 ! NE
    PMAXS_F  11    '../GenPMAXS/reflector/refl_rad.PMAX'            11 ! no adf
    PMAXS_F  12    '../GenPMAXS/reflector/refl_rad_diag.PMAX'       12 ! corner
!*******************************************************************
    PMAXS_F  13    '../GenPMAXS/fuel/b1_1.878_bp00.PMAX'            13
    PMAXS_F  14    '../GenPMAXS/fuel_spacer/b1_1.878_bp00.PMAX'     14
    PMAXS_F  15    '../GenPMAXS/fuel/b2_2.573_bp00.PMAX'            15
    PMAXS_F  16    '../GenPMAXS/fuel_spacer/b2_2.573_bp00.PMAX'     16
    PMAXS_F  17    '../GenPMAXS/fuel/b2_2.573_bp12.PMAX'            17
    PMAXS_F  18    '../GenPMAXS/fuel_spacer/b2_2.573_bp12.PMAX'     18
    PMAXS_F  19    '../GenPMAXS/fuel/b3_3.117_bp00.PMAX'            19
    PMAXS_F  20    '../GenPMAXS/fuel_spacer/b3_3.117_bp00.PMAX'     20
    PMAXS_F  21    '../GenPMAXS/fuel/b3_3.117_bp12.PMAX'            21
    PMAXS_F  22    '../GenPMAXS/fuel_spacer/b3_3.117_bp12.PMAX'     22
    PMAXS_F  23    '../GenPMAXS/fuel/b4a_3.330_bp00.PMAX'           23
    PMAXS_F  24    '../GenPMAXS/fuel_spacer/b4a_3.330_bp00.PMAX'    24
    PMAXS_F  25    '../GenPMAXS/fuel/b4a_3.330_bp12.PMAX'           25
    PMAXS_F  26    '../GenPMAXS/fuel_spacer/b4a_3.330_bp12.PMAX'    26
    PMAXS_F  27    '../GenPMAXS/fuel/b4a_3.330_bp20.PMAX'           27
    PMAXS_F  28    '../GenPMAXS/fuel_spacer/b4a_3.330_bp20.PMAX'    28
    PMAXS_F  29    '../GenPMAXS/fuel/b4b_2.610_bp08.PMAX'           29
    PMAXS_F  30    '../GenPMAXS/fuel_spacer/b4b_2.610_bp08.PMAX'    30
```

```
    PMAXS_F  31    '../GenPMAXS/fuel/b4b_2.610_bp12.PMAX'           31
    PMAXS_F  32    '../GenPMAXS/fuel_spacer/b4b_2.610_bp12.PMAX'    32
    PMAXS_F  33    '../GenPMAXS/fuel/b4c_1.860_bp00.PMAX'           33
    PMAXS_F  34    '../GenPMAXS/fuel_spacer/b4c_1.860_bp00.PMAX'    34
    PMAXS_F  35    '../GenPMAXS/fuel/b4x_1.860_bp00.PMAX'           35
    PMAXS_F  36    '../GenPMAXS/fuel_spacer/b4x_1.860_bp00.PMAX'    36
    PMAXS_F  37    '../GenPMAXS/fuel/b5_2.100_bp00.PMAX'            37
    PMAXS_F  38    '../GenPMAXS/fuel_spacer/b5_2.100_bp00.PMAX'     38
!*******************************************************************************
MCYCLE
     bank_def    1  137.7  144.0    0.0
     bank_def    2  137.7  144.0    0.0
     bank_def    3  140.2  144.0    0.0
     bank_def    4  134.5  144.0    0.0
     bank_def    5  134.3  144.0    0.0
     bank_def    6  135.2  144.0    0.0
     bank_def    7  135.2  144.0    0.0
     bank_def    8  135.2  144.0    0.0
     bank_def    9  135.2  144.0    0.0
     bank_def   10  135.8  144.0    0.0
     bank_def   11  135.2  144.0    0.0
     bank_def   12  137.1  144.0    0.0
     bank_def   13  138.3  144.0    0.0
     bank_def   14  137.7  144.0    0.0
     bank_def   15  137.7  144.0    0.0
     bank_def   16  139.6  144.0    0.0
     bank_def   17  137.1  144.0    0.0
     bank_def   18  140.2  144.0    0.0
     bank_def   19  142.1  144.0    0.0
     bank_def   20  144.0  144.0    0.0
     bank_def   21  144.0  144.0    0.0
     bank_def   22  142.1  144.0    0.0
     bank_def   23  138.3  144.0    0.0
     bank_def   24  141.5  144.0    0.0
     bank_def   25  142.7  144.0    0.0
     bank_def   26  141.5  144.0    0.0
     bank_def   27  142.7  144.0    0.0
     bank_def   28  143.4  144.0    0.0
     bank_def   29  143.4  144.0    0.0
     bank_def   30  144.0  144.0    0.0
     bank_def   31  140.8  144.0    0.0
     bank_def   32  144.0  144.0    0.0
     bank_def   33  144.0  144.0    0.0
     bank_def   34  144.0  144.0    0.0
     bank_def   35  144.0  144.0    0.0
     bank_def   36  144.0  144.0    0.0
     bank_def   37  144.0  144.0    0.0
     bank_def   38  144.0  144.0    0.0
     bank_def   39  144.0  144.0    0.0
     bank_def   40  144.0  144.0    0.0
     bank_def   41  144.0  144.0    0.0
     bank_def   42  144.0  144.0    0.0
     bank_def   43  144.0  144.0    0.0
     bank_def   44  144.0  144.0    0.0
     bank_def   45  144.0  144.0    0.0
     bank_def   46  144.0  144.0    0.0
     bank_def   47  144.0  144.0    0.0
     bank_def   48  144.0  144.0    0.0
     bank_def   49  144.0  144.0    0.0
     bank_def   50  144.0  144.0    0.0
     bank_def   51  144.0  144.0    0.0
     bank_def   52  144.0  144.0    0.0
     bank_def   53  144.0  144.0    0.0
     bank_def   54  144.0  144.0    0.0
     bank_def   55  144.0  144.0    0.0
     bank_def   56  144.0  144.0    0.0
     bank_def   57  144.0  144.0    0.0
     bank_def   58  140.0  144.0    0.0
     bank_def   59  141.5  144.0    0.0
     bank_def   60  143.4  144.0    0.0
     bank_def   61  142.1  144.0    0.0
     bank_def   62  140.8  144.0    0.0
     bank_def   63  140.0  144.0    0.0
     bank_def   64  143.4  144.0    0.0
     bank_def   65  142.7  144.0    0.0
     bank_def   66  141.5  144.0    0.0
     bank_def   67  140.2  144.0    0.0
     bank_def   68  143.4  144.0    0.0
     bank_def   69  138.9  144.0    0.0
     bank_def   70  142.1  144.0    0.0
     bank_def   71  140.2  144.0    0.0
```

```
      bank_def   72  143.4  144.0    0.0
      bank_def   73  135.8  144.0    0.0
      bank_def   74  140.2  144.0    0.0
      bank_def   75  132.0  144.0    0.0
      bank_def   76  135.8  144.0    0.0

      cycle_def     1 ! 76 steps
      depl_step   -0.115 -0.030 -0.145 -0.205 -0.035 -0.035 -0.035 -0.100 -0.160 -0.035 -0.255 -0.040 -0.030 -0.030 -0.045 -0.030 -0.025 -0.335 -
0.040 -0.040 -0.025 -0.070 -0.060 -0.070 -0.030 -0.070 -0.035 -0.035 -0.030 -0.030 -0.350 -0.030 -0.040 -0.030 -0.040 -0.030 -0.035 -0.035 -0.035
-0.035 -0.030 -0.035 -0.035 -0.030 -0.035 -0.040 -0.025 -0.040 -0.040 -0.030 -0.030 -0.050 -0.020 -0.030 -0.035 -0.035 -0.132 -0.038 -0.300 -0.025
-0.045 -0.030 -0.035 -0.035 -0.035 -0.035 -0.035 -0.235 -0.210 -0.235 -0.155 -0.385 -0.345 -0.330 -0.490
      bank_seq    1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34
35  36  37  38  39  40  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71
72  73  74  75  76
      power_lev   98.4 98.4 99.1 99.5 99.8 99.5 100.0 100.0 100.0 99.5 99.8 98.9 99.0 98.6 97.7 98.8 98.3 99.7 99.2 98.4 99.5 99.5 98.8 99.9 99.3
99.1 98.9 99.5 97.9 98.2 99.3 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0
100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 99.9 99.9 99.9 99.9 100.0 99.8 99.9 99.1 99.8 99.8 99.3 98.8 99.7 94.1 100.0
      inlet_ent   -568.71 -568.71 -569.26 -569.26 -569.26 -568.71 -569.26 -569.26 -569.26 -569.82 -569.82 -569.26 -569.82 -569.82 -569.26 -566.48
-569.82 -570.37 -569.82 -569.26 -569.26 -570.37 -570.37 -570.37 -570.37 -569.82 -564.26 -569.82 -566.48 -569.82 -569.82 -567.59 -567.59 -567.59 -
567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -567.59 -
567.59 -567.59 -567.59 -567.59 -567.59 -569.82 -569.82 -569.26 -569.26 -569.82 -569.82 -569.26 -566.48 -569.26 -569.26 -569.82 -569.82 -569.65 -
569.59 -569.59 -569.82 -569.59 -568.76 -568.76
      flow_rate   76*80.9758

      LOCATION
                          0   0   0   0   0
                  0   0   0   1   2   3   0   0   0
              0   0   4   5   6   7   8   9  10   0   0
          0   0  11  12  13  14  15  16  17  18  19   0   0
      0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
      0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
  0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
  0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
  0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
  0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
  0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
      0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
      0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
          0   0 139 140 141 142 143 144 145 146 147   0   0
              0   0 148 149 150 151 152 153 154   0   0
                  0   0   0 155 156 157   0   0   0
                          0   0   0   0   0

      SHUF_MAP   1   1
                          0   0   0   0   0
                  0   0   0   1   2   3   0   0   0
              0   0   4   5   6   7   8   9  10   0   0
          0   0  11  12  13  14  15  16  17  18  19   0   0
      0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
      0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
  0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
  0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
  0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
  0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
  0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
      0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
      0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
          0   0 139 140 141 142 143 144 145 146 147   0   0
              0   0 148 149 150 151 152 153 154   0   0
                  0   0   0 155 156 157   0   0   0
                          0   0   0   0   0

      CYCLE_IND    1   0   1
!
      CONV_EC    0.1   1      ! convergence criterion (GWD/T), max number of iteration
!******************************************************************************************
.
```

C.7 PARCS Input for the HZP Cycle 3 Fuel Shuffling "c2_c3_shuf_s.inp" File

```
!******************************************************************************
CASEID cyc3_BOC-s                 Surry Unit 1 - Cycle 1-2 Shuffle
!******************************************************************************
CNTL
      core_type       pwr
      core_power      0.0001  ! 2441 MW zero power during shuffling
!                     D       BP2
      bank_pos        144.0    0.0
!
      depletion       T  1.0E-5 F
```

```
!                        NSET    LADF LXES LJ1F LDED LCHI LCHD LINV LDET LYLD LCDF LGFF LBET LAMB LDEC
     tree_xs          T    38     T    T    F    F    F    F    F    T    T    F    T    F    F    F
     int_th           F   -1
     xe_sm            0   0
     mult_cyc         T
!
!*******************************************************************************
!XSEC
!     group_spec     2  1
!*******************************************************************************
PARAM
     n_iters_ss     5  200
     nlupd_ss       3  3  1
     conv_ss        1.0e-6 1.0e-5 5.0e-5
     cnv_th_ss      0.001
     cmfd           2
     decusp         2
!*******************************************************************************
GEOM
     geo_dim        17 17 41  1  1   !nasyx,nasyy,nz
     rad_conf

      0   0   0   0   0   0  90   4   4   4  90   0   0   0   0   0   0
      0   0   0   0  99   4   5  40  40  40   8   4  99   0   0   0   0
      0   0   0  99   5  40  43  40  30  40  43  40   8  99   0   0   0
      0   0  99   5  40  42  30  10  30  10  30  42  40   8  99   0   0
      0  99   5  40  30  70  80  32  32  32  80  60  30  40   8  99   0
      0   1  40  42  60  30  80  60  32  60  80  30  60  42  40   3   0
     90   5  43  30  80  80  60  30  10  30  60  80  80  30  43   8  90
      1  40  40  10  32  60  30  51  30  51  30  60  32  10  40  40   3
      1  40  30  30  32  32  10  30  10  30  10  32  32  30  30  40   3
      1  40  40  10  32  60  30  51  30  51  30  60  30  10  40  40   3
     90   6  43  30  80  80  60  30  10  30  60  80  80  30  43   7  90
      0   1  40  42  60  32  80  60  32  60  80  30  60  42  40   3   0
      0  99   6  40  30  60  80  32  32  32  80  70  30  40   7  99   0
      0   0  99   6  40  42  30  10  30  10  30  42  40   7  99   0   0
      0   0   0  99   6  40  43  40  30  40  43  40   7  99   0   0   0
      0   0   0   0  99   2   6  40  40  40   7   2  99   0   0   0   0
      0   0   0   0   0   0  90   2   2   2  90   0   0   0   0   0   0

     assy_type      1  1*1  39*3  1*2  REFL  ! W         36*3
     assy_type      2  1*1  39*4  1*2  REFL  ! S         36*4
     assy_type      3  1*1  39*5  1*2  REFL  ! E         36*5
     assy_type      4  1*1  39*6  1*2  REFL  ! N         36*6
     assy_type      5  1*1  39*7  1*2  REFL  ! NW        36*7
     assy_type      6  1*1  39*8  1*2  REFL  ! SW        36*8
     assy_type      7  1*1  39*9  1*2  REFL  ! SE        36*9
     assy_type      8  1*1  39*10 1*2  REFL  ! NE        36*10
     assy_type     90  1*1  39*11 1*2  REFL  ! no adf    36*11
     assy_type     99  1*1  39*12 1*2  REFL  ! corner    36*12

     assy_type     10  1*1  1*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 2*13 1*2  FUEL  ! 1.87   A, also Plug
     assy_type     20  1*1  1*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 2*15 1*2  FUEL  ! 2.57   B, also Plug
     assy_type     22  1*1  1*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 2*17 1*2  FUEL  ! 2.57   B, BP-12
     assy_type     30  1*1  1*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 2*19 1*2  FUEL  ! 3.12   C, also Plug
     assy_type     32  1*1  1*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 2*21 1*2  FUEL  ! 3.12   C, BP-12
     assy_type     40  1*1  1*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 2*23 1*2  FUEL  ! 3.33  4A, also Plug
     assy_type     42  1*1  1*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 2*25 1*2  FUEL  ! 3.33  4A, BP-12
     assy_type     43  1*1  1*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 2*27 1*2  FUEL  ! 3.33  4A, BP-20
     assy_type     51  1*1  1*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 2*29 1*2  FUEL  ! 2.61  4B, BP-08
     assy_type     54  1*1  1*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 2*31 1*2  FUEL  ! 2.61  4B, BPR-12
     assy_type     60  1*1  1*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 2*33 1*2  FUEL  ! 1.86  4C, also Plug
     assy_type     70  1*1  1*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 2*35 1*2  FUEL  ! 1.86  4X, 17x17 Plug
     assy_type     80  1*1  1*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 2*37 1*2  FUEL  ! 2.10   5, also Plug

     grid_x        17*21.60912
     neutmesh_x    17*1
     grid_y        17*21.60912
     neutmesh_y    17*1
     grid_z        1*15.24 1*12.923 1*3.81 6*9.642 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 2*11.522 1*14.098

     boun_cond      2 2 2 2 2 2      !ibcw,ibce,ibcn,ibcs,ibcb,ibct

     cr_axinfo      15.24 2.561271
     bank_conf
! cycle 2   (Bank D +  Cycle-2 BP)
                        0  0  0  0  0
                  0  0  0  0  0  0  0  0  0
               0  0  0  0  0  1  0  0  0  0  0
            0  0  0  0  2  0  0  0  2  0  0  0  0
         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

```
        0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
     0  0  0  2  0  0  1  0  0  0  1  0  0  2  0  0  0
     0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
     0  0  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0
     0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
     0  0  0  2  0  0  1  0  0  0  1  0  0  0  0  0  0
        0  0  0  0  0  0  0  0  0  0  0  0  2  0  0
        0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
           0  0  0  0  2  0  0  0  2  0  0  0  0
              0  0  0  0  0  1  0  0  0  0  0
                 0  0  0  0  0  0  0  0  0
                       0  0  0  0  0

     crb_def       2
                   1 0   1 0 1.27     361.95   2.54  ! Cd/In/Ag Abso
                   2 0   1 0 1.27     362.41   2.08  ! Burnable Poison as CR

     crb_type      1   2
!                 D  BP1  BP2
!     crb_type      1 1 1 1 2 1  3
!                   A B C D R S BP
!    crb_def is used to specify type of crb for each bank
!*****************************************************************************
FDBK
     fa_powpit     15.548   21.60912         !assembly power(Mw) and pitch(cm)
     gamma_frac    0.019                     !direc heating fraction
!*****************************************************************************
TH
     unif_th       0.74300 600.0 293.33      ! cool den, ftemp(C), ctemp(C)
     n_pingt       225 21                    !npin,ngt
     pin_dim       4.647 5.359 0.617 6.901   !pin radii, rs,rw,tw, and rgt in mm
     flow_cond     289.74 80.976             !tin,cmfrfa(Kg/sec)
     hgap          15000.0                   !hgap(w/M^2-C)                    Need estimate!!
     n_ring        10                        !number of meshes in pellet
!*****************************************************************************
DEPL
     !inp_hst       'depl-cyc2-s.parcs_cyc-01' 1 75
     !inp_opt       F F F F
     hst_opt       T T F F F
     out_opt       T T F F F
!*****************************************************************
    PMAXS_F  1   '../GenPMAXS/reflector/refl_bot.PMAX'            1  ! Bottom
    PMAXS_F  2   '../GenPMAXS/reflector/refl_top.PMAX'            2  ! Top
    PMAXS_F  3   '../GenPMAXS/reflector/refl_rad_W.PMAX'          3  ! W
    PMAXS_F  4   '../GenPMAXS/reflector/refl_rad_S.PMAX'          4  ! S
    PMAXS_F  5   '../GenPMAXS/reflector/refl_rad_E.PMAX'          5  ! E
    PMAXS_F  6   '../GenPMAXS/reflector/refl_rad_N.PMAX'          6  ! N
    PMAXS_F  7   '../GenPMAXS/reflector/refl_rad_NW.PMAX'         7  ! NW
    PMAXS_F  8   '../GenPMAXS/reflector/refl_rad_SW.PMAX'         8  ! SW
    PMAXS_F  9   '../GenPMAXS/reflector/refl_rad_SE.PMAX'         9  ! SE
    PMAXS_F 10   '../GenPMAXS/reflector/refl_rad_NE.PMAX'         10 ! NE
    PMAXS_F 11   '../GenPMAXS/reflector/refl_rad.PMAX'            11 ! no adf
    PMAXS_F 12   '../GenPMAXS/reflector/refl_rad_diag.PMAX'       12 ! corner
!*****************************************************************
    PMAXS_F 13   '../GenPMAXS/fuel/b1_1.878_bp00.PMAX'            13
    PMAXS_F 14   '../GenPMAXS/fuel_spacer/b1_1.878_bp00.PMAX'     14
    PMAXS_F 15   '../GenPMAXS/fuel/b2_2.573_bp00.PMAX'            15
    PMAXS_F 16   '../GenPMAXS/fuel_spacer/b2_2.573_bp00.PMAX'     16
    PMAXS_F 17   '../GenPMAXS/fuel/b2_2.573_bp12.PMAX'            17
    PMAXS_F 18   '../GenPMAXS/fuel_spacer/b2_2.573_bp12.PMAX'     18
    PMAXS_F 19   '../GenPMAXS/fuel/b3_3.117_bp00.PMAX'            19
    PMAXS_F 20   '../GenPMAXS/fuel_spacer/b3_3.117_bp00.PMAX'     20
    PMAXS_F 21   '../GenPMAXS/fuel/b3_3.117_bp12.PMAX'            21
    PMAXS_F 22   '../GenPMAXS/fuel_spacer/b3_3.117_bp12.PMAX'     22
    PMAXS_F 23   '../GenPMAXS/fuel/b4a_3.330_bp00.PMAX'           23
    PMAXS_F 24   '../GenPMAXS/fuel_spacer/b4a_3.330_bp00.PMAX'    24
    PMAXS_F 25   '../GenPMAXS/fuel/b4a_3.330_bp12.PMAX'           25
    PMAXS_F 26   '../GenPMAXS/fuel_spacer/b4a_3.330_bp12.PMAX'    26
    PMAXS_F 27   '../GenPMAXS/fuel/b4a_3.330_bp20.PMAX'           27
    PMAXS_F 28   '../GenPMAXS/fuel_spacer/b4a_3.330_bp20.PMAX'    28
    PMAXS_F 29   '../GenPMAXS/fuel/b4b_2.610_bp08.PMAX'           29
    PMAXS_F 30   '../GenPMAXS/fuel_spacer/b4b_2.610_bp08.PMAX'    30
    PMAXS_F 31   '../GenPMAXS/fuel/b4b_2.610_bp12.PMAX'           31
    PMAXS_F 32   '../GenPMAXS/fuel_spacer/b4b_2.610_bp12.PMAX'    32
    PMAXS_F 33   '../GenPMAXS/fuel/b4c_1.860_bp00.PMAX'           33
    PMAXS_F 34   '../GenPMAXS/fuel_spacer/b4c_1.860_bp00.PMAX'    34
    PMAXS_F 35   '../GenPMAXS/fuel/b4x_1.860_bp00.PMAX'           35
    PMAXS_F 36   '../GenPMAXS/fuel_spacer/b4x_1.860_bp00.PMAX'    36
    PMAXS_F 37   '../GenPMAXS/fuel/b5_2.100_bp00.PMAX'            37
    PMAXS_F 38   '../GenPMAXS/fuel_spacer/b5_2.100_bp00.PMAX'     38
!*****************************************************************************
```

```
MCYCLE
      bank_def    1  144.0  0.0

      cycle_def   1
      depl_step   0.0001
      bank_seq    2*1
      power_lev   2*0.001

      !cycle_def   2
      !depl_step   0.0001
      !bank_seq    2*1
      !power_lev   2*0.001

      prev_cyc       2
                   './su_c2_lay.mcyc' './depl-cyc2-s.parcs_cyc-01'  1  76
                   './su_c1_lay.mcyc' './depl-cyc1-s.parcs_cyc-01'  1  117

      LOCATION 1
                                         0     0     0     0     0
                             0     0     0    -1    -1    -1     0     0     0
                       0     0    -1    -1    -1    -1    -1    -1    -1     0     0
                 0     0    -1    -1    -1    -1    -1    -1    -1    -1    -1     0     0
           0     0    -1    -1    -1     0    -1    -1    -1     0    -1    -1    -1     0     0
           0    -1    -1    -1    -1     0    -1    -1    -1     0    -1    -1    -1    -1     0
     0     0    -1    -1     0     0    -1    -1    -1    -1    -1     0     0    -1    -1     0     0
     0    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1     0
     0    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1     0
     0    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1    -1     0
     0     0    -1    -1     0     0    -1    -1    -1    -1    -1     0     0    -1    -1     0     0
           0    -1    -1    -1    -1     0    -1    -1    -1     0    -1    -1    -1    -1     0
           0     0    -1    -1    -1     0    -1    -1    -1     0    -1    -1    -1     0     0
                 0     0    -1    -1    -1    -1    -1    -1    -1    -1    -1     0     0
                       0     0    -1    -1    -1    -1    -1    -1    -1     0     0
                             0     0     0    -1    -1    -1     0     0     0
                                         0     0     0     0     0

      SHUF_MAP   1   1
! no BP re-insertion
                                         0     0     0     0     0
                             0     0     0 4A-25 4A-31  4A-3     0     0     0
                       0     0 4A-11 4A-33  4A-7  C-20 4A-36 4A-46 4A-29     0     0
                 0     0 4A-10  4A-1  C-30   A-9   C-3  A-52  C-16 4A-35 4A-44     0     0
           0     0 4A-12  C-37  4X-1 5A-15  C-17   C-2  C-11  5A-6  4C-8  C-45 4A-42     0     0
           0 4A-24 4A-34 4C-17  C-28  5A-1  4C-1  C-51 4C-18  5A-8  C-15 4C-10 4A-16 4A-37     0
     0     0 4A-50  C-37 5A-13  5A-2  4C-4  C-32  A-46  C-43  4C-5 5A-14  5A-3  C-39 4A-26     0     0
     0 4A-49 4A-21  A-17  C-19  4C-6  C-12 4B-10  C-42  4B-8   C-9 4C-14  C-18  A-24  4A-2 4A-14     0
     0 4A-41  C-46  C-26   C-8  C-25  A-14  C-49  A-12  C-38  A-25  C-44  C-36  C-10  C-23 4A-39     0
     0 4A-28 4A-45  A-50  C-40  4C-9  C-47  4B-9  C-27  4B-2   C-6  4C-7   C-1  A-43 4A-17 4A-43     0
     0     0  4A-6  C-35 5A-11 5A-12  4C-2   C-4  A-33  C-24 4C-13  5A-9 5A-10  C-29  4A-4     0     0
           0 4A-30 4A-18  4C-3   C-7 5A-16 4C-15  C-52 4C-16  5A-4  C-48 4C-12  4A-9 4A-20     0
           0     0 4A-51  C-33 4C-11  5A-5  C-13  C-50  C-21  5A-7  4X-2  C-31 4A-27     0     0
                 0     0 4A-48 4A-47  C-41  A-76  C-14  A-36   C-5 4A-15 4A-13     0     0
                       0     0 4A-38 4A-52 4A-19  C-22  4A-8 4A-40 4A-23     0     0
                             0     0     0  4A-5 4A-22 4A-32     0     0     0
                                         0     0     0     0     0
!
      CYCLE_IND    1   0   1
      CYCLE_IND    2   1   1
!
      CONV_EC    0.1   2     ! convergence criterion (GWD/T), max number of iteration
!*******************************************************************************************
.
```

C.8 PARCS Input for the HFP Cycle 3 "c3_depl_s.inp" File

```
!*******************************************************************************
CASEID depl-cyc3-s              Surry Unit 1 - Cycle 3
!*******************************************************************************
CNTL
      core_type        pwr
      core_power       100.0  ! 2441 MW
!
      search          ppm
!                          D    BP1
      bank_pos         144.0    0.0
!
      depletion        T  1.0E-5 T
!                           NSET     IADF IXES IJ1F LDED LCHI LCHD LINV LDET LYLD LCDF LGFF LBET LAMB LDEC
      tree_xs          T     38       T    T    F    F    F    F    F    T    T    F    T    F    F    F
```

```
     int_th           T  -1
     xe_sm            1  1
     mult_cyc         T
     detector         T  250.0  2
     pin_power        T
!
!*****************************************************************************
!XSEC
!     group_spec     2  1
!*****************************************************************************
PARAM
     n_iters_ss     5  200
     nlupd_ss       3  3  1
     conv_ss        1.0e-6 1.0e-5 5.0e-5
     cnv_th_ss      0.001
     cmfd           2
     decusp         2
!*****************************************************************************
GEOM
     geo_dim        17 17 41  1  1   !nasyx,nasyy,nz
     rad_conf

      0   0   0   0   0   0  90   4   4   4  90   0   0   0   0   0   0
      0   0   0   0  99   4   5  40  40  40   8   4  99   0   0   0   0
      0   0   0  99   5  40  43  40  30  40  43  40   8  99   0   0   0
      0   0  99   5  40  42  30  10  30  10  30  42  40   8  99   0   0
      0  99   5  40  30  70  80  32  32  32  80  60  30  40   8  99   0
      0   1  40  42  60  30  80  60  32  60  80  30  60  42  40   3   0
     90   5  43  30  80  80  60  30  10  30  60  80  80  30  43   8  90
      1  40  40  10  32  60  30  51  30  51  30  60  32  10  40  40   3
      1  40  30  30  32  32  10  30  10  30  10  32  32  30  30  40   3
      1  40  40  10  32  60  30  51  30  51  30  60  30  10  40  40   3
     90   6  43  30  80  80  60  30  10  30  60  80  80  30  43   7  90
      0   1  40  42  60  32  80  60  32  60  80  30  60  42  40   3   0
      0  99   6  40  30  60  80  32  32  32  80  70  30  40   7  99   0
      0   0  99   6  40  42  30  10  30  10  30  42  40   7  99   0   0
      0   0   0  99   6  40  43  40  30  40  43  40   7  99   0   0   0
      0   0   0   0  99   2   6  40  40  40   7   2  99   0   0   0   0
      0   0   0   0   0   0  90   2   2   2  90   0   0   0   0   0   0

     assy_type      1  1*1  39*3  1*2  REFL  ! W         36*3
     assy_type      2  1*1  39*4  1*2  REFL  ! S         36*4
     assy_type      3  1*1  39*5  1*2  REFL  ! E         36*5
     assy_type      4  1*1  39*6  1*2  REFL  ! N         36*6
     assy_type      5  1*1  39*7  1*2  REFL  ! NW        36*7
     assy_type      6  1*1  39*8  1*2  REFL  ! SW        36*8
     assy_type      7  1*1  39*9  1*2  REFL  ! SE        36*9
     assy_type      8  1*1  39*10 1*2  REFL  ! NE        36*10
     assy_type     90  1*1  39*11 1*2  REFL  ! no adf    36*11
     assy_type     99  1*1  39*12 1*2  REFL  ! corner    36*12

     assy_type     10  1*1  1*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 6*13 1*14 2*13 1*2  FUEL  ! 1.87   A, also Plug
     assy_type     20  1*1  1*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 6*15 1*16 2*15 1*2  FUEL  ! 2.57   B, also Plug
     assy_type     22  1*1  1*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 6*17 1*18 2*17 1*2  FUEL  ! 2.57   B, BP-12
     assy_type     30  1*1  1*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 6*19 1*20 2*19 1*2  FUEL  ! 3.12   C, also Plug
     assy_type     32  1*1  1*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 6*21 1*22 2*21 1*2  FUEL  ! 3.12   C, BP-12
     assy_type     40  1*1  1*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 6*23 1*24 2*23 1*2  FUEL  ! 3.33  4A, also Plug
     assy_type     42  1*1  1*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 6*25 1*26 2*25 1*2  FUEL  ! 3.33  4A, BP-12
     assy_type     43  1*1  1*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 6*27 1*28 2*27 1*2  FUEL  ! 3.33  4A, BP-20
     assy_type     51  1*1  1*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 6*29 1*30 2*29 1*2  FUEL  ! 2.61  4B, BP-08
     assy_type     54  1*1  1*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 6*31 1*32 2*31 1*2  FUEL  ! 2.61  4B, BPR-12
     assy_type     60  1*1  1*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 6*33 1*34 2*33 1*2  FUEL  ! 1.86  4C, also Plug
     assy_type     70  1*1  1*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 6*35 1*36 2*35 1*2  FUEL  ! 1.86  4X, 17x17 Plug
     assy_type     80  1*1  1*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 6*37 1*38 2*37 1*2  FUEL  ! 2.10   5, also Plug

     grid_x        17*21.60912
     neutmesh_x    17*1
     grid_y        17*21.60912
     neutmesh_y    17*1
     grid_z        1*15.24 1*12.923 1*3.81 6*9.642 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 6*10.5060 1*3.81 2*11.522 1*14.098

     boun_cond      2 2 2 2 2 2      !ibcw,ibce,ibcn,ibcs,ibcb,ibct

     PINCAL_LOC
                         0   0   0   0   0
                 0   0   0   1   2   3   0   0   0
             0   0   4   5   6   7   8   9  10   0   0
         0   0  11  12  13  14  15  16  17  18  19   0   0
     0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
     0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
 0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
```

```
     0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
     0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
     0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
     0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
         0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
         0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
             0   0 139 140 141 142 143 144 145 146 147   0   0
                 0   0 148 149 150 151 152 153 154   0   0
                     0   0   0 155 156 157   0   0   0
                             0   0   0   0   0

     cr_axinfo      15.24 2.561271
     bank_conf
! cycle 3  (Bank D + Cycle-1 BP )
                         0  0  0  0  0
                   0  0  0  0  0  0  0  0  0
                0  0  0  0  0  1  0  0  0  0  0
             0  0  0  0  2  0  0  0  2  0  0  0  0
          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
       0  0  0  2  0  0  1  0  0  0  1  0  0  2  0  0  0
       0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
       0  0  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0
       0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
       0  0  0  2  0  0  1  0  0  0  1  0  0  0  0  0  0
          0  0  0  0  0  0  0  0  0  0  0  0  0  2  0  0
          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
             0  0  0  0  2  0  0  0  2  0  0  0  0
                0  0  0  0  0  1  0  0  0  0  0
                   0  0  0  0  0  0  0  0  0
                         0  0  0  0  0
! w/ bpr
!                         0  0  0  0  0
!                   0  0  0  0  0  0  0  0  0
!                0  0  0  1  7  4  7  1  0  0  0
!             0  0  0  7  0  6  7  6  0  7  0  0  0
!          0  0  0  3  0  2  0  6  0  2  0  3  0  0  0
!          0  0  7  0  6  0  0  7  0  0  6  0  7  0  0
!       0  0  1  0  2  0  4  0  3  0  4  0  2  0  1  0  0
!       0  0  7  6  0  0  0  6  7  6  0  0  0  6  7  0  0
!       0  0  4  7  6  7  3  7  6  7  3  7  6  7  4  0  0
!       0  0  7  6  0  0  0  6  7  6  0  0  0  6  7  0  0
!       0  0  1  0  2  0  4  0  3  0  4  0  2  0  1  0  0
!          0  0  7  0  6  0  0  7  0  0  6  0  7  0  0
!          0  0  0  3  0  2  0  6  0  2  0  3  0  0  0
!             0  0  0  7  0  6  7  6  0  7  0  0  0
!                0  0  0  1  7  4  7  1  0  0  0
!                   0  0  0  0  0  0  0  0  0
!                         0  0  0  0  0

     crb_def        2
                    1 0   1 0 1.27      361.95   2.54  ! Cd/In/Ag Abso
                    2 0   1 0 1.27      362.41   2.08  ! Burnable Poison as CR

     crb_type      1    2
!                  D  BP1
!     crb_type      1 1 1 1 2 1  3
!                   A B C D R S BP
!    crb_def is used to specify type of crb for each bank

     file  './depl_detect_full.geom'

!*******************************************************************************
FDBK
     fa_powpit      15.548   21.60912          !assembly power(Mw) and pitch(cm)
     gamma_frac     0.019                      !direc heating fraction
!*******************************************************************************
TH
     unif_th        0.74300 600.0 293.33       ! cool den, ftemp(C), ctemp(C)
     n_pingt        225 21                     !npin,ngt
     pin_dim        4.647 5.359 0.617 6.901    !pin radii, rs,rw,tw, and rgt in mm
     flow_cond      289.74 80.976              !tin,cmfrfa(Kg/sec)
     hgap           15000.0                    !hgap(w/M^2-C)                    Need estimate!!
     n_ring         10                         !number of meshes in pellet
!*******************************************************************************
DEPL
     inp_hst        'cyc3_BOC-s.parcs_cyc-02' 1 2
     inp_opt        F  F  F  F
     hst_opt        T T F F F
     out_opt        T T F F F
!*****************************************************************
```

```
    PMAXS_F  1    '../GenPMAXS/reflector/refl_bot.PMAX'            1  ! Bottom
    PMAXS_F  2    '../GenPMAXS/reflector/refl_top.PMAX'            2  ! Top
    PMAXS_F  3    '../GenPMAXS/reflector/refl_rad_W.PMAX'          3  ! W
    PMAXS_F  4    '../GenPMAXS/reflector/refl_rad_S.PMAX'          4  ! S
    PMAXS_F  5    '../GenPMAXS/reflector/refl_rad_E.PMAX'          5  ! E
    PMAXS_F  6    '../GenPMAXS/reflector/refl_rad_N.PMAX'          6  ! N
    PMAXS_F  7    '../GenPMAXS/reflector/refl_rad_NW.PMAX'         7  ! NW
    PMAXS_F  8    '../GenPMAXS/reflector/refl_rad_SW.PMAX'         8  ! SW
    PMAXS_F  9    '../GenPMAXS/reflector/refl_rad_SE.PMAX'         9  ! SE
    PMAXS_F 10    '../GenPMAXS/reflector/refl_rad_NE.PMAX'         10 ! NE
    PMAXS_F 11    '../GenPMAXS/reflector/refl_rad.PMAX'            11 ! no adf
    PMAXS_F 12    '../GenPMAXS/reflector/refl_rad_diag.PMAX'       12 ! corner
!*****************************************************************
    PMAXS_F 13    '../GenPMAXS/fuel/b1_1.878_bp00.PMAX'            13
    PMAXS_F 14    '../GenPMAXS/fuel_spacer/b1_1.878_bp00.PMAX'     14
    PMAXS_F 15    '../GenPMAXS/fuel/b2_2.573_bp00.PMAX'            15
    PMAXS_F 16    '../GenPMAXS/fuel_spacer/b2_2.573_bp00.PMAX'     16
    PMAXS_F 17    '../GenPMAXS/fuel/b2_2.573_bp12.PMAX'            17
    PMAXS_F 18    '../GenPMAXS/fuel_spacer/b2_2.573_bp12.PMAX'     18
    PMAXS_F 19    '../GenPMAXS/fuel/b3_3.117_bp00.PMAX'            19
    PMAXS_F 20    '../GenPMAXS/fuel_spacer/b3_3.117_bp00.PMAX'     20
    PMAXS_F 21    '../GenPMAXS/fuel/b3_3.117_bp12.PMAX'            21
    PMAXS_F 22    '../GenPMAXS/fuel_spacer/b3_3.117_bp12.PMAX'     22
    PMAXS_F 23    '../GenPMAXS/fuel/b4a_3.330_bp00.PMAX'           23
    PMAXS_F 24    '../GenPMAXS/fuel_spacer/b4a_3.330_bp00.PMAX'    24
    PMAXS_F 25    '../GenPMAXS/fuel/b4a_3.330_bp12.PMAX'           25
    PMAXS_F 26    '../GenPMAXS/fuel_spacer/b4a_3.330_bp12.PMAX'    26
    PMAXS_F 27    '../GenPMAXS/fuel/b4a_3.330_bp20.PMAX'           27
    PMAXS_F 28    '../GenPMAXS/fuel_spacer/b4a_3.330_bp20.PMAX'    28
    PMAXS_F 29    '../GenPMAXS/fuel/b4b_2.610_bp08.PMAX'           29
    PMAXS_F 30    '../GenPMAXS/fuel_spacer/b4b_2.610_bp08.PMAX'    30
    PMAXS_F 31    '../GenPMAXS/fuel/b4b_2.610_bp12.PMAX'           31
    PMAXS_F 32    '../GenPMAXS/fuel_spacer/b4b_2.610_bp12.PMAX'    32
    PMAXS_F 33    '../GenPMAXS/fuel/b4c_1.860_bp00.PMAX'           33
    PMAXS_F 34    '../GenPMAXS/fuel_spacer/b4c_1.860_bp00.PMAX'    34
    PMAXS_F 35    '../GenPMAXS/fuel/b4x_1.860_bp00.PMAX'           35
    PMAXS_F 36    '../GenPMAXS/fuel_spacer/b4x_1.860_bp00.PMAX'    36
    PMAXS_F 37    '../GenPMAXS/fuel/b5_2.100_bp00.PMAX'            37
    PMAXS_F 38    '../GenPMAXS/fuel_spacer/b5_2.100_bp00.PMAX'     38
!******************************************************************************
MCYCLE
     bank_def    1  144.0    0.0
     bank_def    2  144.0    0.0
     bank_def    3  144.0    0.0
     bank_def    4  144.0    0.0
     bank_def    5  144.0    0.0
     bank_def    6  144.0    0.0
     bank_def    7  144.0    0.0
     bank_def    8  144.0    0.0
     bank_def    9  144.0    0.0
     bank_def   10  144.0    0.0
     bank_def   11  144.0    0.0
     bank_def   12  144.0    0.0
     bank_def   13  144.0    0.0
     bank_def   14  144.0    0.0
     bank_def   15  144.0    0.0
     bank_def   16  144.0    0.0
     bank_def   17  144.0    0.0
     bank_def   18  144.0    0.0
     bank_def   19  144.0    0.0
     bank_def   20  144.0    0.0
     bank_def   21  144.0    0.0
     bank_def   22  144.0    0.0
     bank_def   23  144.0    0.0
     bank_def   24  144.0    0.0
     bank_def   25  144.0    0.0
     bank_def   26  144.0    0.0
     bank_def   27  144.0    0.0
     bank_def   28  144.0    0.0
     bank_def   29  144.0    0.0
     bank_def   30  144.0    0.0
     bank_def   31  144.0    0.0
     bank_def   32  144.0    0.0
     bank_def   33  144.0    0.0
     bank_def   34  144.0    0.0
     bank_def   35  144.0    0.0

     cycle_def     1 ! 34 steps
     depl_step   -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -
0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25 -0.25
```

```
     bank_seq    1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34
35
     power_lev   100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100
100 100 100
     inlet_ent   -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26
-569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -569.26 -
569.26
     flow_rate   35*80.9758

     LOCATION
                           0   0   0   0   0
                   0   0   0   1   2   3   0   0   0
               0   0   4   5   6   7   8   9  10   0   0
           0   0  11  12  13  14  15  16  17  18  19   0   0
       0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
       0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
   0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
   0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
   0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
   0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
   0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
       0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
       0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
           0   0 139 140 141 142 143 144 145 146 147   0   0
               0   0 148 149 150 151 152 153 154   0   0
                   0   0   0 155 156 157   0   0   0
                           0   0   0   0   0

     SHUF_MAP   1   1
                           0   0   0   0   0
                   0   0   0   1   2   3   0   0   0
               0   0   4   5   6   7   8   9  10   0   0
           0   0  11  12  13  14  15  16  17  18  19   0   0
       0   0  20  21  22  23  24  25  26  27  28  29  30   0   0
       0  31  32  33  34  35  36  37  38  39  40  41  42  43   0
   0   0  44  45  46  47  48  49  50  51  52  53  54  55  56   0   0
   0  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71   0
   0  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86   0
   0  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101   0
   0   0 102 103 104 105 106 107 108 109 110 111 112 113 114   0   0
       0 115 116 117 118 119 120 121 122 123 124 125 126 127   0
       0   0 128 129 130 131 132 133 134 135 136 137 138   0   0
           0   0 139 140 141 142 143 144 145 146 147   0   0
               0   0 148 149 150 151 152 153 154   0   0
                   0   0   0 155 156 157   0   0   0
                           0   0   0   0   0

     CYCLE_IND    1   0   1
!
     CONV_EC    0.1   1      ! convergence criterion (GWD/T), max number of iteration
!*******************************************************************************************
.
```

APPENDIX D. PROGRAM TO COMPARE POWER MAPS FOR PWRs

D.1 Program Source

```
      program DetectorResponse
!     This is for the PWR detector response
      implicit none
!
      character(4) :: ss4
      character(5) :: ss5
      character(10) :: ss10,ss10x
      character(100) :: ctitle, file1, file2
      character(400) :: ssw
      integer :: nmeasure,nburn,naxial,ndets,nassembly,nassembly0,nxa,nya,numdet,isym,naxial0,naxial1
      integer :: i,j,k,nx,nid,ix,j1,j2,k2,idparcs,kid,ix2,ip,idum,il,nline,iy2
      integer,allocatable :: nidmeasure(:),numx(:),mapaxial(:,:),mapradial(:)
      character(3),allocatable  :: mDET(:),config(:,:)
      character(4),allocatable  :: cDET(:)
      real,allocatable :: weight(:),axialmesh0(:),axialmesh(:),datax(:,:)
      real :: tempr,sumfa,totsum,sum0,sum1,sum2,sum3,diff,diff2,zpoint,x1,x2,y1,y2,yout
      real :: mao,cao,dz,height
      logical :: kr
!
      type meas_type
        integer :: nid,ndets,naxial,ndets_active
        real :: burnup,efpd
        character(3),allocatable :: mDET(:)
        real,allocatable :: axialmesh(:)
        real,allocatable :: mpownodal(:,:),mpowradial(:),mpowaxial(:)
        real,allocatable :: mpownodal2(:,:),mpowradial2(:),mpowaxial2(:)
        real,allocatable :: cpownodal(:,:),cpowradial(:),cpowaxial(:)
        logical,allocatable :: ldata(:)
      end type
      type(meas_type),allocatable :: measdata(:)
!
      type calc_type
        character(4),allocatable :: cDET(:)
        real,allocatable :: pownodal(:,:),axialmesh(:)
      end type
      type(calc_type),allocatable :: calcdata(:)
      real :: rms_all,rms_radial,rms_axial
      real :: max_all,max_radial,max_axial,min_all,min_radial,min_axial
!
!     read input file
      open(1,file='DetRes.in',status='old')
      open(21,file='DetRes.out',status='unknown')
      read(1,*) !%TITLE
      read(1,*) ctitle
      read(1,*) !%MEASURED
      read(1,*) ss10, file1
      read(1,*) ss10, nmeasure, ndets, naxial0, height
      allocate(nidmeasure(nmeasure))
      read(1,*) (nidmeasure(i),i=1,nmeasure)
      read(1,*) !%CALCULATED
      read(1,*) ss10, file2
      read(1,*) ss10,nburn,naxial,nassembly,nassembly0,isym

      allocate(axialmesh(0:naxial))
      axialmesh(0)=0.0
      do i=1,naxial
        read(1,*) axialmesh(i)
      enddo
      read(1,*) !%INDEX
      allocate(mDET(ndets),cDET(ndets),weight(ndets))
      do i=1,ndets
        read(1,*) ix,mDET(i),cDET(i) !Detector names in meas. and calc.
      enddo
      read(1,*) !%CORE
      read(1,*) nxa,nya
      allocate(config(nxa,nya))
      do j=1,nya
        read(1,*) (config(i,j),i=1,nxa)
      enddo
!
!     read calculated data
      open(3,file=file2,status='old')
      read(3,*)
      allocate(calcdata(nmeasure))
```

```
      allocate(datax(naxial,nassembly0))
      do i=1,nmeasure
        allocate(calcdata(i)%cDET(nassembly))
        allocate(calcdata(i)%pownodal(naxial,nassembly))
        rewind(3)
        do ix=1,1000000
          read(3,'(x,a10)',end=111) ss10
          if (ss10 == 'BEGIN STEP') then
            read(3,*)
            read(3,*)
            read(3,*) kid
            if (kid == nidmeasure(i)) then
              do ix2=1,1000
                read(3,'(1x,a10)') ss10x
                if (ss10x == 'RPF 3D MAP') then
                  read(3,*)
                  datax=0.0
                  do ip=1,(nassembly0-1)/10+1
                    read(3,*)
                    read(3,*)
                    if (ip == (nassembly0-1)/10+1) then
                      nline=mod(nassembly0,10)
                    else
                      nline=10
                    endif
                    do il=naxial,1,-1
                    !do il=1,naxial
                      read(3,*) idum,(datax(il,10*(ip-1)+iy2),iy2=1,nline)
                    enddo
                    read(3,*)
                    read(3,*)
                  enddo
                  goto 222
                endif
              enddo
            endif
          endif
        enddo
  222   continue
        ix=0
        do j=1,nassembly0
          if (sum(datax(:,j)) > 1.0e-20) then
            ix=ix+1
            calcdata(i)%pownodal(:,ix)=datax(:,j)
            ss4=''
            write(ss4,'("D",i3.3)') ix
            calcdata(i)%cDET(ix)=ss4
          endif
        enddo
      enddo
  111 continue
!
!     read measured data
      open(2,file=file1,status='old')
      allocate(measdata(nmeasure))
      allocate(axialmesh0(naxial0))
      axialmesh0(:)=0.0
      do j=2,naxial0
        axialmesh0(j)=axialmesh0(j-1)+height/float(naxial0-1)
      enddo
      write(6,*) axialmesh0(:)
      read(2,*) ss10,nx,naxial1
      if (naxial0 .ne. naxial1) then
        write(6,*) "Error: # of axial meshes do not match in the measured data"
        stop
      endif
      if (nx .ne. nmeasure) then
        write(6,*) "Error: # of cases do not match in the measured data"
        stop
      endif
      do i=1,nmeasure
        idparcs=i
        measdata(i)%naxial=naxial1
        read(2,*)
        read(2,*)
        read(2,*) ss10,measdata(i)%ndets
        allocate(measdata(i)%mDET(measdata(i)%ndets))
        allocate(measdata(i)%mpownodal(measdata(i)%naxial,measdata(i)%ndets))
        allocate(measdata(i)%axialmesh(measdata(i)%naxial))
        read(2,*) (measdata(i)%mDET(k),k=1,measdata(i)%ndets)
        !do j=1,measdata(i)%naxial
```

```
      do j=measdata(i)%naxial,1,-1
        read(2,*) tempr,(measdata(i)%mpownodal(j,k),k=1,measdata(i)%ndets)
        measdata(i)%axialmesh(j)=axialmesh0(j)
      enddo
      read(2,*,end=200)
200   continue
      !sum over radial & axial and normalize
      allocate(measdata(i)%mpowradial(measdata(i)%ndets))
      allocate(measdata(i)%ldata(measdata(i)%ndets))
      allocate(measdata(i)%mpowaxial(measdata(i)%naxial))
      measdata(i)%mpowradial(:)=0.0
      measdata(i)%mpowaxial(:)=0.0
      sum0=0.0
      do j=1,measdata(i)%naxial
        do k=1,measdata(i)%ndets
          measdata(i)%mpowradial(k)=measdata(i)%mpowradial(k)+measdata(i)%mpownodal(j,k)
          measdata(i)%mpowaxial(j)=measdata(i)%mpowaxial(j)+measdata(i)%mpownodal(j,k)
          sum0=sum0+measdata(i)%mpownodal(j,k)
        enddo
      enddo
      !Sort out the detectors without data
      measdata(i)%ldata(:)=.false.
      numdet=0
      do k=1,measdata(i)%ndets
        if (measdata(i)%mpowradial(k) > 1.0e-5) then
          measdata(i)%ldata(k)=.true.
          numdet=numdet+1
        endif
      enddo
      measdata(i)%ndets_active=numdet
      !normalization
      do k=1,measdata(i)%ndets
        measdata(i)%mpowradial(k)=measdata(i)%mpowradial(k)/sum0*float(numdet)
      enddo
      do j=1,measdata(i)%naxial
        measdata(i)%mpowaxial(j)=measdata(i)%mpowaxial(j)/sum0*float(measdata(i)%naxial)
      enddo
      do j=1,measdata(i)%naxial
        do k=1,measdata(i)%ndets
          measdata(i)%mpownodal(j,k)=measdata(i)%mpownodal(j,k)/sum0*float(numdet*measdata(i)%naxial)
        enddo
      enddo
      !
      !convert the calculated data into the measured format
      allocate(measdata(i)%cpownodal(naxial,measdata(i)%ndets))
      allocate(measdata(i)%cpowradial(measdata(i)%ndets))
      allocate(measdata(i)%cpowaxial(naxial))
      allocate(measdata(i)%mpownodal2(naxial,measdata(i)%ndets))
      allocate(measdata(i)%mpowradial2(measdata(i)%ndets))
      allocate(measdata(i)%mpowaxial2(naxial))
      allocate(mapradial(measdata(i)%ndets))
      allocate(mapaxial(naxial,2))
      !axial mesh mapping
      mapaxial(:,:)=0
      do j=1,naxial
        zpoint=0.5*(axialmesh(j-1)+axialmesh(j))
        do j2=1,measdata(i)%naxial-1
          if ((zpoint-measdata(i)%axialmesh(j2))*(zpoint-measdata(i)%axialmesh(j2+1)) < 0.0) then
            nid=j2
            !write(6,*) j,j2,measdata(i)%axialmesh(j),axialmesh(j2),axialmesh(j2+1)
            exit
          elseif ((zpoint-measdata(i)%axialmesh(j2))*(zpoint-measdata(i)%axialmesh(j2+1)) == 0.0) then
            if (zpoint == measdata(i)%axialmesh(j2)) then
              nid=j2
            else
              nid=j2+1
            endif
            exit
          endif
        enddo
        if (nid > measdata(i)%naxial) nid=nid-1
        mapaxial(j,1)=nid
        mapaxial(j,2)=nid+1
      enddo
      !radial mesh mapping
      mapradial(:)=0
      do k=1,measdata(i)%ndets
        if (.not.measdata(i)%ldata(k)) cycle
        kr=.false.
        do k2=1,ndets
          if (measdata(i)%mDET(k) == mDET(k2)) then
```

```
      !write(6,*) k,mDET(k2),"  ",cDET(k2)
      kr=.true.
      kid=k2
      exit
    endif
  enddo
  if (.not.kr) then
    write(6,*) "Error: there is no matching detector #1!"
  endif
  kr=.false.
  do k2=1,nassembly
    if (calcdata(idparcs)%cDET(k2) == cDET(kid)) then
      kr=.true.
      mapradial(k)=k2
      exit
    endif
  enddo
  if (.not.kr) then
    write(6,*) "Error: there is no matching detector #2!"
  endif
enddo
!Data re-assignment for the calculated
measdata(i)%cpownodal(:,:)=0.0
do j=1,naxial
  do k=1,measdata(i)%ndets
    if (.not.measdata(i)%ldata(k)) cycle
    k2=mapradial(k)
    measdata(i)%cpownodal(j,k)=calcdata(idparcs)%pownodal(j,k2)
  enddo
enddo
measdata(i)%cpowradial(:)=0.0
measdata(i)%cpowaxial(:)=0.0
sum0=0.0
do j=1,naxial
  do k=1,measdata(i)%ndets
    if (.not.measdata(i)%ldata(k)) cycle
    measdata(i)%cpowradial(k)=measdata(i)%cpowradial(k)+measdata(i)%cpownodal(j,k)
    measdata(i)%cpowaxial(j)=measdata(i)%cpowaxial(j)+measdata(i)%cpownodal(j,k)
    sum0=sum0+measdata(i)%cpownodal(j,k)
  enddo
enddo
!normalization
do k=1,measdata(i)%ndets
  measdata(i)%cpowradial(k)=measdata(i)%cpowradial(k)/sum0*float(measdata(i)%ndets_active)
enddo
do j=1,naxial
  measdata(i)%cpowaxial(j)=measdata(i)%cpowaxial(j)/sum0*float(naxial)
enddo
do j=1,naxial
  do k=1,measdata(i)%ndets
    measdata(i)%cpownodal(j,k)=measdata(i)%cpownodal(j,k)/sum0*float(measdata(i)%ndets_active*naxial)
  enddo
enddo
!Data re-assignment for the measured
measdata(i)%mpownodal2(:,:)=0.0
do j=1,naxial
  zpoint=0.5*(axialmesh(j-1)+axialmesh(j))
  j1=mapaxial(j,1)
  j2=mapaxial(j,2)
  x1=measdata(i)%axialmesh(j1)
  x2=measdata(i)%axialmesh(j2)
  do k=1,measdata(i)%ndets
    if (.not.measdata(i)%ldata(k)) cycle
    y1=measdata(i)%mpownodal(j1,k)
    y2=measdata(i)%mpownodal(j2,k)
    if (j1 == j2) then
      yout=measdata(i)%mpownodal(j1,k)
    else
      yout=(y2-y1)*zpoint/(x2-x1)+(y1*x2-y2*x1)/(x2-x1)
    endif
    measdata(i)%mpownodal2(j,k)=yout
  enddo
enddo
measdata(i)%mpowradial2(:)=0.0
measdata(i)%mpowaxial2(:)=0.0
sum0=0.0
do j=1,naxial
  do k=1,measdata(i)%ndets
    measdata(i)%mpowradial2(k)=measdata(i)%mpowradial2(k)+measdata(i)%mpownodal2(j,k)
    measdata(i)%mpowaxial2(j)=measdata(i)%mpowaxial2(j)+measdata(i)%mpownodal2(j,k)
    sum0=sum0+measdata(i)%mpownodal2(j,k)
```

```
  enddo
enddo
!normalization
do k=1,measdata(i)%ndets
  measdata(i)%mpowradial2(k)=measdata(i)%mpowradial2(k)/sum0*float(measdata(i)%ndets_active)
enddo
do j=1,naxial
  measdata(i)%mpowaxial2(j)=measdata(i)%mpowaxial2(j)/sum0*float(naxial)
enddo
do j=1,naxial
  do k=1,measdata(i)%ndets
    measdata(i)%mpownodal2(j,k)=measdata(i)%mpownodal2(j,k)/sum0*float(measdata(i)%ndets_active*naxial)
  enddo
enddo
!
!Data processing for %RMSs
rms_all=0.0
rms_radial=0.0
rms_axial=0.0
max_all=0.0
max_radial=0.0
max_axial=0.0
min_all=0.0
min_radial=0.0
min_axial=0.0
do j=1,naxial
  do k=1,measdata(i)%ndets
    if (.not.measdata(i)%ldata(k)) cycle
    diff=measdata(i)%cpownodal(j,k)-measdata(i)%mpownodal2(j,k)
    diff2=diff**2
    rms_all=rms_all+diff2
    if (diff > max_all) max_all=diff
    if (diff < min_all) min_all=diff
  enddo
enddo
rms_all=sqrt(rms_all/float(measdata(i)%ndets_active*naxial))*100.0
do k=1,measdata(i)%ndets
  if (.not.measdata(i)%ldata(k)) cycle
  diff=measdata(i)%cpowradial(k)-measdata(i)%mpowradial2(k)
  diff2=diff**2
  rms_radial=rms_radial+diff2
  if (diff > max_radial) max_radial=diff
  if (diff < min_radial) min_radial=diff
enddo
rms_radial=sqrt(rms_radial/float(measdata(i)%ndets_active))*100.0
do j=1,naxial
  diff=measdata(i)%cpowaxial(j)-measdata(i)%mpowaxial2(j)
  diff2=diff**2
  rms_axial=rms_axial+diff2
  if (diff > max_axial) max_axial=diff
  if (diff < min_axial) min_axial=diff
enddo
rms_axial=sqrt(rms_axial/float(naxial))*100.0
mao=0.0
cao=0.0
sum1=0.0
sum2=0.0
zpoint=0.5*axialmesh(naxial)
do j=1,naxial
  dz=axialmesh(j)-axialmesh(j-1)
  sum1=sum1+measdata(i)%mpowaxial2(j)*dz
  sum2=sum2+measdata(i)%cpowaxial(j)*dz
  if (zpoint > axialmesh(j)) then
    mao=mao+measdata(i)%mpowaxial2(j)*dz
    cao=cao+measdata(i)%cpowaxial(j)*dz
  elseif (zpoint < axialmesh(j-1)) then
    cycle
  elseif (zpoint > axialmesh(j-1) .and. zpoint < axialmesh(j) ) then
    dz=abs(zpoint-axialmesh(j-1))
    mao=mao+measdata(i)%mpowaxial2(j)*dz
    cao=cao+measdata(i)%cpowaxial(j)*dz
  endif
enddo
mao=(sum1-2.0*mao)/sum1*100.0
cao=(sum2-2.0*cao)/sum2*100.0
!
if (i==1) write(21,*) ctitle
write(21,*)
write(21,'("@Case =        ",i5)') i
write(21,'("Burnup(MWD/kgU)",f10.3)') measdata(i)%burnup
write(21,'("% RMS for 3D    ",f10.3,i5)")') rms_all,measdata(i)%ndets_active*naxial
```

```
        write(21,'("% RMS for radial",f10.3,i5)")') rms_radial,measdata(i)%ndets_active
        write(21,'("% RMS for axial ",f10.3,i5)")') rms_axial,naxial
        !write(21,'("% axial offsets ",2f10.3)")') mao,cao

        write(21,*)
        do k=1,measdata(i)%ndets
          if (.not.measdata(i)%ldata(k)) cycle
          diff=(measdata(i)%cpowradial(k)-measdata(i)%mpowradial2(k))*100.0
          write(21,'(a5,4f10.3)') measdata(i)%mDET(k),measdata(i)%mpowradial2(k),measdata(i)%cpowradial(k),diff
        enddo
!
        write(21,*)
        do j=1,naxial
          diff=(measdata(i)%cpowaxial(j)-measdata(i)%mpowaxial2(j))*100.0
          zpoint=0.5*(axialmesh(j-1)+axialmesh(j))
          write(21,'(i5,4f10.3)') j,zpoint,measdata(i)%mpowaxial2(j),measdata(i)%cpowaxial(j),diff
        enddo
!
        deallocate(mapaxial)
        deallocate(mapradial)
      enddo
  100 continue
!
      close(21)
!
      stop
      end
```

D.2 Cycle–1 Input

```
%TITLE
 'SURRY cycle-1'
%MEASURED
 file surry_cyc1_measure.dat
 dim   5   50  61  368.832  !# of parc burnup points, # of detectors, # of axial, height
    29  42  78  107  114
%CALCULATED
 file depl-cyc1-s.parcs_cyc-01_s
 dim  117  39  157  221  1 !# of burnups / # of axials / # of assemblies / symmetry (1:full, 4:quarter
     6.123   !1   6.123 bottom to top
     9.933   !2   3.81
     19.574  !3   9.642
     29.216  !4   9.642
     38.858  !5   9.642
     48.499  !6   9.642
     58.141  !7   9.642
     67.783  !8   9.642
     71.593  !9   3.81
     82.099  !10  10.506
     92.606  !11  10.506
     103.112 !12  10.506
     113.619 !13  10.506
     124.125 !14  10.506
     134.632 !15  10.506
     138.442 !16  3.81
     148.948 !17  10.506
     159.455 !18  10.506
     169.961 !19  10.506
     180.467 !20  10.506
     190.974 !21  10.506
     201.480 !22  10.506
     205.290 !23  3.81
     215.797 !24  10.506
     226.303 !25  10.506
     236.810 !26  10.506
     247.316 !27  10.506
     257.823 !28  10.506
     268.329 !29  10.506
     272.139 !30  3.81
     282.646 !31  10.506
     293.152 !32  10.506
     303.659 !33  10.506
     314.165 !34  10.506
     324.672 !35  10.506
     335.178 !36  10.506
     338.988 !37  3.81
     353.910 !38  14.9220
     368.832 !39  14.9220
```

```
%INDEX   50
         1   H01  D002    ! PARCS MEASURED
         2   F02  D009    !
         3   M03  D011    !
         4   J03  D014    !
         5   H03  D015    !
         6   D03  D019    !
         7   L04  D022    !
         8   H04  D025    !
         9   F04  D027    !
        10   N05  D032    !
        11   L05  D034    !
        12   J05  D036    !
        13   E05  D040    !
        14   D05  D041    !
        15   B05  D043    !
        16   L06  D047    !
        17   H06  D050    !
        18   F06  D052    !
        19   N07  D059    !
        20   J07  D063    !
        21   G07  D065    !
        22   D07  D068    !
        23   B07  D070    !
        24   R08  D072    !
        25   N08  D074    !
        26   L08  D076    !
        27   F08  D081    !
        28   C08  D084    !
        29   B08  D085    !
        30   L09  D091    !
        31   G09  D095    !
        32   F09  D096    !
        33   A09  D101    !
        34   N10  D103    !
        35   J10  D107    !
        36   D10  D112    !
        37   B10  D114    !
        38   L11  D118    !
        39   H11  D121    !
        40   F11  D123    !
        41   E11  D124    !
        42   N12  D128    !
        43   J12  D132    !
        44   D12  D137    !
        45   C12  D138    !
        46   H13  D143    !
        47   F13  D145    !
        48   L14  D148    !
        49   G14  D152    !
        50   J15  D155    !
%CORE
 15  15
    0   0   0   0   0   0   0   1   0   0   0   0   0   0   0  !1
    0   0   0   0   0   0   0   0   0   2   0   0   0   0   0  !2
    0   0   0   3   0   0   4   5   0   0   0   6   0   0   0  !3
    0   0   0   0   7   0   0   8   0   9   0   0   0   0   0  !4
    0   0  10   0  11   0  12   0   0   0  13  14   0  15   0  !5
    0   0   0   0  16   0   0  17   0  18   0   0   0   0   0  !6
    0   0  19   0   0   0  20   0  21   0   0  22   0  23   0  !7
   24   0  25   0  26   0   0   0   0  27   0   0  28  29   0  !8
    0   0   0   0  30   0   0   0  31  32   0   0   0   0  33  !9
    0   0  34   0   0   0  35   0   0   0   0  36   0  37   0  !10
    0   0   0   0  38   0   0  39   0  40  41   0   0   0   0  !11
    0   0  42   0   0   0  43   0   0   0   0  44  45   0   0  !12
    0   0   0   0   0   0   0  46   0  47   0   0   0   0   0  !13
    0   0   0   0  48   0   0   0  49   0   0   0   0   0   0  !14
    0   0   0   0   0   0  50   0   0   0   0   0   0   0   0  !15
%END
```

D.3 Cycle–2 Input

```
%TITLE
 'SURRY cycle-2'
%MEASURED
 file surry_cyc2_measure.dat
 dim   5   50  61  368.832  !# of parc burnup points, # of detectors, # of axial, height
    2  4  26  65  76
%CALCULATED
```

```
 file depl-cyc2-s.parcs_cyc-01_s
 dim  75  39  157  221  1 !# of burnups / # of axials / # of assemblies / symmetry (1:full, 4:quarter
     6.123   !1   6.123 bottom to top
     9.933   !2   3.81
     19.574  !3   9.642
     29.216  !4   9.642
     38.858  !5   9.642
     48.499  !6   9.642
     58.141  !7   9.642
     67.783  !8   9.642
     71.593  !9   3.81
     82.099  !10  10.506
     92.606  !11  10.506
     103.112 !12  10.506
     113.619 !13  10.506
     124.125 !14  10.506
     134.632 !15  10.506
     138.442 !16  3.81
     148.948 !17  10.506
     159.455 !18  10.506
     169.961 !19  10.506
     180.467 !20  10.506
     190.974 !21  10.506
     201.480 !22  10.506
     205.290 !23  3.81
     215.797 !24  10.506
     226.303 !25  10.506
     236.810 !26  10.506
     247.316 !27  10.506
     257.823 !28  10.506
     268.329 !29  10.506
     272.139 !30  3.81
     282.646 !31  10.506
     293.152 !32  10.506
     303.659 !33  10.506
     314.165 !34  10.506
     324.672 !35  10.506
     335.178 !36  10.506
     338.988 !37  3.81
     353.910 !38  14.9220
     368.832 !39  14.9220
%INDEX   50
          1   H01  D002    ! PARCS MEASURED
          2   F02  D009    !
          3   M03  D011    !
          4   J03  D014    !
          5   H03  D015    !
          6   D03  D019    !
          7   L04  D022    !
          8   H04  D025    !
          9   F04  D027    !
         10   N05  D032    !
         11   L05  D034    !
         12   J05  D036    !
         13   E05  D040    !
         14   D05  D041    !
         15   B05  D043    !
         16   L06  D047    !
         17   H06  D050    !
         18   F06  D052    !
         19   N07  D059    !
         20   J07  D063    !
         21   G07  D065    !
         22   D07  D068    !
         23   B07  D070    !
         24   R08  D072    !
         25   N08  D074    !
         26   L08  D076    !
         27   F08  D081    !
         28   C08  D084    !
         29   B08  D085    !
         30   L09  D091    !
         31   G09  D095    !
         32   F09  D096    !
         33   A09  D101    !
         34   N10  D103    !
         35   J10  D107    !
         36   D10  D112    !
         37   B10  D114    !
         38   L11  D118    !
         39   H11  D121    !
```

```
           40    F11  D123     !
           41    E11  D124     !
           42    N12  D128     !
           43    J12  D132     !
           44    D12  D137     !
           45    C12  D138     !
           46    H13  D143     !
           47    F13  D145     !
           48    L14  D148     !
           49    G14  D152     !
           50    J15  D155     !
%CORE
 15  15
    0   0   0   0   0   0   0   1   0   0   0   0   0   0   0  !1
    0   0   0   0   0   0   0   0   0   2   0   0   0   0   0  !2
    0   0   0   3   0   0   4   5   0   0   0   6   0   0   0  !3
    0   0   0   0   7   0   0   8   0   9   0   0   0   0   0  !4
    0   0  10   0  11   0  12   0   0   0  13  14   0  15   0  !5
    0   0   0   0  16   0   0  17   0  18   0   0   0   0   0  !6
    0   0  19   0   0   0  20   0  21   0   0  22   0  23   0  !7
   24   0  25   0  26   0   0   0   0  27   0   0  28  29   0  !8
    0   0   0   0  30   0   0   0  31  32   0   0   0   0  33  !9
    0   0  34   0   0   0  35   0   0   0   0  36   0  37   0  !10
    0   0   0   0  38   0   0  39   0  40  41   0   0   0   0  !11
    0   0  42   0   0   0  43   0   0   0   0  44  45   0   0  !12
    0   0   0   0   0   0   0  46   0  47   0   0   0   0   0  !13
    0   0   0   0  48   0   0   0  49   0   0   0   0   0   0  !14
    0   0   0   0   0   0  50   0   0   0   0   0   0   0   0  !15
%END
```

D.4 Cycle–1 Power Map Measured Data

cycl 5 61
MAP43 Date time MWT press P/L HT D HT HFP
3/19/1973 2245 2250 144 128.2
num_det 31

	H01	F02	J03	H03	D03	F04	N05	J05	D05	B05	L06	N07	J07	R08	N08	L08	L09	G09	F09	N10	J10	L11	H11	F11	N12	D12	C12	H13	F13	L14	J15
1	1.172	1.135	1.585	1.684	0.961	1.265	0.923	1.460	1.247	0.735	1.241	1.097	1.445	0.848	1.281	1.534	1.452	1.364	1.393	1.148	1.541	1.243	1.503	1.411	0.704	0.949	0.729	1.113	1.162	0.765	0.713
2	1.531	1.282	2.070	2.200	1.046	1.784	1.156	1.967	1.276	0.677	1.555	1.374	1.982	1.100	1.605	2.051	1.942	1.818	1.858	1.440	1.774	1.733	1.730	1.967	0.883	1.336	1.026	1.458	1.453	0.998	0.798
3	1.858	1.765	2.513	2.671	1.424	2.316	1.534	2.551	1.725	0.929	2.064	1.823	2.595	1.479	2.140	2.665	2.523	2.382	2.433	1.920	2.397	2.255	2.337	2.549	1.177	1.714	1.316	1.960	1.961	1.314	1.109
4	2.154	2.185	2.912	3.096	1.767	2.835	1.923	3.043	2.189	1.181	2.487	2.286	3.388	1.876	2.659	3.256	3.086	2.909	2.972	2.386	2.973	2.701	2.899	3.110	1.462	2.092	1.606	2.446	2.433	1.613	1.410
5	2.307	2.563	3.112	3.308	2.075	3.277	2.301	3.550	2.624	1.451	3.096	2.735	3.716	2.273	3.129	3.796	3.594	3.455	3.529	2.808	3.540	3.221	3.461	3.604	1.721	2.424	1.861	2.947	2.869	1.862	1.721
6	2.945	2.711	3.983	4.234	2.178	3.379	2.490	3.657	2.972	1.635	3.350	2.960	3.916	2.435	3.372	3.930	3.721	3.600	3.678	3.026	3.891	3.329	3.794	3.713	1.854	2.498	1.910	3.182	3.087	1.896	1.868
7	3.347	3.278	4.526	4.810	2.624	4.302	3.046	4.687	3.117	1.858	4.098	3.620	4.847	3.246	3.956	4.927	4.665	4.655	4.755	3.549	4.405	4.245	4.295	4.741	2.175	3.189	2.448	3.904	3.613	2.428	2.270
8	3.684	3.803	4.982	5.296	3.036	4.872	3.580	5.286	3.914	2.298	4.816	4.255	5.592	3.788	4.653	5.579	5.282	5.360	5.480	4.175	5.275	4.863	5.145	5.385	2.559	3.622	2.781	4.578	4.231	2.727	2.711
9	3.991	4.202	5.396	5.736	3.362	5.353	3.991	5.809	4.378	2.573	5.369	4.743	6.169	4.275	5.172	6.135	5.808	5.964	6.093	4.641	5.868	5.354	5.722	5.892	2.844	3.963	3.043	5.095	4.685	3.010	3.051
10	4.265	4.560	5.768	6.131	3.653	5.796	4.358	6.270	4.784	2.815	5.863	5.179	6.710	4.671	5.577	6.634	6.280	6.455	6.594	5.004	6.350	5.799	6.192	6.372	3.067	4.286	3.290	5.550	5.084	3.226	3.357
11	4.497	4.896	6.082	6.465	3.928	6.188	4.692	5.585	5.161	3.088	6.312	5.576	7.179	5.032	5.982	7.075	6.698	6.910	7.059	5.368	6.801	6.182	6.633	6.810	3.290	4.501	3.517	5.973	5.447	3.442	3.629
12	4.687	5.169	6.339	6.738	4.151	6.517	4.969	7.038	5.480	3.222	6.685	5.906	7.563	5.303	6.323	7.458	7.061	7.292	7.449	5.673	7.175	6.520	6.987	7.166	3.477	4.920	3.701	6.318	5.756	3.608	3.849
13	4.846	5.400	6.553	5.965	4.339	5.795	5.214	7.330	5.770	3.386	7.075	6.197	7.896	5.483	6.615	7.765	7.351	7.619	7.783	5.935	7.502	6.211	7.316	7.481	3.638	5.032	3.863	6.647	6.028	3.758	4.019
14	4.962	5.589	6.710	7.132	4.477	7.023	5.414	7.576	5.928	3.522	7.284	6.435	8.155	5.627	6.858	8.033	7.605	7.892	8.062	6.153	7.782	7.041	7.589	7.742	3.771	5.207	3.990	6.929	6.264	3.874	4.155
15	4.930	5.736	6.667	7.087	4.597	7.188	5.570	7.760	6.191	3.609	7.493	6.620	8.351	5.753	7.052	8.244	7.805	8.110	8.285	6.328	8.015	7.195	7.817	7.934	3.878	5.336	4.097	7.180	6.464	3.974	4.262
16	4.677	5.862	6.324	6.723	4.665	7.251	5.680	7.822	6.335	3.696	7.628	6.739	8.431	5.808	7.215	8.359	7.914	8.219	8.396	6.473	8.218	7.256	8.014	7.988	3.967	5.373	4.125	7.337	6.591	3.991	4.336
17	5.331	5.463	7.209	7.663	4.357	6.605	5.336	7.376	6.321	3.570	7.179	6.342	7.825	5.230	6.874	7.650	7.242	7.565	7.727	6.168	7.968	6.612	7.771	7.303	3.780	4.912	3.771	6.898	6.301	3.625	4.059
18	5.521	6.009	7.466	7.937	4.768	7.605	5.826	8.329	5.944	3.657	7.837	6.924	8.758	6.060	7.344	8.319	8.349	8.692	8.879	6.590	8.171	7.609	7.968	8.468	4.039	5.696	4.373	7.572	6.737	4.224	4.224
19	5.680	6.451	7.681	8.164	5.111	7.935	6.248	8.728	6.814	4.054	8.405	7.426	9.273	6.349	7.928	9.299	8.803	9.092	9.288	7.114	9.074	7.977	8.849	8.865	4.360	5.693	4.578	8.089	7.281	4.390	4.390
20	5.838	6.682	7.895	8.392	5.300	8.263	6.459	9.005	7.089	4.198	8.690	7.677	9.576	6.547	8.236	9.566	9.075	9.365	9.566	7.390	9.447	8.222	9.213	9.180	4.529	6.175	4.741	8.372	7.554	4.523	4.380
21	5.932	6.871	8.009	8.513	5.420	8.453	6.626	9.205	7.278	4.334	8.914	7.875	9.790	6.709	8.479	9.236	9.311	9.565	9.771	7.608	9.712	8.391	9.471	9.386	4.663	6.313	4.847	8.591	7.772	4.606	5.010
22	5.997	6.976	8.109	8.619	5.506	8.592	6.759	9.358	5.423	4.450	9.093	8.033	9.941	6.836	8.641	10.000	9.475	9.729	9.938	7.754	9.930	8.528	9.683	9.550	4.752	6.424	4.932	8.746	7.953	4.673	5.100
23	6.049	7.081	8.180	8.695	5.592	8.706	6.848	9.466	7.553	4.528	9.213	8.139	10.062	6.944	8.755	10.142	9.602	9.856	10.068	7.855	10.054	8.637	9.805	9.633	4.814	6.479	4.974	8.889	8.044	4.722	5.180
24	6.070	7.144	8.209	8.726	5.626	8.769	6.904	9.527	7.655	4.576	9.288	8.205	10.128	7.076	8.836	10.219	9.674	9.910	10.124	7.928	10.132	8.698	9.881	9.701	4.859	6.525	5.010	8.952	8.117	4.756	5.236
25	6.070	7.186	8.209	8.726	5.660	8.795	6.926	9.543	7.713	4.605	9.318	8.232	10.155	7.052	8.852	10.257	9.711	9.929	10.142	7.943	10.117	8.729	9.865	9.715	4.868	6.534	5.017	8.967	8.135	4.789	5.247
26	5.796	7.186	7.838	8.331	5.643	3.795	6.926	9.512	7.742	4.625	9.318	8.232	10.139	7.034	8.852	10.257	9.711	9.910	10.124	7.943	10.070	8.729	9.820	9.674	4.868	6.507	4.996	8.967	8.117	4.806	5.259
27	5.638	7.123	7.623	8.103	5.557	8.643	6.871	9.251	7.742	4.605	9.243	8.166	9.960	6.926	8.803	10.123	9.583	9.765	9.975	7.899	9.976	8.590	9.729	9.413	4.841	6.332	4.661	8.873	8.062	4.722	5.213
28	6.187	6.325	8.366	8.893	4.932	7.808	6.204	8.406	7.408	4.305	8.346	7.373	9.077	6.132	7.944	9.011	9.531	8.765	8.953	7.128	9.167	7.747	8.940	8.550	4.369	6.751	4.415	7.948	7.318	4.224	4.732
29	6.313	7.081	8.537	9.075	5.454	8.845	6.815	9.558	7.249	4.383	9.165	8.099	10.117	6.944	8.722	10.238	9.632	9.910	10.124	7.826	9.712	8.851	9.471	9.701	4.797	6.525	5.010	8.839	7.935	4.806	5.032
30	6.408	7.291	8.666	9.211	5.626	9.073	7.126	9.789	7.945	4.712	9.587	8.469	10.417	7.124	9.111	10.545	9.983	10.201	10.421	8.175	10.210	9.112	9.857	9.907	5.011	6.664	5.116	9.218	8.244	4.922	5.264
31	6.493	7.375	8.780	9.333	5.677	9.199	7.249	9.896	8.104	4.799	9.752	8.615	10.583	7.232	9.241	10.717	10.146	10.347	10.570	8.292	10.366	9.250	10.108	10.057	5.022	6.705	5.194	9.344	8.329	5.005	5.327
32	6.514	7.438	8.808	9.363	5.746	9.263	7.326	9.973	8.249	4.847	9.856	8.707	10.694	7.287	9.355	10.832	10.255	10.420	10.644	8.394	10.475	9.311	10.215	10.167	5.144	6.839	5.250	9.453	8.462	5.055	5.378
33	6.535	7.459	8.837	9.393	5.763	9.313	7.382	10.004	8.322	4.886	9.531	8.773	10.761	7.323	9.436	10.890	10.309	10.438	10.662	8.466	10.552	9.342	10.290	10.208	5.189	6.866	5.271	9.500	8.571	5.088	5.406
34	6.514	7.480	8.808	9.363	5.780	9.313	7.398	9.973	8.336	4.895	9.946	8.757	10.769	7.341	9.452	10.909	10.328	10.438	10.662	8.481	10.599	9.327	10.336	10.194	5.198	6.887	5.264	9.488	8.643	5.122	5.434
35	6.451	7.459	8.723	9.272	5.746	9.275	7.382	9.927	8.293	4.895	9.931	8.773	10.728	7.341	9.468	10.871	10.291	10.401	10.625	8.496	10.583	9.296	10.321	10.167	5.207	6.839	5.250	9.453	8.643	5.122	5.429
36	6.345	7.375	8.580	9.120	5.694	9.187	5.315	9.835	8.191	4.857	9.041	8.694	10.646	7.269	9.403	10.775	10.201	10.329	10.551	8.437	10.490	9.189	10.230	10.098	5.171	6.793	5.215	9.376	8.607	5.088	5.372
37	5.912	7.291	7.995	8.498	5.609	9.060	7.226	9.712	8.075	4.799	9.722	8.586	10.494	7.160	9.290	10.660	10.092	10.220	10.439	8.335	10.366	9.035	10.108	9.989	5.109	6.719	5.158	9.265	8.516	5.005	5.304
38	5.775	7.123	7.809	8.301	5.472	8.757	7.082	9.312	7.930	4.721	9.527	8.417	10.121	6.962	9.095	10.392	9.838	9.983	10.198	8.161	10.148	8.713	9.896	9.578	5.002	6.442	4.946	9.077	8.334	4.839	5.191
39	6.187	7.262	8.366	8.893	4.820	7.871	6.270	8.529	7.408	4.315	5.435	7.452	9.076	6.132	8.058	9.107	9.621	8.838	9.028	7.230	9.012	7.747	8.788	8.769	4.431	5.899	4.529	8.042	7.427	4.323	4.625
40	6.229	7.078	8.423	8.953	5.351	8.845	6.904	9.527	7.350	4.441	9.288	8.205	10.044	6.926	8.917	10.276	9.729	9.965	10.179	8.001	9.712	8.805	9.471	9.770	4.904	6.571	5.045	8.983	8.098	4.855	4.970
41	6.239	7.166	8.437	8.968	5.454	8.959	7.048	9.620	7.872	4.663	9.482	8.377	10.164	7.034	9.095	10.430	9.874	10.110	10.328	8.161	10.023	8.928	9.774	9.833	5.002	6.617	5.080	9.171	8.262	4.922	5.123
42	6.239	7.249	8.437	8.968	5.472	8.997	7.048	9.620	7.945	4.712	9.482	8.377	10.141	7.070	9.095	10.411	9.256	10.092	10.309	8.161	10.039	8.959	9.790	9.824	5.002	6.608	5.073	9.218	6.262	4.939	5.151
43	6.187	7.270	8.366	8.893	5.472	8.984	6.993	9.558	7.988	4.702	9.400	8.311	10.073	7.052	9.079	10.353	9.801	10.020	10.235	8.146	10.008	8.928	9.759	9.756	4.993	6.562	5.038	9.171	8.207	4.922	5.163
44	6.070	7.228	8.209	8.726	5.437	8.908	6.915	9.420	7.945	4.683	9.303	8.218	9.951	7.016	8.998	10.233	9.692	9.910	10.124	8.074	9.945	8.836	9.699	9.633	4.948	6.479	4.974	9.077	8.117	4.839	5.129
45	5.912	7.123	7.995	8.498	5.369	8.769	6.793	9.235	7.843	4.654	9.138	8.073	9.731	6.908	8.836	10.066	9.529	9.747	9.957	7.928	9.821	8.683	9.577	9.468	4.859	6.369	4.889	8.920	8.008	4.806	5.072
46	5.707	6.976	7.709	8.195	5.249	8.567	6.637	8.990	7.684	4.576	8.929	7.888	9.573	6.745	8.641	9.797	9.275	9.474	9.678	7.754	9.634	8.498	9.395	9.222	4.752	6.203	4.752	8.717	7.826	4.656	4.981
47	5.448	6.766	7.367	7.830	5.077	3.288	6.415	8.713	7.466	4.460	8.030	7.624	9.308	6.529	8.398	9.490	8.984	9.165	9.362	7.535	9.369	8.238	9.137	8.920	4.618	6.000	4.006	8.450	7.608	4.490	4.840
48	4.840	6.514	6.553	6.965	4.888	7.934	6.161	8.344	7.191	4.296	8.316	7.346	8.989	6.277	8.090	9.126	8.640	8.801	8.991	7.259	9.027	7.885	8.803	8.536	4.449	5.742	4.408	8.121	7.354	4.273	4.636
49	4.719	6.178	6.381	6.783	4.631	7.365	5.859	7.730	6.857	4.102	7.882	6.963	8.417	5.916	7.666	8.608	8.150	8.274	8.452	6.201	8.607	7.333	8.393	7.851	4.217	5.281	4.054	7.682	7.009	3.958	4.421
50	4.740	5.253	6.410	6.814	3.928	6.428	4.958	6.884	6.118	3.541	6.671	5.930	7.373	4.996	6.469	7.236	6.597	7.055	7.207	5.804	7.377	6.320	7.194	7.043	3.557	4.737	3.637	6.506	5.956	3.425	3.759
51	4.529	5.631	6.124	6.510	4.185	6.846	5.336	7.299	5.907	3.618	7.179	6.342	7.273	5.429	6.980	7.818	7.496	7.637	7.802	6.270	7.720	6.857	7.528	7.454	3.843	5.010	3.849	7.023	6.355	3.658	3.962
52	4.286	5.484	5.796	6.161	4.082	6.605	5.225	7.088	5.930	3.560	7.329	6.210	7.640	3.248	6.809	7.609	7.260	7.365	7.523	6.110	7.564	6.642	7.376	7.180	3.745	4.820	3.708	6.820	6.228	3.509	3.889
53	4.001	5.232	5.411	5.751	3.876	6.276	4.969	6.654	5.654	3.377	6.685	5.906	7.246	4.978	6.436	7.247	6.861	7.001	7.152	5.775	7.191	6.289	7.012	6.783	3.539	4.562	3.503	6.506	5.956	3.326	3.713
54	3.632	4.917	4.911	5.220	3.636	5.859	4.647	6.193	5.306	3.183	6.252	5.523	6.769	4.635	6.015	6.798	6.407	6.546	6.687	5.397	6.739	5.891	6.572	6.330	3.308	4.258	3.269	6.161	5.593	3.093	3.493
55	3.241	4.539	4.383	4.659	3.362	5.365	4.280	5.670	4.929	2.951	5.758	5.087	6.208	4.275	5.528	6.193	5.863	6.001	6.130	4.961	6.226	5.400	6.071	5.782	3.040	3.869	2.986	5.675	5.157	2.827	3.215
56	2.703	4.097	3.655	3.885	3.079	4.720	3.802	5.070	4.451	2.632	5.115	4.519	5.506	3.824	4.961	5.464	5.173	5.323	5.443	4.451	5.572	4.817	5.434	5.152	2.728	3.465	2.661	5.048	4.630	2.528	2.898
57	2.185	3.593	2.955	3.141	2.641	4.062	3.302	4.287	3.929	2.322	4.442	3.924	4.774	3.337	4.329	4.737	4.483	4.582	4.681	3.944	4.872	4.157	4.751	4.439	2.380	2.986	2.293	4.421	4.049	2.195	2.536
58	1.605	3.026	2.170	2.307	2.230	3.323	2.757	3.504	3.334	1.945	3.709	3.277	3.948	2.778	3.015	3.950	3.739	3.764	3.845	3.244	4.078	3.436	3.977	3.645	1.988	4.452	1.602	3.700	3.396	1.812	2.151
59	1.225	2.374	1.656	1.760	1.750	2.505	2.123	2.612	2.697	1.558	2.857	2.524	3.013	2.164	2.837	3.010	2.850	2.891	2.954	2.546	3.206	2.623	3.127	2.727	1.560	1.834	1.408	2.900	2.669	1.397	1.704
60	1.024	1.555	1.385	1.472	1.149	1.582	1.367	1.706	1.972	1.064	1.840	1.625	1.984	1.389	1.897	1.956	1.851	1.891	1.932	1.702	2.148	1.672	2.095	1.768	1.043	1.189	0.913	1.960	1.834	0.898	1.132

61	0.232	1.366	0.314	0.334	1.072	1.177	1.178	1.260	1.421	0.900	1.585	1.401	1.554	1.244	1.702	1.630	1.543	1.637	1.672	1.527	1.852	1.237	1.606	1.302	0.936	0.876	0.672	1.693	1.562	0.782	0.974

MAP53 Date time MWT press P/L HT D HT
8/1/1973 900 2220 2250 144 126.3
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	H01	F02	J03	H03	D03	H04	N05	J05	D05	B05	N07	B07	R08	N08	L08	B08	L09	A09	N10	J10	D10	B10	L11	H11	F11	N12	J12	C12	L14	J15
1	1.083	1.341	2.228	2.223	1.128	2.464	1.953	1.760	1.642	1.348	1.648	1.299	1.091	1.645	2.094	0.657	1.838	0.763	1.580	1.941	1.741	1.518	1.612	2.222	1.665	1.372	1.761	0.972	0.840	0.651
2	1.383	1.862	2.846	2.839	1.566	3.147	1.741	2.033	2.196	1.059	1.870	1.760	1.309	1.865	2.809	0.890	2.466	0.937	1.955	2.117	2.440	1.864	2.225	2.424	2.334	1.135	2.329	1.186	1.243	0.822
3	1.660	2.413	3.415	3.407	2.029	3.776	2.251	2.761	2.910	1.395	2.473	2.263	1.780	2.467	3.550	1.144	3.116	1.244	2.566	2.823	3.098	2.475	2.858	3.232	2.964	1.556	3.081	1.636	1.840	1.083
4	1.865	2.883	3.838	3.829	2.425	4.244	2.824	3.519	3.588	1.790	3.056	2.766	2.283	3.049	4.265	1.399	3.744	1.535	3.129	3.529	3.715	3.052	3.511	4.040	3.554	1.984	3.448	2.051	2.003	1.324
5	2.000	3.294	4.114	4.105	2.770	4.550	3.270	4.172	4.195	2.146	3.639	3.227	2.736	3.630	4.827	1.632	4.237	1.725	3.614	4.176	4.181	3.432	3.960	4.781	3.999	2.337	4.439	2.419	2.296	1.518
6	2.402	3.324	5.106	5.095	2.796	5.647	3.482	4.688	4.498	2.400	4.021	3.311	2.888	4.011	4.878	1.674	4.282	1.742	3.801	4.607	4.326	3.465	4.021	5.275	4.052	2.561	4.640	2.668	2.296	1.518
7	3.298	4.156	5.485	5.675	3.227	5.983	3.938	4.732	4.794	2.439	4.410	4.389	3.743	4.563	6.052	3.226	5.484	2.579	4.443	5.120	5.205	4.369	5.060	5.447	5.384	2.730	5.360	2.751	2.880	2.392
8	4.157	4.698	5.734	6.160	3.349	6.164	4.538	5.906	5.297	3.046	5.138	5.152	4.378	5.520	6.715	4.887	6.275	3.317	5.096	6.172	5.672	4.900	5.695	6.070	6.327	3.333	5.701	3.316	3.225	3.219
9	4.432	5.066	6.113	6.568	3.612	6.571	4.939	6.501	5.767	3.358	5.700	5.624	4.878	6.125	7.175	5.335	6.709	3.588	5.531	6.765	6.108	5.301	6.188	6.654	6.812	3.648	6.230	3.620	3.487	3.480
10	4.663	5.382	6.431	6.910	3.837	6.914	5.256	6.974	6.174	3.601	6.150	6.007	5.189	6.608	7.609	5.698	7.110	3.826	5.842	7.260	6.477	5.653	6.579	7.140	7.224	3.923	6.678	3.882	3.696	3.689
11	4.628	5.627	6.659	7.155	4.012	7.159	5.530	7.356	6.488	3.805	6.507	6.299	5.499	6.991	7.966	5.976	7.444	4.030	6.152	7.675	6.767	5.954	6.887	7.549	7.548	4.183	6.999	4.078	3.888	3.881
12	4.949	5.821	6.826	7.334	4.150	7.338	5.784	7.661	6.754	3.974	6.844	6.569	5.688	7.354	8.222	6.232	7.683	4.154	6.395	8.031	7.018	6.137	7.134	7.899	7.827	4.300	7.319	4.252	4.010	4.002
13	5.048	5.975	6.962	7.480	4.260	7.485	5.974	7.920	6.974	4.096	7.050	6.749	5.826	7.575	8.401	6.402	7.850	4.245	6.556	8.289	7.203	6.271	7.319	8.152	8.033	4.430	7.575	4.379	4.097	4.089
14	5.081	6.077	7.008	7.529	4.332	7.534	6.142	8.119	7.115	4.190	7.219	6.884	5.861	7.757	8.554	6.530	7.993	4.324	6.681	8.447	7.321	6.388	7.442	8.307	8.166	4.533	7.751	4.448	4.149	4.142
15	4.327	6.118	6.795	7.301	4.362	7.305	6.246	8.210	7.193	4.251	7.313	6.929	5.873	7.857	8.630	6.573	8.065	4.335	6.805	8.566	7.374	6.405	7.524	8.424	8.225	4.629	7.879	4.506	4.207	4.194
16	4.762	6.077	6.568	7.057	4.332	7.061	6.269	8.271	7.240	4.278	7.351	6.862	5.844	7.898	8.579	6.509	8.037	4.267	6.836	8.605	7.242	6.305	7.442	8.463	8.077	4.656	7.912	4.529	4.149	4.142
17	5.235	5.423	7.220	7.758	3.866	7.762	5.762	8.042	6.707	4.163	6.882	6.164	5.154	7.394	7.737	5.847	7.230	3.837	6.246	8.170	6.662	5.669	6.661	8.085	7.430	4.403	7.159	4.321	3.713	3.707
18	5.356	6.220	7.387	7.937	4.434	7.941	6.206	7.401	7.130	3.974	7.200	7.064	5.895	7.736	8.962	6.701	8.375	4.426	6.867	8.308	7.611	6.539	7.627	8.171	8.489	4.533	8.056	4.286	4.259	4.281
19	5.433	6.424	7.493	8.051	4.580	8.055	6.543	8.409	7.585	4.434	7.688	7.289	6.119	8.260	9.218	6.915	8.613	4.539	7.240	8.941	7.823	6.706	7.853	8.794	8.725	4.869	8.376	4.702	4.393	4.365
20	5.510	6.546	7.599	8.165	4.667	8.169	6.691	8.653	7.710	4.563	7.857	7.447	6.223	8.442	9.371	7.064	8.757	4.630	7.411	9.100	7.968	6.840	7.977	8.949	8.887	4.986	8.552	4.806	4.463	4.455
21	5.532	6.608	7.630	8.198	4.711	8.202	6.754	8.760	7.789	4.637	7.969	7.537	6.326	8.563	9.473	7.149	8.852	4.698	7.488	9.218	8.060	6.940	8.038	9.066	8.990	5.020	8.648	4.876	4.480	4.472
22	5.565	6.659	7.675	8.246	4.748	8.251	6.860	8.866	7.867	4.718	8.063	7.627	6.367	8.663	9.550	7.235	8.924	4.743	7.566	9.278	8.100	7.007	8.100	9.124	9.034	5.068	8.728	4.922	4.515	4.507
23	5.576	6.669	7.690	8.263	4.755	8.267	6.902	8.927	7.914	4.746	8.138	7.672	6.412	8.744	9.550	7.277	8.924	4.743	7.582	9.317	8.100	7.007	8.100	9.163	9.084	5.033	8.760	4.945	4.533	4.524
24	5.565	6.669	7.675	8.246	4.755	8.251	6.944	8.958	7.930	4.773	8.138	7.717	6.412	8.744	9.524	7.320	8.900	4.765	7.597	9.317	8.086	7.041	8.121	9.163	9.019	5.095	8.728	4.956	4.515	4.504
25	5.510	6.638	7.599	8.165	4.733	8.169	6.966	8.958	7.914	4.779	8.119	7.649	6.412	8.724	9.498	7.256	8.876	4.754	7.551	9.297	8.134	7.024	8.100	9.144	8.960	5.109	8.696	4.933	4.515	4.507
26	5.037	6.587	6.947	7.464	4.697	7.463	6.923	8.897	7.883	4.766	8.101	7.604	6.343	8.704	9.396	7.213	8.780	4.731	7.473	9.238	7.954	6.990	8.059	9.085	8.872	5.102	8.664	4.910	4.480	4.472
27	5.312	6.363	7.326	7.872	4.536	7.876	6.818	8.790	7.757	4.725	7.988	7.289	6.171	8.583	8.988	6.915	8.399	4.539	7.349	9.100	7.585	6.706	7.853	8.949	8.460	5.040	8.456	4.841	4.306	4.298
28	5.576	5.842	7.690	8.263	4.165	8.267	5.995	8.149	6.911	4.312	7.125	6.772	5.499	7.656	8.298	6.424	7.754	4.233	6.510	8.130	7.150	6.255	7.098	7.996	7.974	4.533	7.543	4.321	4.045	4.037
29	5.675	6.577	7.827	8.409	4.689	8.414	6.776	8.103	7.726	4.522	7.913	7.582	6.223	8.502	9.345	7.192	8.733	4.698	7.380	8.902	7.915	6.940	8.100	8.755	8.828	4.896	8.568	4.714	4.463	4.455
30	5.752	6.700	7.933	8.524	4.777	8.528	6.944	8.699	7.961	4.752	8.232	7.717	6.343	8.845	9.524	7.320	8.900	4.777	7.582	9.258	8.047	7.057	8.285	9.105	8.975	5.095	8.776	4.922	4.550	4.542
31	5.807	6.761	8.009	8.605	4.820	8.610	7.029	8.821	8.039	4.827	8.382	7.784	6.412	9.006	9.626	7.364	6.995	4.833	7.659	9.396	8.152	7.141	8.388	9.241	9.093	5.150	8.856	4.980	4.585	4.577
32	5.851	6.802	8.070	8.670	4.849	3.675	7.113	8.912	8.102	4.867	8.476	7.852	6.481	9.107	9.703	7.448	9.067	4.867	7.753	9.476	8.218	7.191	8.429	9.319	9.166	5.178	8.920	5.037	4.620	4.611
33	5.851	6.812	8.070	6.670	4.857	8.675	7.134	8.988	8.118	4.881	8.551	7.897	6.516	9.187	9.728	7.491	9.091	4.890	7.830	9.515	8.245	7.225	8.429	9.358	9.196	5.219	8.952	5.072	4.637	4.629
34	5.829	6.812	8.039	8.638	4.857	8.642	7.177	9.034	8.133	4.901	8.607	7.919	5.516	9.248	9.754	7.512	9.115	4.935	7.830	9.495	8.231	7.291	8.429	9.338	9.181	5.246	8.952	5.107	4.672	4.664
35	5.763	6.781	7.948	8.540	4.835	8.545	7.177	9.084	8.118	4.915	8.607	7.897	6.516	9.248	9.728	7.491	9.091	4.913	7.846	9.456	8.231	7.258	8.388	9.299	9.181	5.253	8.920	5.107	4.672	4.664
36	5.653	6.730	7.796	8.377	4.799	8.381	7.156	9.019	8.071	4.874	8.532	7.874	6.481	9.167	9.677	7.469	9.043	4.901	7.799	9.416	8.205	7.241	8.326	9.267	9.152	5.239	8.872	5.072	4.637	4.629
37	4.949	6.659	6.826	7.334	4.748	7.338	7.092	8.988	7.992	4.813	8.432	7.762	6.315	9.066	9.575	7.363	8.947	4.833	7.737	9.317	8.139	7.141	8.223	9.163	9.078	5.184	8.792	5.026	4.585	4.577
38	5.510	6.281	7.599	8.165	4.478	8.169	6.902	8.866	7.789	4.725	8.251	7.334	6.119	8.865	9.039	6.957	8.446	4.539	7.519	9.179	7.611	6.706	7.874	9.027	8.489	5.075	8.536	4.922	4.271	4.263
39	5.697	6.138	7.857	8.442	4.376	8.447	6.079	7.966	6.927	4.224	7.238	7.109	5.671	7.777	8.630	6.744	8.065	4.381	6.696	8.071	7.519	6.472	7.237	7.938	8.386	5.499	7.783	4.321	4.271	4.263
40	5.763	6.700	7.948	8.540	4.777	8.545	6.881	8.531	7.898	4.624	8.157	7.762	6.343	8.764	9.550	7.363	8.924	4.788	7.613	9.159	8.165	7.074	8.223	9.008	9.107	5.027	8.776	4.876	4.585	4.577
41	5.829	6.812	8.039	8.638	4.857	8.642	6.987	8.912	8.086	4.806	8.344	7.829	6.447	8.965	9.652	7.427	9.019	4.867	7.784	9.456	8.258	7.191	8.388	9.299	9.210	5.164	8.936	5.074	4.655	4.646
42	5.862	6.863	8.085	8.696	4.893	8.691	7.092	9.019	8.165	4.867	8.401	7.897	6.533	9.026	9.728	7.491	9.091	4.913	7.815	9.574	8.311	7.258	8.449	9.416	9.269	5.212	9.001	5.060	4.707	4.698
43	5.851	6.904	8.070	8.670	4.922	8.675	7.156	9.065	8.212	4.908	8.438	7.919	6.568	9.066	9.703	7.512	9.067	4.935	7.846	9.614	8.284	7.291	8.511	9.455	9.240	5.260	9.033	5.084	4.724	4.716
44	5.807	6.894	8.009	8.605	4.915	8.610	7.177	9.080	8.227	4.915	8.438	7.919	6.585	9.066	9.677	7.512	9.043	4.913	7.799	9.634	8.258	7.258	8.470	9.475	9.210	5.246	9.001	5.084	4.707	4.698
45	5.697	6.843	7.857	6.442	4.879	8.447	7.177	9.050	8.165	4.888	8.363	7.874	6.533	8.986	9.601	7.469	8.971	4.679	7.706	9.535	8.192	7.208	8.408	9.377	9.137	5.212	8.936	5.060	4.672	4.664
46	5.554	6.751	7.660	8.230	4.813	8.235	7.071	8.988	8.055	4.834	8.251	7.784	6.464	8.865	9.447	7.364	8.828	4.811	7.597	9.396	8.073	7.107	8.326	9.241	9.004	5.143	8.808	4.980	4.568	4.559
47	5.323	6.618	7.341	7.888	4.718	7.892	6.966	8.851	7.898	4.746	8.119	7.604	6.343	8.724	9.243	7.213	8.637	4.698	7.488	9.238	7.915	6.940	8.162	9.085	8.828	5.034	8.616	4.887	4.445	4.437
48	4.564	6.373	6.295	6.763	4.544	6.767	6.754	8.653	7.648	4.617	7.913	7.379	6.154	8.502	8.988	7.000	8.399	4.550	7.302	9.007	7.677	6.723	7.936	8.852	8.563	4.890	8.360	4.760	4.254	4.246
49	5.004	5.719	6.902	7.415	4.078	7.419	6.396	8.332	7.209	4.414	7.576	6.637	5.706	8.139	8.171	6.296	7.635	4.098	6.914	8.625	6.820	6.054	7.278	8.482	7.607	4.663	7.799	4.529	3.766	3.759
50	4.905	5.719	6.765	7.269	4.078	7.273	5.572	7.157	6.425	3.771	6.544	6.637	5.413	7.031	8.043	6.296	7.516	4.098	6.168	7.438	6.952	6.054	6.825	7.315	7.754	4.025	7.175	3.928	3.835	3.828
51	4.729	5.862	6.522	7.008	4.180	7.012	6.079	7.829	6.939	4.116	7.275	6.839	5.688	7.817	8.375	6.466	7.826	4.168	6.758	8.249	7.123	6.188	7.298	8.113	7.945	4.416	7.687	4.333	3.870	3.863
52	4.553	5.699	6.280	6.747	4.063	6.751	5.910	7.783	6.848	4.055	7.163	6.659	5.550	7.696	8.145	6.317	7.611	4.075	6.603	8.111	6.952	6.020	7.154	7.977	7.754	4.300	7.527	4.263	3.748	3.741
53	4.278	5.474	5.900	6.340	3.903	6.343	5.657	7.569	6.613	3.893	6.919	6.367	5.309	7.434	7.813	6.040	7.301	3.894	6.339	7.814	6.648	5.753	6.887	7.685	7.415	4.128	7.287	4.113	3.574	3.567
54	3.905	5.168	5.385	5.786	3.684	5.789	5.340	7.218	6.284	3.689	6.582	6.007	5.033	7.072	7.354	5.698	6.872	3.690	5.950	7.418	6.279	5.452	6.517	7.296	7.008	3.902	6.967	3.894	3.347	3.341
55	3.476	4.790	4.793	5.150	3.415	5.153	4.960	6.745	5.861	3.432	6.113	5.534	4.671	6.568	6.766	5.250	6.323	3.407	5.500	6.924	5.317	5.034	6.044	6.809	6.488	3.614	6.454	3.628	3.086	3.080
56	2.948	4.310	4.065	4.368	3.073	4.370	4.454	6.135	5.313	3.080	5.550	4.972	4.154	5.964	5.975	4.716	5.583	3.045	4.878	6.231	5.211	4.499	5.469	6.128	5.812	3.285	5.862	3.258	2.720	2.715
57	2.343	3.717	3.231	3.471	2.650	3.473	3.884	5.433	4.623	2.694	4.857	4.275	3.620	5.218	5.158	4.055	4.820	2.649	4.241	5.460	4.485	3.913	4.708	5.370	5.002	2.887	5.109	2.854	2.353	2.349
58	1.584	3.033	2.184	2.347	2.163	2.348	3.229	4.609	3.871	2.281	4.050	3.487	2.965	4.352	4.187	3.308	3.913	2.128	3.480	4.570	3.654	3.144	3.866	4.494	4.046	2.428	4.244	2.357	1.900	1.897
59	1.408	2.175	1.942	2.096	1.551	2.087	2.470	3.617	2.946	1.780	3.169	2.520	2.155	3.405	3.013	2.390	2.815	1.517	2.641	3.541	2.559	2.241	2.878	3.482	2.898	1.893	3.283	1.791	1.290	1.288
60	0.847	1.563	1.168	1.255	1.114	1.256	1.689	2.365	1.928	1.144	2.100	1.912	1.569	2.256	2.400	1.814	2.243	1.200	1.864	2.354	1.926	1.773	1.932	2.315	2.148	1.221	4.306	1.167	1.081	1.079
61	0.165	1.385	0.228	0.244	0.968	0.245	1.562	1.938	1.457	0.995	1.819	1.687	1.396	1.954	2.094	1.601	1.957	1.245	1.569	2.018	1.702	1.840	1.521	1.984	1.898	1.084	1.890	0.878	0.941	0.940

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	H01	F02	D03	N05	B05	D07	L08	N10	L11	N12	L14	J15
1	1.668	2.303	1.963	2.783	1.937	3.432	3.216	2.598	2.410	1.791	1.339	1.500
2	2.070	2.800	2.412	3.239	1.752	3.629	3.713	3.237	3.079	2.071	1.775	1.942
3	2.578	3.508	3.026	4.025	2.287	4.734	4.674	4.021	3.919	2.649	2.302	2.442
4	3.147	4.040	3.491	4.560	2.748	5.759	5.570	4.688	4.740	3.135	2.214	2.898
5	3.613	4.402	3.779	4.827	3.122	6.197	6.278	5.261	5.360	3.493	3.155	3.192
6	3.623	4.409	3.783	5.095	3.108	6.029	6.290	5.179	5.530	3.421	3.360	3.295
7	4.548	5.334	4.564	5.928	3.663	6.646	7.155	6.285	6.088	4.151	3.705	3.918
8	4.953	5.725	4.879	6.369	4.033	7.674	7.921	6.911	6.939	4.487	4.074	4.319
9	5.222	6.009	5.104	6.636	4.237	8.153	8.207	7.216	7.364	4.711	4.346	4.572
10	5.473	6.137	5.330	6.903	4.422	8.462	8.587	7.434	7.630	5.067	4.600	4.794
11	5.589	6.329	5.465	7.092	4.552	8.702	8.786	7.609	7.870	5.085	4.683	4.283
12	5.666	6.436	5.570	7.171	4.644	8.839	8.953	7.696	7.949	5.104	4.731	4.913
13	5.666	6.436	5.585	7.265	4.644	8.904	8.919	7.754	8.002	5.123	4.747	4.913
14	5.646	6.471	5.570	7.328	4.644	8.941	8.886	7.740	8.056	5.160	4.763	4.896
15	5.569	6.400	5.495	7.265	4.663	8.873	8.853	7.725	7.949	5.104	4.747	4.624
16	5.377	6.116	5.240	6.777	4.570	8.702	8.720	7.594	7.790	4.992	4.667	4.616
17	4.779	5.547	4.744	6.479	4.052	7.982	7.888	6.707	7.045	4.375	4.322	4.207
18	5.434	6.294	5.390	7.060	4.422	7.914	8.254	7.507	7.152	4.992	4.475	4.705
19	5.531	6.365	5.435	7.171	4.626	8.496	8.753	7.754	7.630	5.104	4.619	4.760
20	5.531	6.471	5.465	7.155	4.626	8.530	8.720	7.798	7.630	5.067	4.619	4.794
21	5.492	6.542	5.435	7.123	4.644	8.530	8.720	7.769	7.604	5.048	4.613	4.765
22	5.492	6.400	5.420	7.139	4.644	8.530	8.686	7.754	7.577	5.029	4.555	4.765
23	5.454	6.329	5.390	7.139	4.607	8.496	8.653	7.725	7.524	4.992	4.555	4.720
24	5.434	6.294	5.315	7.108	4.589	8.462	8.520	7.638	7.471	4.973	4.539	4.690
25	5.357	6.222	5.255	7.076	4.570	8.359	8.387	7.565	7.418	4.936	4.723	4.631
26	5.280	6.080	5.149	6.982	4.515	8.256	8.320	7.391	7.338	4.861	4.443	4.557
27	5.049	5.725	4.864	6.447	4.404	8.119	8.121	7.202	7.205	4.655	4.362	4.260
28	4.471	5.369	4.519	6.227	3.867	7.400	7.222	6.300	6.434	4.169	3.785	4.008
29	5.068	5.938	4.984	6.777	4.311	7.468	7.588	7.187	6.806	4.711	4.234	4.379
30	5.145	5.974	4.984	6.825	4.422	8.070	8.021	7.362	7.231	4.786	4.362	4.408
31	5.145	6.009	5.074	6.903	4.459	8.085	8.087	7.420	7.311	4.824	4.362	4.423
32	5.145	5.974	4.969	6.919	4.478	8.119	8.154	7.449	7.338	4.824	4.378	4.438
33	5.184	5.974	4.999	6.888	4.496	8.153	8.121	7.478	7.338	4.842	4.427	4.423
34	3.184	5.938	5.014	6.903	4.478	8.188	8.087	7.522	7.285	4.842	4.427	4.453
35	5.165	5.902	4.954	6.935	4.459	8.188	8.121	7.507	7.231	4.824	4.410	4.402
36	5.126	5.902	4.939	6.856	4.422	8.188	8.087	7.478	7.231	4.824	4.410	4.394
37	5.088	5.796	4.879	6.777	4.348	8.158	8.054	7.362	7.205	4.768	4.378	4.319
38	4.837	5.476	4.609	6.259	4.293	8.051	7.888	7.129	7.079	4.543	4.282	4.052
39	4.509	5.262	4.444	6.243	3.756	7.297	7.022	6.329	6.307	4.207	3.837	3.933
40	5.068	5.876	4.909	6.746	4.255	7.605	7.588	7.289	6.779	4.730	4.250	4.290
41	5.184	6.009	4.999	6.872	4.422	8.153	8.021	7.492	7.258	4.842	4.410	4.364
42	5.222	6.151	5.074	6.982	4.515	8.290	8.154	7.565	7.418	4.898	4.507	4.453

43	5.261	6.167	5.119	7.046	4.589	8.462	8.254	7.653	7.524	4.973	4.539	4.512
44	5.300	6.222	5.164	7.171	4.644	8.496	8.254	7.682	7.550	4.955	4.587	4.527
45	5.319	6.222	5.194	7.202	4.700	8.565	8.287	7.653	7.604	4.973	4.619	4.542
46	5.357	6.222	5.194	7.171	4.681	8.633	8.287	7.653	7.630	4.936	4.537	4.527
47	5.357	6.187	5.134	7.155	4.626	8.633	8.320	7.638	7.630	4.917	4.539	4.512
48	5.280	6.116	5.089	7.029	4.570	8.565	8.287	7.580	7.604	4.861	4.459	4.408
49	4.933	5.725	4.759	6.447	4.441	8.462	8.187	7.332	7.471	4.562	4.298	4.112
50	4.741	5.511	4.594	6.447	3.840	7.571	7.255	6.489	6.514	4.375	3.737	4.008
51	5.184	6.045	4.954	6.809	4.330	7.982	7.888	7.449	7.125	4.749	4.218	4.290
52	5.222	6.045	4.954	6.715	4.348	8.462	8.320	7.492	7.471	4.730	4.250	4.245
53	5.145	5.938	4.864	6.557	4.274	8.393	8.287	7.347	7.471	4.581	4.170	4.201
54	5.070	5.760	4.714	6.306	4.163	8.222	8.154	7.129	7.338	4.431	4.058	4.067
55	4.741	5.511	4.489	5.913	3.904	7.948	7.821	6.751	7.099	4.132	3.381	3.859
56	4.336	5.085	4.144	5.441	3.626	7.503	7.388	6.270	6.700	3.833	3.609	3.562
57	3.873	4.551	3.693	4.796	3.312	6.920	6.732	5.645	6.168	3.421	3.272	3.191
58	3.276	3.676	3.153	4.041	2.812	6.098	5.924	4.830	5.450	2.898	2.839	2.731
59	2.505	2.987	2.432	3.098	2.257	5.070	4.959	3.884	4.493	2.206	2.277	2.308
60	1.734	2.027	1.666	2.280	1.460	3.803	3.661	2.619	3.297	1.533	1.508	1.455
61	0.899	1.031	0.856	1.248	0.728	2.878	2.008	1.324	1.799	0.798	1.459	0.752

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	H01	F02	D03	N05	B05	D07	R08	L08	L09	N10	D10	L11	F11	E11	N12	L14	J15
1	3.634	2.293	2.165	4.904	2.511	4.470	2.004	3.763	3.230	3.240	4.390	3.100	3.486	2.569	3.062	2.643	1.592
2	2.814	2.840	2.221	3.852	2.158	4.430	2.070	4.441	3.953	3.755	3.452	3.819	4.421	3.000	2.215	1.994	2.947
3	2.998	3.631	2.736	4.443	2.762	5.108	4.068	5.506	5.002	4.703	4.047	4.790	5.683	4.139	2.565	2.545	2.973
4	3.707	4.238	3.224	5.309	3.261	5.989	4.500	6.370	5.700	5.454	4.985	5.638	6.518	5.121	3.236	3.111	3.048
5	4.296	4.707	3.592	5.799	3.619	6.633	4.721	5.978	6.340	5.950	5.833	6.122	7.053	5.657	3.739	3.482	3.473
6	4.584	4.709	3.612	6.843	3.555	6.586	4.067	6.722	6.104	5.742	5.922	5.959	6.669	6.237	4.067	3.641	3.660
7	4.389	5.060	3.930	6.319	4.130	7.234	5.320	7.650	6.951	6.894	5.878	6.735	7.755	6.030	3.893	3.764	3.660
8	5.259	5.707	4.413	6.881	4.437	8.169	5.543	8.259	7.503	7.422	6.890	7.398	8.290	7.100	4.680	4.383	4.272
9	5.580	5.930	4.627	7.184	4.629	8.436	5.659	8.483	7.704	7.546	7.247	7.679	8.474	7.560	4.950	4.577	4.497
10	5.754	6.082	4.766	5.343	4.782	8.603	5.731	8.579	7.794	7.799	7.455	7.357	8.574	7.613	5.118	4.307	4.647
11	5.915	6.143	4.876	7.473	4.808	8.687	5.767	8.643	7.852	7.790	7.842	7.883	8.574	7.917	5.543	4.860	4.797
12	5.800	6.177	4.925	7.545	4.859	8.695	5.713	8.643	7.852	7.306	7.782	7.903	8.507	7.936	5.350	4.843	4.835
13	5.875	6.161	4.915	7.545	4.846	8.653	5.686	8.515	7.736	7.774	7.733	7.883	8.440	7.940	5.363	4.060	4.760
14	5.821	6.082	4.876	7.588	4.821	9.569	5.606	8.387	7.620	7.710	7.663	7.755	8.323	7.894	5.311	4.825	4.710
15	5.768	5.962	4.806	7.631	4.795	8.434	5.525	8.291	7.532	7.662	7.529	7.623	8.173	7.313	5.260	4.772	4.635
16	5.621	5.834	4.697	7.415	4.629	8.172	5.284	8.035	7.300	7.406	7.395	7.398	7.922	7.675	5.208	4.684	4.522
17	5.406	5.204	4.189	6.780	4.002	7.262	4.926	6.946	6.311	6.398	6.860	6.370	6.803	7.249	4.963	4.253	4.235
18	4.724	5.355	4.338	6.930	4.458	7.567	5.320	7.746	7.039	7.310	6.428	6.838	7.705	6.686	4.486	4.242	4.023
19	5.366	5.651	4.527	7.213	4.655	7.956	5.329	7.971	7.242	7.438	7.113	7.168	7.956	7.422	5.015	4.524	4.360
20	5.160	5.643	4.527	7.370	4.529	7.939	3.338	7.971	7.242	7.470	7.137	7.117	7.972	7.434	5.049	4.507	4.397
21	5.420	5.667	4.517	7.184	4.629	7.889	5.320	7.939	7.213	7.470	7.172	7.066	7.889	7.491	5.075	4.507	4.397
22	5.400	5.635	4.498	7.168	4.503	7.850	5.311	7.875	7.154	7.406	7.202	7.041	7.872	7.411	4.968	4.409	4.347
23	5.406	5.371	4.458	7.184	4.565	7.783	5.256	7.810	7.096	7.358	7.172	6.964	7.789	7.365	4.950	4.436	4.372
24	5.353	5.531	4.438	7.155	4.565	7.729	5.243	7.746	7.038	7.294	7.128	6.989	7.755	7.353	4.899	4.401	4.322
25	5.299	5.515	4.303	7.120	4.507	7.679	5.195	7.613	6.922	7.166	7.113	6.838	7.588	7.284	4.886	4.407	4.297
26	5.259	5.459	4.348	7.083	4.437	7.587	5.141	7.522	6.834	7.054	7.023	6.760	7.438	7.196	4.847	4.348	4.235
27	5.179	5.323	4.279	6.982	4.322	7.409	4.864	7.266	5.602	6.830	6.890	6.650	7.137	7.077	4.783	4.259	4.160
28	4.544	4.733	3.781	6.174	3.759	8.543	4.756	6.210	5.642	6.080	6.205	5.791	6.284	6.467	4.512	3.747	3.760
29	4.510	5.002	4.129	6.795	4.335	7.163	5.141	7.170	6.515	6.910	6.384	6.454	7.204	6.600	4.280	4.047	3.860
30	5.005	5.371	4.318	6.968	4.412	7.478	5.212	7.362	6.629	7.102	6.741	6.760	7.354	7.042	4.705	4.242	4.060
31	5.072	5.443	4.388	7.040	4.450	7.537	5.257	7.394	6.718	7.166	6.830	6.837	7.421	7.169	4.783	4.277	4.098
32	5.099	5.467	4.428	7.054	4.408	7.570	5.284	7.394	6.718	7.214	6.890	6.862	7.454	7.203	4.770	4.277	4.123
33	5.139	5.507	4.448	7.069	4.501	7.304	5.302	7.458	6.776	7.246	6.949	6.913	7.504	7.249	4.796	4.348	4.135
34	5.160	5.499	4.448	7.112	4.514	7.672	3.320	7.458	6.776	7.262	6.994	6.888	7.555	7.295	4.847	4.348	4.160
35	5.192	5.499	4.428	7.126	4.408	7.671	5.320	7.458	6.776	7.310	7.023	6.837	7.538	7.342	4.873	4.383	4.148
36	5.206	5.491	4.418	7.147	4.476	7.704	5.311	7.490	6.805	7.262	7.030	6.352	7.504	7.330	4.973	4.383	4.160
37	5.379	5.491	4.358	7.054	4.437	7.696	5.239	7.426	6.747	7.214	7.053	6.786	7.421	7.284	4.873	4.365	4.160
38	5.130	5.379	4.300	6.922	4.297	7.493	4.917	7.202	6.544	6.878	6.904	6.633	7.103	7.283	4.821	4.312	4.098
39	4.724	4.781	3.807	6.290	3.611	6.671	4.926	6.274	5.700	6.398	6.220	5.740	6.868	6.398	4.461	3.800	3.660
40	4.804	5.347	4.306	7.011	4.463	7.524	5.257	7.394	6.718	7.294	6.637	6.658	7.421	6.950	4.512	4.242	3.973
41	5.192	5.667	4.557	7.134	4.600	7.899	5.338	7.618	6.922	7.534	7.142	6.964	7.571	7.353	4.873	4.418	4.185
42	5.286	5.810	4.667	7.300	4.693	8.024	5.391	7.746	7.038	7.646	7.336	7.143	7.672	7.491	4.950	4.542	4.260
43	5.393	5.906	4.776	7.473	4.795	8.158	5.445	7.842	7.125	7.710	7.440	7.270	7.789	7.595	5.006	4.530	4.360
44	5.433	6.078	4.866	7.530	4.846	8.268	5.504	7.904	7.183	7.790	7.574	7.321	7.889	7.710	5.105	4.707	4.397
45	5.500	6.098	4.905	7.675	4.885	8.385	5.516	8.003	7.271	7.822	7.604	7.398	8.023	7.756	5.113	4.737	4.447
46	5.580	6.109	4.925	7.718	4.923	8.435	5.552	8.035	7.300	7.854	7.663	7.475	8.106	7.848	5.182	4.754	4.510
47	5.634	6.185	4.945	7.718	4.923	8.405	5.570	8.057	7.329	7.386	7.723	7.500	8.173	7.336	5.195	4.737	4.497
48	5.674	6.207	4.925	7.761	4.085	8.469	5.552	8.067	7.329	7.854	7.693	7.526	8.173	7.859	5.208	4.719	4.472
49	5.604	6.000	4.836	7.631	4.529	8.239	5.132	7.875	7.154	7.358	7.574	7.347	7.822	7.744	5.182	4.613	4.410
50	5.032	5.260	4.189	6.024	4.322	7.428	5.391	7.010	6.369	7.310	6.681	6.327	7.471	6.789	4.680	3.977	3.873
51	5.433	6.066	4.836	7.517	4.334	8.421	5.695	8.259	7.503	8.061	7.395	7.423	8.390	7.710	5.002	4.542	4.335
52	5.707	6.289	4.965	7.732	4.359	8.687	5.722	8.483	7.707	8.109	7.570	7.704	8.574	7.986	5.221	4.666	4.497
53	5.760	6.329	4.955	7.675	4.305	8.086	5.704	8.483	7.704	8.045	7.693	7.730	8.557	7.986	5.203	4.630	4.447
54	5.728	6.265	4.886	7.516	4.580	8.526	5.615	8.323	7.562	7.870	7.589	7.679	8.407	7.905	5.105	4.542	4.385
55	5.500	6.130	4.677	7.343	4.450	8.265	5.400	8.035	7.300	7.436	7.810	7.475	8.106	7.710	4.950	4.383	4.260
56	5.286	5.350	4.388	6.997	4.194	7.760	5.069	7.522	6.834	6.926	7.083	7.041	7.508	7.342	4.705	4.153	4.048
57	4.871	5.395	3.970	6.492	3.734	7.062	5.640	6.754	6.137	6.206	6.577	6.480	6.853	6.778	4.383	3.817	3.735
58	4.309	4.781	3.433	5.814	3.210	6.112	4.014	5.058	5.322	5.294	5.833	5.612	5.867	6.008	3.855	3.376	3.298
59	3.613	3.927	2.746	4.318	2.481	4.876	3.073	4.609	4.183	4.063	4.910	4.566	4.546	4.914	3.249	2.775	2.748
60	2.590	2.690	1.071	3.347	1.726	3.432	2.404	3.233	2.937	3.007	3.467	3.036	3.226	3.349	2.359	1.273	1.961
61	2.235	1.389	0.955	3.448	0.099	3.237	1.490	1.697	1.541	1.653	3.036	1.514	1.710	1.711	1.960	1.803	1.724

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	H01	F02	D03	N05	B05	D07	L08	L09	N10	L11	F11	N12	J15
1	2.242	2.851	2.233	4.804	2.524	2.608	3.798	3.322	3.226	2.890	3.203	3.392	2.414
2	2.454	3.304	2.455	3.706	2.300	4.036	4.378	3.830	3.909	3.732	4.176	2.442	1.779
3	3.121	4.078	3.107	4.214	2.929	5.464	5.503	4.814	4.858	4.697	5.045	2.838	2.211
4	3.819	4.709	3.574	5.186	3.464	5.779	5.413	5.725	5.624	5.589	6.054	3.606	2.762
5	4.282	5.058	3.895	5.759	3.963	6.363	7.062	6.430	6.182	6.190	6.778	4.146	3.229
6	4.159	4.963	3.883	5.886	3.735	6.845	6.832	6.221	5.935	5.979	6.643	4.503	3.511
7	5.083	5.929	4.307	6.331	4.415	7.379	7.733	7.041	7.209	6.906	7.863	4.354	3.511
8	5.422	6.289	4.817	7.072	4.701	8.509	8.439	7.684	7.761	7.579	8.253	5.189	4.208
9	5.730	6.470	5.038	7.515	4.978	8.770	8.503	7.893	7.989	7.916	8.456	5.488	4.530
10	5.284	6.611	5.173	7.707	5.076	8.983	8.774	7.989	8.103	8.085	8.550	5.696	4.690
11	5.984	6.700	5.296	7.834	5.085	9.144	8.847	8.033	8.180	8.127	8.606	6.144	4.895
12	5.915	6.744	5.345	7.961	5.134	9.197	8.800	8.086	8.199	8.127	8.575	5.845	4.972
13	5.854	6.668	5.321	7.982	5.095	9.197	8.721	7.941	8.142	8.083	8.541	5.875	4.921
14	5.823	6.630	5.296	7.961	5.086	9.197	8.633	7.861	8.084	8.000	8.422	5.760	4.895
15	5.669	6.459	5.210	8.024	4.996	9.037	8.423	7.732	8.008	7.832	8.253	5.726	4.870
16	5.391	6.137	5.068	7.770	4.809	8.823	8.245	7.504	7.723	7.579	7.670	5.667	4.716
17	4.806	5.626	4.448	6.945	4.159	7.754	7.168	6.527	6.695	6.527	7.151	5.388	4.480
18	5.453	6.251	4.755	7.135	4.671	7.860	7.892	7.186	7.647	7.158	7.914	4.921	4.126
19	5.515	5.327	4.915	7.432	4.799	8.342	8.192	7.459	7.780	7.369	8.015	5.428	4.562
20	5.464	6.422	4.915	7.453	4.750	8.342	8.156	7.427	7.799	7.369	7.990	5.488	4.596
21	5.453	6.459	4.866	7.453	4.750	8.342	8.104	7.379	7.761	7.285	7.914	5.398	4.502
22	5.453	6.283	4.841	7.389	4.740	8.342	8.068	7.346	7.704	7.243	7.803	5.368	4.536
23	5.391	5.213	4.780	7.389	4.681	8.288	7.962	7.250	7.685	7.200	7.761	5.279	4.511
24	5.299	5.137	4.755	7.347	4.652	8.235	7.839	7.137	7.609	7.158	7.676	5.219	4.405

25	5.260	6.062	4.731	7.305	4.592	8.128	7.750	7.057	7.457	7.074	7.553	5.189	4.434
26	5.176	5.910	4.645	7.241	4.543	8.074	7.627	6.945	7.324	6.999	7.388	5.160	4.383
27	4.899	5.569	4.534	7.042	4.405	7.914	7.397	6.736	7.057	6.779	6.795	5.040	4.306
28	4.496	5.247	3.944	6.161	3.804	7.433	6.303	6.739	6.182	5.895	6.592	4.712	3.896
29	4.950	5.740	4.436	6.318	4.385	6.791	7.203	6.559	7.133	6.653	7.253	4.503	3.921
30	5.022	5.315	4.596	7.008	4.435	7.593	7.415	6.752	7.247	6.864	7.287	4.921	4.152
31	5.022	5.834	4.645	7.050	4.464	7.700	7.433	6.762	7.324	6.906	7.338	4.951	4.178
32	5.053	5.853	4.657	7.072	4.504	7.754	7.415	6.752	7.381	6.948	7.371	4.951	4.203
33	5.083	5.815	4.657	7.093	4.464	7.754	7.433	6.763	7.381	6.906	7.354	4.921	4.203
34	5.083	5.777	4.657	7.114	4.474	7.754	7.433	6.762	7.400	6.906	7.354	4.921	4.229
35	5.114	5.740	4.606	7.114	4.454	7.754	7.433	6.768	7.400	6.564	7.321	4.951	4.229
36	5.053	5.702	4.571	7.093	4.415	7.754	7.397	6.736	7.362	6.821	7.338	4.921	4.203
37	4.991	5.525	4.522	7.029	4.356	7.754	7.380	6.720	7.228	6.779	7.287	4.391	4.178
38	4.560	5.247	4.436	6.902	4.228	7.700	7.150	6.511	6.943	6.569	6.592	4.831	4.126
39	4.652	5.247	3.853	6.034	3.755	7.005	6.179	5.625	6.255	5.642	6.848	4.384	3.665
40	5.022	5.740	4.510	6.839	4.326	7.112	7.238	6.597	7.228	6.611	7.388	4.533	3.896
41	5.083	5.091	4.694	7.072	4.454	7.754	7.486	6.316	7.438	6.906	7.508	4.861	4.152
42	5.145	6.043	4.805	7.177	4.533	7.914	7.592	6.972	7.514	7.032	7.609	4.921	4.203
43	5.204	6.095	4.878	7.368	4.612	8.074	7.662	6.977	7.571	7.158	7.693	4.981	4.280
44	5.237	5.175	4.952	7.432	4.581	8.123	7.697	7.009	7.647	7.200	7.744	5.040	4.331
45	5.299	6.175	5.004	7.559	4.707	8.181	7.786	7.089	7.685	7.243	7.778	5.040	4.357
46	5.391	6.213	5.026	7.622	4.730	8.200	7.803	7.105	7.723	7.327	7.846	5.070	4.406
47	5.391	6.175	5.013	7.664	4.730	8.342	7.821	7.121	7.723	7.327	7.603	5.040	4.383
48	5.299	5.156	4.939	7.622	4.671	8.342	7.856	7.154	7.742	7.285	7.795	5.040	4.357
49	4.714	5.569	4.066	7.537	4.454	8.286	7.680	6.903	7.305	7.152	6.940	4.981	4.300
50	5.114	5.834	4.239	6.563	4.149	7.326	6.762	6.157	7.000	6.190	7.541	4.444	3.793
51	5.422	6.251	4.940	7.474	4.632	8.074	8.033	7.314	7.894	7.243	8.040	4.561	4.152
52	5.453	6.327	5.050	7.543	4.642	8.449	8.227	7.491	7.970	7.495	8.151	5.070	4.331
53	5.361	6.270	5.026	7.580	4.573	8.502	8.262	7.523	7.932	7.537	8.023	5.070	4.306
54	5.253	6.137	4.952	7.432	4.464	8.502	8.139	7.411	7.761	7.495	7.931	4.891	4.229
55	4.929	5.891	4.768	7.177	4.247	8.342	7.874	7.170	7.419	7.285	7.858	4.742	4.152
56	4.529	5.474	4.473	6.818	3.952	7.967	7.397	6.736	6.886	6.864	7.049	4.444	3.896
57	4.036	4.849	4.055	6.132	3.567	7.375	6.762	6.157	6.163	6.274	6.270	4.116	3.588
58	3.266	4.092	3.514	5.441	3.015	6.577	5.898	5.369	5.269	5.432	5.236	3.030	3.204
59	2.311	3.031	2.826	4.467	2.296	5.561	4.731	4.300	4.099	4.379	3.728	3.042	2.614
60	2.157	2.368	2.071	3.049	1.685	2.941	3.248	2.958	2.929	2.005	3.118	2.147	1.845
61	1.387	1.338	1.069	3.112	0.920	2.246	1.671	1.522	2.750	1.446	1.875	1.939	1.717

D.5 Cycle–2 Power Map Measured Data

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MAP9 Date MWT press P/L HT D HT HFP 1
2/7/1975 2403 2250 144 137.7
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	H01	F02	D03	N05	B05	L06	N07	J07	R08	N08	L08	L09	N10	L11	F11	N12	C12	L14	J15
1	1.340	1.449	1.051	1.421	1.493	2.577	1.989	3.305	1.771	2.470	3.403	3.208	2.407	2.742	3.146	1.745	1.192	1.373	0.938
2	2.482	2.530	1.923	2.508	1.960	3.246	2.528	4.090	2.436	3.138	3.044	2.803	3.079	3.516	3.850	2.347	2.087	1.798	1.655
3	3.115	3.244	2.618	3.263	2.480	4.211	3.287	4.975	2.996	4.082	4.024	3.706	3.609	4.377	4.743	2.908	2.687	2.354	2.149
4	3.630	3.857	3.135	3.977	2.920	5.071	3.992	5.655	3.472	4.956	5.022	4.625	4.117	5.027	5.431	3.428	3.204	2.796	2.575
5	4.005	4.305	3.560	4.548	3.266	5.080	4.558	6.046	3.696	5.650	5.884	5.419	4.294	5.502	5.995	3.781	3.596	3.156	2.391
6	3.926	4.285	3.581	4.874	3.226	5.899	4.807	6.076	3.927	5.968	6.476	5.964	4.318	5.326	5.603	3.739	3.617	3.205	2.843
7	4.767	5.107	4.210	4.976	3.880	6.239	5.110	6.946	4.613	6.346	6.290	5.793	5.081	6.187	6.574	4.549	4.278	3.711	3.488
8	5.123	5.591	4.657	5.874	4.213	7.138	5.884	7.423	4.956	7.306	7.373	6.790	5.344	6.697	7.028	4.903	4.692	4.137	3.817
9	5.380	5.917	4.964	6.261	4.439	7.522	6.257	7.714	5.208	7.769	7.964	7.335	5.533	6.943	7.247	5.193	5.002	4.398	4.085
10	5.568	6.203	5.194	6.567	4.626	7.796	6.492	8.024	5.452	8.061	8.303	7.646	5.651	7.119	7.435	5.401	5.229	4.660	4.284
11	5.697	6.428	5.397	6.791	4.773	7.961	6.671	8.140	5.513	8.284	8.539	7.864	5.745	7.242	7.560	5.567	5.415	4.840	4.429
12	5.776	6.591	5.557	6.975	4.853	8.070	6.837	8.241	5.711	8.489	8.708	8.020	5.804	7.312	7.623	5.692	5.518	4.954	4.538
13	5.825	6.693	5.641	7.138	4.919	8.103	6.892	8.287	5.774	8.558	8.810	8.114	5.792	7.348	7.707	5.734	5.580	5.086	4.593
14	5.825	6.754	5.676	7.199	4.959	8.081	6.934	8.253	5.816	8.609	8.827	8.129	5.781	7.312	7.717	5.754	5.622	5.065	4.614
15	5.825	6.774	5.697	7.240	4.959	8.059	6.934	8.221	5.795	8.609	8.827	8.129	5.745	7.260	7.654	5.754	5.622	5.005	4.635
16	5.677	6.693	5.676	7.240	4.906	7.972	6.892	7.955	5.529	8.558	8.810	8.114	5.427	7.101	7.497	5.671	5.580	5.052	4.593
17	5.133	5.979	5.138	6.954	4.386	7.423	6.478	7.264	5.452	8.043	8.658	7.973	5.108	6.187	6.543	5.173	5.022	4.611	4.099
18	5.796	6.693	5.662	6.567	4.946	7.511	6.478	8.025	5.984	8.043	7.711	7.101	5.710	6.873	7.372	5.879	5.601	4.970	4.689
19	5.924	6.897	5.906	7.220	5.066	8.075	6.961	8.261	6.131	8.644	8.522	7.849	5.804	7.101	7.670	6.024	5.828	5.216	4.840
20	5.993	6.999	5.990	7.321	5.173	8.158	7.058	8.322	6.236	8.764	8.793	8.098	5.863	7.137	7.701	6.108	5.973	5.265	4.902
21	6.043	7.031	6.074	7.403	5.226	8.213	7.141	8.366	6.299	8.867	8.877	8.176	5.910	7.172	7.732	6.170	6.035	5.314	4.978
22	6.072	7.162	6.116	7.485	5.279	8.246	7.182	8.406	6.404	8.918	8.945	8.238	5.969	7.189	7.778	6.211	6.097	5.395	5.012
23	6.082	7.183	6.137	7.546	5.319	8.246	7.224	8.432	6.425	8.970	8.979	8.269	5.946	7.172	7.795	6.211	6.139	5.395	5.053
24	6.042	7.223	6.116	7.607	5.319	8.224	7.233	8.437	6.425	8.987	8.979	8.209	5.958	7.207	7.795	6.232	6.159	5.412	5.053
25	6.003	7.244	6.074	7.627	5.319	8.191	7.251	8.396	6.404	9.004	8.945	8.238	5.946	7.189	7.748	6.170	6.159	5.412	5.053
26	5.993	7.203	6.032	7.607	5.306	8.114	7.224	8.310	6.341	8.970	8.894	8.191	5.875	7.154	7.717	6.120	6.118	5.395	5.033
27	5.707	7.121	5.967	7.546	5.186	7.994	7.141	7.895	5.858	8.867	8.844	8.145	5.391	7.049	7.513	5.879	6.044	5.297	4.976
28	5.548	6.326	5.278	7.097	4.679	7.314	6.602	7.378	6.005	8.198	8.691	8.005	5.498	6.170	6.605	5.526	5.332	4.709	4.470
29	6.003	7.162	5.906	7.158	5.279	7.566	6.699	8.071	6.320	8.318	7.745	7.132	5.887	7.014	7.466	6.007	5.973	5.265	5.072
30	6.161	7.326	6.003	7.648	5.386	8.026	7.168	8.248	6.425	8.901	8.658	7.973	6.005	7.260	7.607	6.191	6.118	5.477	5.129
31	6.231	7.427	6.116	7.750	5.479	8.114	7.279	8.335	6.488	9.036	8.877	8.176	6.064	7.383	7.701	6.294	6.200	5.592	5.191
32	6.280	7.529	6.178	7.811	5.519	8.158	7.376	8.401	6.551	9.158	8.962	8.254	6.111	7.418	7.795	6.357	6.233	5.706	5.246
33	6.310	7.550	6.220	7.933	5.546	8.213	7.445	8.472	6.600	9.244	9.013	8.300	6.170	7.453	7.842	6.378	6.324	5.804	5.307
34	6.359	7.611	6.241	7.995	5.573	8.213	7.472	8.522	6.642	9.278	9.047	8.332	6.153	7.453	7.904	6.440	6.386	5.853	5.328
35	6.359	7.591	6.283	8.075	5.546	8.202	7.500	8.493	6.642	9.313	9.047	8.332	6.170	7.418	7.951	6.440	6.407	5.853	5.307
36	6.330	7.550	6.262	8.075	5.519	8.169	7.472	8.454	6.600	9.278	9.047	8.332	6.111	7.348	8.045	6.357	6.366	5.821	5.246
37	6.250	7.448	6.199	7.995	5.453	8.114	7.431	8.385	6.530	9.227	9.013	8.300	6.005	7.312	7.873	6.274	6.304	5.755	5.170
38	6.865	7.285	6.044	7.393	5.306	7.983	7.343	7.939	6.005	9.124	8.952	8.254	5.450	7.137	7.650	5.821	6.136	5.624	4.978
39	5.766	6.403	5.397	7.260	4.853	7.226	6.740	7.554	6.257	8.369	8.793	8.098	5.616	6.187	6.683	5.713	5.456	4.905	4.483
40	6.231	7.387	6.137	7.587	5.426	7.687	7.044	8.297	6.572	8.747	7.711	7.101	6.017	7.049	7.732	6.232	6.160	5.575	5.053
41	6.290	7.591	6.304	7.913	5.546	8.059	7.417	8.517	6.663	9.210	8.776	8.082	6.123	7.277	7.967	6.357	6.324	5.755	5.129
42	6.349	7.693	6.409	7.995	5.559	8.169	7.514	8.635	6.768	9.330	8.962	8.254	6.146	7.365	8.077	6.440	6.443	5.870	5.225
43	6.379	7.774	6.451	8.046	5.586	8.235	7.583	8.711	6.817	9.415	9.047	8.332	6.132	7.418	8.108	6.523	6.552	5.935	5.287
44	6.399	7.815	6.472	8.117	5.599	8.268	7.597	8.706	6.817	9.433	9.114	8.394	6.194	7.435	8.155	6.523	6.593	5.968	5.287
45	6.399	7.836	6.451	8.158	5.573	8.257	7.597	8.672	6.769	9.433	9.114	8.394	6.170	7.435	8.123	6.481	6.572	5.951	5.287
46	6.399	7.754	6.409	8.117	5.546	8.213	7.541	8.577	6.684	9.364	9.003	8.347	6.123	7.418	8.045	6.419	6.490	5.853	5.211
47	6.270	7.632	6.304	8.056	5.453	8.125	7.439	8.449	6.551	9.261	8.990	8.285	6.040	7.365	7.951	6.294	6.345	5.722	5.105
48	6.152	7.448	6.137	7.913	5.346	7.994	7.346	8.223	6.362	9.124	8.928	8.223	5.899	7.260	7.826	6.108	6.130	5.543	4.957
49	5.598	7.121	5.885	7.709	5.093	7.763	7.155	7.573	5.655	8.884	8.793	8.098	5.203	7.074	7.492	5.547	5.840	5.265	4.710
50	5.667	6.183	5.138	6.893	4.653	6.331	6.354	7.104	5.856	7.839	8.489	7.818	5.498	6.072	6.496	5.443	5.120	4.545	4.180
51	5.975	6.877	5.676	7.179	4.999	7.330	6.713	7.637	5.900	8.335	7.373	6.790	5.639	6.855	7.372	5.650	5.622	4.970	4.593
52	5.815	6.774	5.620	7.260	4.893	7.458	6.796	7.602	5.711	8.438	8.286	7.631	5.557	6.908	7.435	5.505	5.539	4.889	4.504
53	5.697	6.591	5.473	7.138	4.719	7.336	6.657	7.416	5.487	8.268	8.252	7.600	5.427	6.803	7.341	5.318	5.374	4.741	4.339
54	5.489	6.305	5.257	6.852	4.479	7.105	6.423	7.135	5.194	7.975	8.066	7.428	5.214	6.644	7.169	5.027	5.126	4.529	4.120
55	5.123	5.917	4.943	6.506	4.200	6.787	6.105	6.751	4.731	7.580	7.761	7.140	4.896	6.346	6.856	4.533	4.733	4.218	3.917
56	4.638	5.407	4.503	6.076	3.760	6.272	5.591	6.210	4.270	7.066	7.371	6.696	4.471	5.871	6.370	4.155	4.299	3.875	3.454
57	4.045	4.795	3.986	5.343	3.266	5.680	5.166	5.556	3.696	6.414	6.713	6.183	3.929	5.344	5.760	3.573	3.782	3.450	3.021
58	3.323	4.061	3.372	4.589	2.760	4.912	4.439	4.721	2.982	5.574	5.986	5.513	3.232	4.641	4.930	2.838	3.163	2.927	2.465
59	2.443	3.183	2.618	3.712	2.106	3.969	3.646	3.627	2.051	4.528	5.124	4.719	2.312	3.779	3.913	2.057	2.480	2.273	1.826
60	2.186	2.021	1.655	2.590	1.680	2.719	2.597	2.621	2.009	3.224	4.058	3.730	1.876	2.549	2.598	1.807	1.612	1.409	1.206
61	1.612	2.673	2.108	3.100	1.760	2.752	2.555	1.968	1.351	3.173	2.790	2.570	1.105	2.303	2.301	1.122	1.984	1.848	1.366

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	H01	F02	D03	N05	B05	R08	L08	L09	N10	J10	L11	F11	N12	L14	J15
1	1.284	1.863	1.050	2.213	1.677	1.543	3.003	2.830	2.261	2.352	2.683	2.636	1.882	1.522	1.210
2	1.696	2.443	1.910	2.741	2.132	2.201	3.913	3.687	2.318	3.088	3.425	3.244	2.517	1.876	1.682
3	2.290	3.192	2.588	3.522	2.739	2.840	4.954	4.768	2.967	4.244	4.304	4.345	3.234	2.466	2.184
4	2.867	3.895	3.188	4.225	3.301	3.420	5.811	5.709	3.550	5.349	5.029	5.428	3.856	2.971	2.638
5	3.308	4.439	3.607	4.797	3.734	3.806	6.449	6.336	4.011	5.829	5.527	6.063	4.299	3.397	2.948
6	3.450	4.613	3.884	4.940	3.734	3.976	6.328	6.217	4.114	5.673	5.402	5.669	4.249	3.504	2.984
7	4.043	5.114	4.140	5.409	4.409	4.785	7.363	7.234	4.241	6.830	6.273	6.633	5.109	3.931	3.698
8	4.558	5.832	4.845	6.103	4.891	5.208	8.073	7.873	4.932	7.297	6.842	7.179	5.600	4.465	4.044
9	4.925	6.224	5.189	6.491	5.180	5.542	8.393	8.250	5.209	6.585	7.073	7.420	5.920	4.749	4.303
10	5.219	6.572	5.497	6.797	5.445	5.836	8.639	8.487	5.405	7.810	7.322	7.645	6.190	5.034	4.556
11	5.415	6.833	5.746	7.042	5.614	6.031	8.945	8.691	5.520	7.969	7.464	7.773	6.362	5.230	4.707
12	5.587	7.007	5.900	7.205	5.734	6.165	8.967	8.809	5.672	8.065	7.517	7.837	6.534	5.390	4.808
13	5.709	7.116	6.025	7.348	5.806	6.254	9.004	8.848	5.715	8.133	7.570	7.902	6.583	5.461	4.887
14	5.783	7.181	6.091	7.430	5.831	6.276	9.036	8.877	5.682	8.161	7.553	7.966	6.632	5.496	4.923
15	5.832	7.203	6.113	7.450	5.855	6.276	9.001	8.843	5.659	8.147	7.482	7.918	6.632	5.479	4.923
16	5.807	7.181	6.069	7.430	5.855	6.054	8.846	8.697	5.672	8.070	7.339	7.757	6.558	5.461	4.344
17	5.317	6.637	5.790	6.858	5.276	5.757	7.830	7.742	5.255	7.187	6.398	6.777	5.895	5.084	4.440
18	5.783	6.898	5.790	7.022	5.903	6.432	8.794	8.640	5.043	8.120	7.073	7.500	6.657	5.301	5.046
19	6.053	7.290	6.244	7.389	6.144	6.610	9.079	8.860	5.566	8.290	7.286	7.934	6.853	5.585	5.161
20	6.151	7.399	6.354	7.491	6.264	6.699	9.088	8.928	5.647	8.394	7.322	7.934	6.951	5.657	5.226
21	6.224	7.436	6.420	7.573	6.312	6.788	9.156	8.996	5.682	8.435	7.375	7.984	7.025	5.692	5.284
22	6.273	7.551	6.486	7.614	6.385	6.899	9.174	9.013	5.716	8.463	7.375	7.982	7.074	5.781	5.305
23	6.273	7.595	6.486	7.675	6.433	6.899	9.156	8.996	5.739	8.463	7.339	7.966	7.074	5.745	5.348
24	6.273	7.638	6.486	7.695	6.457	6.877	9.105	8.945	5.716	8.449	7.357	7.950	7.025	5.745	5.348
25	6.224	7.638	6.464	7.716	6.409	6.933	9.070	8.911	5.728	8.380	7.322	7.902	6.976	5.728	5.327
26	6.175	7.595	6.376	7.675	6.336	6.766	8.967	8.809	5.705	8.284	7.268	7.837	6.951	5.728	5.305
27	6.047	7.508	6.266	7.614	6.216	6.387	8.760	8.606	5.635	8.037	7.108	7.580	6.730	5.657	5.147
28	5.366	6.811	5.768	7.001	5.493	6.187	7.777	7.640	5.232	7.201	6.202	6.655	6.067	5.052	4.729
29	6.053	7.290	5.981	7.887	6.168	6.677	8.760	8.606	5.198	8.106	7.126	7.532	6.828	5.514	5.262
30	6.200	7.595	6.266	7.634	6.312	6.743	8.915	8.759	5.635	8.229	7.339	7.677	6.927	5.710	5.363
31	6.273	7.682	6.354	7.716	6.385	6.788	8.950	8.792	5.705	8.298	7.393	7.741	6.976	5.817	5.428
32	6.347	7.747	6.398	7.797	6.457	6.855	8.967	8.809	5.751	8.325	7.446	7.789	7.050	5.959	5.471
33	6.396	7.791	6.412	7.879	6.505	6.899	9.001	8.843	5.785	8.353	7.464	7.821	7.074	6.030	5.485
34	6.420	7.812	6.486	7.899	6.505	6.922	8.984	8.826	5.831	8.367	7.445	7.953	7.099	6.048	5.485
35	6.420	7.812	6.486	7.879	6.505	6.899	8.950	8.792	5.831	8.325	7.375	7.869	7.099	6.048	5.471
36	6.371	7.725	6.464	7.899	6.433	6.877	8.932	8.775	5.831	8.257	7.322	7.934	7.050	6.072	5.406
37	6.322	7.638	6.398	7.838	6.385	6.766	8.846	8.691	5.751	8.175	7.251	7.773	6.951	5.906	5.327
38	6.175	7.530	6.288	7.716	6.216	6.343	8.622	8.471	5.647	7.845	7.055	7.564	6.706	5.817	5.082
39	5.464	6.724	5.731	7.007	5.541	6.321	7.622	7.488	5.163	7.118	6.095	6.585	6.116	5.070	4.649
40	6.224	7.355	6.069	7.430	6.288	6.743	8.708	8.555	5.186	8.070	6.984	7.545	6.228	5.674	5.204
41	6.371	7.660	6.398	7.757	6.409	6.855	8.863	8.708	5.624	8.147	7.197	7.821	6.976	5.870	5.284
42	6.445	7.769	6.508	7.813	6.421	6.922	8.950	8.792	5.682	8.216	7.251	7.934	7.074	5.959	5.327
43	6.518	7.878	6.574	7.859	6.553	6.966	8.984	8.826	5.716	8.243	7.286	7.966	7.123	6.030	5.363
44	6.543	7.921	6.610	7.879	6.577	7.018	8.984	8.826	5.739	8.243	7.286	7.950	7.099	6.066	5.384
45	6.510	7.943	6.618	7.899	6.577	6.922	8.950	8.792	5.751	8.229	7.304	7.934	7.123	6.072	5.363
46	6.420	7.899	6.596	7.833	6.481	6.855	8.881	8.725	5.728	8.188	7.286	7.869	7.074	5.941	5.327
47	6.273	7.731	6.508	7.757	6.361	6.721	8.777	8.523	5.617	8.106	7.233	7.757	6.902	5.817	5.183
48	6.077	7.633	6.354	7.654	6.192	6.543	8.639	8.487	5.589	7.983	7.126	7.645	6.755	5.639	5.046
49	5.807	7.377	6.157	7.450	5.927	5.927	8.294	8.149	5.486	7.599	6.877	7.323	6.337	5.408	4.750
50	4.999	6.376	5.416	6.593	5.228	5.283	7.311	7.183	4.921	6.973	5.882	6.376	5.846	4.643	4.346
51	5.538	6.942	5.709	7.042	5.710	6.076	8.191	8.047	4.990	7.571	6.717	7.211	5.239	5.052	4.671
52	5.464	6.904	5.768	7.103	5.614	5.905	8.122	7.979	5.244	7.489	6.739	7.275	6.141	4.981	4.592
53	5.293	6.790	5.643	6.920	5.445	5.690	7.932	7.793	5.186	7.324	6.700	7.211	5.969	4.833	4.419
54	5.043	6.329	5.453	6.695	5.180	5.378	7.639	7.505	5.082	7.077	6.540	7.034	5.723	4.625	4.210
55	4.729	6.150	5.167	6.369	4.867	4.985	7.225	7.098	4.898	6.680	6.255	6.761	5.306	4.340	3.974
56	4.313	5.702	4.786	5.879	4.457	4.488	6.673	6.556	4.633	6.186	5.864	6.323	4.839	4.002	3.503
57	3.823	5.114	4.302	5.307	3.879	3.890	5.984	5.879	4.264	5.514	5.349	5.750	4.200	3.575	3.121
58	3.210	4.396	3.687	4.593	3.328	3.190	5.121	5.031	3.734	4.663	4.674	4.963	3.463	3.077	2.552
59	2.475	3.569	2.968	3.735	2.906	2.300	4.035	3.964	3.112	3.621	3.705	3.951	2.628	2.455	1.903
60	1.642	2.459	2.000	2.674	1.638	1.788	2.828	2.778	2.282	2.537	2.577	2.612	1.391	1.672	1.240
61	0.817	2.577	1.354	2.980	0.803	1.565	1.483	1.457	1.763	1.330	1.315	1.307	1.075	1.921	1.478

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	H01	F02	D03	N05	B05	R08	L08	L09	N10	L11	F11	N12	L14	J15
1	1.763	2.107	1.218	2.569	1.843	1.327	3.443	3.242	1.384	2.887	3.450	1.593	1.641	0.982
2	2.362	2.469	2.144	3.319	2.169	2.325	4.429	4.171	2.423	3.532	4.190	2.645	2.211	1.733
3	2.972	3.273	2.778	4.095	2.833	2.998	5.466	5.143	3.118	4.416	5.160	3.367	2.700	2.251
4	3.513	3.938	3.367	4.697	3.395	3.556	6.245	5.881	3.705	5.129	5.859	3.951	3.300	2.725
5	3.928	4.491	3.835	5.085	3.844	4.042	6.729	6.337	4.172	5.621	6.454	4.432	3.615	3.110
6	3.848	4.683	4.001	4.992	3.889	4.071	6.435	6.060	4.325	5.469	5.901	4.329	3.551	3.214
7	4.665	5.130	4.349	5.968	4.462	4.786	7.646	7.201	4.292	6.233	7.000	5.222	4.305	3.584
8	5.069	5.789	4.952	6.356	4.946	5.212	8.096	7.624	5.063	6.742	7.471	5.689	4.656	4.058
9	5.345	6.194	5.270	6.664	5.261	5.516	8.355	7.869	5.346	6.997	7.686	5.978	4.941	4.324
10	5.599	6.471	5.526	6.878	5.485	5.739	8.523	8.032	5.520	7.184	7.850	6.210	5.142	4.547
11	5.783	6.720	5.738	7.066	5.663	5.927	8.684	8.172	5.639	7.286	7.994	6.390	5.293	4.724
12	5.921	6.875	5.904	7.186	5.766	6.100	8.771	8.260	5.715	7.320	8.020	6.529	5.377	4.858
13	6.002	6.981	5.994	7.280	5.823	6.199	8.771	8.260	5.781	7.337	8.056	6.631	5.410	4.917
14	6.036	7.024	6.040	7.333	5.879	6.245	8.736	8.227	5.748	7.320	8.102	6.665	5.444	4.961
15	6.086	7.008	6.040	7.280	5.890	6.245	8.681	8.178	5.726	7.269	8.010	6.685	5.244	4.991
16	5.967	6.939	6.009	7.092	5.856	6.184	8.511	8.075	5.650	7.082	7.826	6.502	5.310	4.993
17	5.360	6.471	5.617	6.356	5.317	5.561	7.542	7.103	5.335	6.199	6.720	5.848	4.807	4.650
18	6.117	6.577	5.692	7.146	5.789	6.184	8.459	7.967	4.955	6.725	7.640	6.601	5.444	4.843
19	6.290	6.981	6.115	7.253	6.081	6.442	8.650	8.148	5.552	7.031	7.948	6.837	5.527	5.154
20	6.370	7.109	6.206	7.320	6.182	6.549	8.707	8.195	5.689	7.065	7.854	6.940	5.594	5.258
21	6.420	7.173	6.296	7.307	6.261	6.540	8.753	8.244	5.661	7.065	8.010	7.043	5.628	5.302
22	6.462	7.216	6.342	7.467	6.329	6.710	8.771	8.260	5.715	7.082	8.025	7.043	5.678	5.332
23	6.451	7.258	6.342	7.507	6.362	6.762	8.788	8.276	5.748	7.082	8.065	7.043	5.661	5.376
24	6.428	7.250	6.342	7.507	6.385	6.777	8.753	8.244	5.737	7.048	8.070	7.043	5.661	5.376
25	6.405	7.258	6.296	7.534	6.362	6.762	8.701	8.195	5.694	7.031	7.963	6.974	5.661	5.361
26	6.370	7.237	6.251	7.481	6.306	6.731	8.632	8.130	5.694	6.997	7.902	6.905	5.594	5.346
27	6.209	7.194	6.160	7.320	6.193	6.579	8.355	7.869	5.639	6.912	7.671	6.699	5.444	5.287
28	5.510	7.662	5.723	6.544	5.508	5.635	7.508	7.071	5.237	6.080	6.700	5.973	4.908	4.754
29	6.290	7.811	5.783	7.374	6.047	6.397	8.459	7.967	5.172	6.725	7.578	6.768	5.594	5.169
30	6.405	7.237	6.145	7.547	6.238	6.594	8.580	8.081	5.607	7.048	7.748	6.905	5.695	5.361
31	6.486	7.301	6.221	7.601	6.272	6.670	8.615	8.113	5.726	7.133	7.794	6.974	5.795	5.435
32	6.555	7.386	6.265	7.695	6.362	6.704	8.632	8.130	5.781	7.167	7.871	7.043	5.896	5.524
33	6.612	7.428	6.326	7.748	6.430	6.731	8.632	8.130	5.802	7.218	7.933	7.077	5.979	5.569
34	6.635	7.471	6.357	7.802	6.430	6.607	8.667	8.162	5.868	7.207	7.948	7.112	5.979	5.583
35	6.547	7.428	6.372	7.789	6.452	6.922	8.667	8.162	5.868	7.150	8.025	7.112	5.996	5.569
36	6.635	7.386	6.357	7.762	6.430	6.807	8.632	8.130	5.968	7.116	8.071	7.009	5.946	5.539
37	6.578	7.322	6.311	7.703	6.373	6.777	8.598	8.097	5.802	7.048	7.902	6.940	5.879	5.465
38	6.324	7.216	6.236	7.467	6.261	6.655	8.286	7.804	5.694	6.895	7.702	6.665	5.628	5.332
39	5.806	6.556	5.707	6.731	5.530	5.695	7.542	7.103	5.140	6.072	6.585	6.115	5.109	4.754
40	6.578	6.960	5.964	7.521	6.250	6.594	8.563	8.064	5.281	6.691	7.763	6.871	5.745	5.183
41	6.716	7.343	6.326	7.655	6.396	6.777	8.700	8.195	5.672	6.900	8.010	7.009	5.896	5.332
42	6.808	7.514	6.432	7.721	6.497	6.898	8.771	8.200	5.770	7.065	8.118	7.112	5.963	5.391
43	6.877	7.520	6.523	7.748	6.564	6.974	8.840	8.325	5.813	7.150	8.164	7.215	6.030	5.435
44	6.900	7.705	6.568	7.802	6.587	7.005	8.857	8.341	5.824	7.150	8.195	7.249	6.063	5.480
45	6.854	7.726	6.583	7.829	6.632	7.020	8.822	8.309	5.846	7.167	8.179	7.249	6.063	5.494

46	6.797	7.684	6.568	7.802	6.587	7.005	8.788	8.276	5.846	7.167	8.113	7.180	5.979	5.450
47	6.847	7.620	6.508	7.748	6.474	6.929	8.719	8.211	5.802	7.150	8.040	7.077	5.845	5.361
48	6.462	7.492	6.372	7.601	6.317	6.777	8.580	8.001	5.737	7.082	7.933	6.905	5.645	5.258
49	6.048	7.307	6.221	7.307	6.081	6.513	8.096	7.624	5.607	6.895	7.640	6.459	5.310	5.109
50	5.622	6.385	5.572	6.544	5.272	5.683	7.580	7.119	4.987	5.944	7.608	6.047	4.841	4.354
51	6.086	6.790	5.783	7.253	5.868	6.260	8.236	7.804	5.194	6.657	7.568	6.493	5.209	4.858
52	5.944	6.896	5.904	7.126	5.811	6.215	8.234	7.755	5.444	6.810	7.671	6.390	5.109	4.828
53	5.760	6.747	5.783	7.026	5.631	6.063	8.027	7.559	5.389	6.759	7.625	6.150	4.924	4.724
54	5.433	6.534	5.602	6.745	5.429	5.835	7.733	7.232	5.292	6.640	7.471	5.944	4.707	4.547
55	5.092	6.194	5.330	6.356	5.092	5.500	7.335	6.908	5.118	6.386	7.193	5.463	4.388	4.265
56	4.654	5.726	4.963	5.794	4.687	5.060	6.747	6.354	4.868	6.029	6.793	4.947	4.037	3.954
57	4.066	5.193	4.454	5.179	4.170	4.528	6.003	5.653	4.498	5.553	6.101	4.329	3.584	3.525
58	3.375	4.491	3.830	4.363	3.563	3.905	5.086	4.750	3.999	4.925	5.391	3.607	3.075	3.021
59	2.500	3.682	3.141	3.412	2.799	3.115	3.675	3.649	3.358	4.059	4.313	2.680	2.311	2.414
60	2.052	2.575	2.250	2.462	1.321	2.127	3.131	2.949	2.543	2.836	2.850	2.892	1.608	1.629
61	1.229	2.746	2.144	3.198	0.888	2.705	2.900	2.737	1.891	1.483	1.412	1.202	1.826	2.044

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	H01	F02	D03	N05	B05	N07	R08	N08	L08	L09	N10	D10	L11	F11	N12	L14	J15
1	1.087	2.418	1.307	2.735	1.879	2.088	1.328	2.224	3.798	2.860	1.740	3.247	2.879	3.071	2.120	1.771	0.970
2	2.231	2.617	2.319	3.534	2.332	3.436	2.350	3.959	4.414	3.849	2.958	3.545	3.651	4.040	2.779	2.277	1.758
3	3.314	3.400	3.033	4.285	2.983	4.262	3.085	5.199	5.294	5.079	3.526	4.696	4.503	5.278	3.453	2.093	2.336
4	4.009	4.104	3.616	4.860	3.512	4.847	3.705	5.913	6.150	5.706	4.153	5.253	5.120	5.908	4.075	3.416	2.849
5	4.524	4.002	4.064	5.244	3.904	5.241	4.207	6.393	6.712	6.164	4.452	5.506	5.531	6.100	4.413	3.740	3.271
6	4.692	4.832	4.141	5.129	3.823	5.072	4.309	6.114	5.517	5.810	4.153	5.190	5.213	5.832	4.284	3.542	3.497
7	4.808	5.124	4.557	6.107	4.503	5.581	4.743	7.297	7.335	6.851	4.989	6.127	6.147	6.385	5.127	4.355	3.633
8	5.534	5.907	5.126	6.446	4.871	6.329	5.303	7.721	7.947	7.289	5.301	6.405	6.540	7.198	5.507	4.743	4.251
9	5.787	6.241	5.419	6.715	5.124	6.321	5.673	7.355	8.210	7.455	5.536	6.532	6.609	7.340	5.782	4.936	4.552
10	5.976	6.503	5.650	6.894	5.309	6.658	5.952	8.122	8.375	7.543	5.601	6.633	6.857	7.454	5.934	5.196	4.740
11	6.113	6.751	5.835	7.086	5.447	6.759	6.136	8.245	8.473	7.705	5.764	6.696	6.914	7.525	6.086	5.326	4.929
12	6.186	6.848	5.988	7.163	5.539	6.795	6.247	8.290	8.485	7.726	5.816	6.722	6.932	7.554	6.168	5.456	5.030
13	6.228	6.945	6.035	7.227	5.585	6.850	6.340	8.357	8.473	7.726	5.774	6.747	6.932	7.582	6.204	5.456	5.125
14	6.239	6.969	6.050	7.278	5.608	6.859	6.386	8.368	8.473	7.684	5.754	6.747	6.895	7.592	6.192	5.456	5.170
15	6.229	6.969	6.050	7.252	5.573	6.823	6.371	8.323	8.387	7.622	5.723	6.633	6.839	7.454	6.130	5.439	5.200
16	6.770	6.890	6.004	7.022	5.516	6.640	6.309	8.100	8.216	7.393	5.526	6.317	6.633	7.098	6.028	5.381	5.105
17	5.818	6.435	5.527	6.421	4.940	5.936	5.875	7.241	7.275	6.352	4.702	5.709	5.699	6.416	5.507	4.776	4.899
18	5.702	6.508	5.804	7.137	5.573	6.731	6.123	8.212	8.033	7.208	5.485	6.401	6.521	7.283	6.227	5.391	4.869
19	6.186	6.896	6.127	7.214	5.792	6.804	6.495	8.307	8.326	7.435	5.650	6.671	6.671	7.407	6.379	5.536	5.300
20	6.249	6.993	6.204	7.316	5.907	6.859	6.650	8.363	8.424	7.435	5.671	6.671	6.671	7.497	6.484	5.601	5.420
21	6.313	7.006	6.266	7.355	5.965	6.951	6.712	8.479	8.461	7.476	5.723	6.671	6.708	7.497	6.520	5.684	5.502
22	6.365	7.115	6.296	7.431	6.071	6.973	6.774	8.513	8.461	7.476	5.785	6.722	6.708	7.554	6.560	5.698	5.532
23	6.380	7.133	6.312	7.420	6.024	6.930	6.882	8.490	8.451	7.435	5.704	6.709	6.671	7.539	6.578	5.690	5.547
24	6.376	7.103	6.296	7.521	6.046	6.930	6.913	8.490	8.412	7.425	5.754	6.658	6.671	7.402	6.555	5.650	5.562
25	6.344	7.163	6.281	7.521	6.000	6.960	6.882	8.490	8.363	7.455	5.754	6.633	6.689	7.454	6.473	5.650	5.577
26	6.334	7.115	6.219	7.457	5.942	6.914	6.836	8.435	8.302	7.393	5.702	6.544	6.633	7.354	6.430	5.634	5.532
27	6.271	7.091	6.090	7.043	5.804	6.622	6.727	8.072	8.106	7.135	5.516	6.046	6.446	6.828	6.130	5.504	5.487
28	5.829	6.362	5.404	6.753	5.170	6.128	6.045	7.475	7.128	6.331	4.865	5.924	5.680	6.657	5.700	4.873	5.004
29	5.892	6.896	5.973	7.431	5.830	6.850	6.417	8.357	8.002	7.372	5.599	6.456	6.675	7.255	6.356	5.569	5.300
30	6.323	7.212	6.142	7.503	5.953	6.997	6.681	8.535	8.314	7.539	5.754	6.544	6.764	7.354	6.473	5.747	5.502
31	6.407	7.285	6.204	7.585	5.988	7.079	6.758	8.685	8.363	7.622	5.805	6.582	6.839	7.397	6.531	5.844	5.668
32	6.491	7.382	6.250	7.738	6.046	7.179	6.805	8.758	8.399	7.684	5.876	6.643	6.895	7.460	6.683	5.909	5.743
33	6.534	7.382	6.296	7.730	6.102	7.234	6.851	8.825	8.424	7.705	5.929	6.709	6.914	7.539	6.637	6.006	5.803
34	6.565	7.406	6.327	7.815	6.138	7.262	6.898	8.859	8.461	7.684	5.950	6.747	6.895	7.582	6.707	6.054	5.803
35	6.586	7.358	6.343	7.853	6.138	7.243	6.944	8.836	8.436	7.643	5.981	6.848	6.857	7.696	6.730	6.071	5.803
36	6.565	7.309	6.327	7.828	6.126	7.179	6.960	8.758	8.399	7.607	5.950	6.760	6.820	7.596	6.613	6.038	5.780
37	6.535	7.285	6.296	7.700	6.080	7.134	6.960	8.702	8.387	7.539	5.807	6.071	6.764	7.497	6.496	5.984	5.698
38	6.430	7.163	6.219	7.214	5.815	6.614	6.867	8.312	8.106	7.125	5.588	6.038	6.446	6.785	6.122	5.779	5.562
39	5.787	6.386	5.465	7.176	5.504	6.512	6.138	7.944	7.275	6.477	5.051	6.266	5.811	7.041	6.028	5.110	4.974
40	6.144	7.115	6.235	7.674	6.103	7.198	6.743	8.731	8.302	7.476	5.774	6.810	6.708	7.653	6.566	5.060	5.426
41	6.407	7.431	6.435	7.764	6.195	7.259	6.901	8.892	8.497	7.607	5.919	6.937	6.820	7.795	6.695	6.006	5.637
42	6.431	7.600	6.558	7.863	6.310	7.362	7.084	8.981	8.563	7.684	5.921	7.073	6.895	7.881	6.836	6.152	5.713
43	6.523	7.722	6.685	7.853	6.368	7.472	7.208	9.115	8.644	7.768	6.033	7.076	6.970	7.952	6.941	6.233	5.788
44	6.576	7.819	6.697	7.956	6.414	7.509	7.316	9.150	8.705	7.789	6.074	7.046	6.988	7.952	6.988	6.233	5.810
45	6.597	7.843	6.712	8.007	6.437	7.490	7.316	9.138	8.705	7.851	6.084	7.089	7.044	7.966	6.929	6.265	5.842
46	6.628	7.819	6.712	8.007	6.391	7.454	7.316	9.093	8.081	7.851	6.084	7.028	7.044	7.909	6.906	6.200	5.933
47	6.649	7.770	6.650	7.969	6.287	7.399	7.235	9.026	8.632	7.830	6.022	6.975	7.026	7.838	6.812	6.135	5.758
48	6.639	7.649	6.558	7.815	6.172	7.298	7.208	8.908	8.534	7.747	5.950	6.861	6.951	7.710	6.637	5.941	5.698
49	6.544	7.431	6.343	7.176	5.654	6.786	7.000	8.273	8.179	7.268	5.578	6.073	6.321	6.757	6.040	5.560	5.562
50	5.787	6.362	5.511	7.303	5.643	6.667	6.107	8.133	7.482	6.831	5.186	6.494	6.129	7.298	6.168	5.099	4.838
51	6.355	7.163	6.189	7.636	5.396	7.106	6.743	8.669	8.375	7.622	5.795	6.610	6.830	7.653	6.414	5.536	5.330
52	6.502	7.212	6.219	7.572	5.792	7.040	6.774	8.624	8.436	7.584	5.616	6.848	6.895	7.693	6.297	5.422	5.306
53	6.523	7.094	6.127	7.431	5.600	6.951	6.665	8.479	8.338	7.622	5.734	6.758	6.839	7.639	6.130	5.323	5.245
54	6.401	6.872	5.942	7.124	5.366	6.731	6.479	8.212	8.155	7.455	5.630	6.620	6.609	7.440	5.876	5.132	5.125
55	6.302	6.556	5.650	6.741	5.009	6.437	6.169	7.877	7.874	7.060	5.392	6.279	6.334	7.056	5.490	4.840	4.854
56	5.455	6.046	5.200	6.191	4.560	6.009	5.735	7.330	7.421	6.581	5.051	5.772	5.903	6.487	5.070	4.484	4.507
57	5.408	5.488	4.695	5.462	3.938	5.396	5.208	6.583	6.737	5.934	4.514	5.107	5.307	5.733	4.356	3.902	4.025
58	4.734	4.735	4.078	4.579	3.213	4.463	4.495	5.445	5.820	5.060	3.903	4.203	4.541	4.723	3.582	3.400	3.467
59	3.861	3.812	3.171	3.415	2.246	3.347	3.612	4.083	4.585	3.853	2.534	2.806	3.457	3.243	2.517	2.623	2.709
60	2.704	2.550	2.124	3.159	2.441	3.055	2.480	3.726	3.277	2.374	2.118	2.071	3.570	3.002	2.660	1.862	1.869
61	3.493	3.400	2.771	2.993	1.693	2.451	3.153	2.990	3.307	1.590	1.797	1.760	1.427	1.921	1.330	2.165	2.427

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	F02	D03	N05	L06	N07	J07	R08	N08	N10	L11	F11	N12	C12	L14	J15
1	2.450	1.357	2.935	3.044	2.002	2.893	1.331	2.164	1.660	2.797	2.912	1.450	1.423	1.914	1.371
2	3.164	2.372	3.668	3.578	3.559	3.520	2.349	3.846	2.771	3.457	3.576	2.588	2.566	2.467	2.320
3	3.904	3.046	4.415	4.454	4.672	4.305	3.056	5.043	3.451	4.254	4.239	3.414	3.428	3.084	2.847
4	4.526	3.652	5.023	5.170	5.040	5.258	3.723	5.795	4.070	4.909	5.265	3.930	4.021	3.567	3.309
5	4.920	4.108	5.418	5.665	5.164	5.777	4.227	6.262	4.470	5.373	6.065	4.266	4.336	3.910	3.563
6	4.741	4.216	5.151	5.460	4.910	5.821	4.305	5.953	4.450	5.119	5.557	4.134	4.154	3.751	3.638
7	5.715	4.446	6.181	6.214	5.337	6.261	4.926	7.078	4.640	5.842	6.669	4.839	4.997	4.466	4.361
8	6.099	5.062	6.550	6.731	6.192	6.820	5.455	7.508	5.334	6.330	7.012	5.247	5.314	4.800	4.639
9	6.381	5.323	6.805	6.925	6.383	7.194	5.765	7.739	5.575	6.545	7.163	5.459	5.539	5.054	4.851
10	6.586	5.523	6.983	7.054	6.519	7.432	6.029	7.905	5.695	6.662	7.300	5.013	5.737	5.197	5.070
11	6.765	5.708	7.135	7.151	6.610	7.635	6.105	8.075	5.796	6.740	7.382	5.710	5.843	5.372	5.124
12	6.868	5.816	7.250	7.151	6.692	7.643	6.325	8.114	5.806	6.740	7.362	5.777	5.896	5.404	5.215
13	6.893	5.877	7.263	7.173	6.728	7.895	6.371	8.158	5.876	6.779	7.437	5.829	5.909	5.467	5.245
14	6.919	5.908	7.313	7.151	6.737	7.603	6.434	8.169	5.870	6.760	7.437	5.856	5.896	5.551	5.245
15	6.868	5.862	7.326	7.097	6.710	7.669	6.449	8.136	5.916	6.682	7.327	5.840	5.843	5.335	5.260
16	6.714	5.831	7.161	6.989	6.546	7.403	6.371	7.938	5.735	6.545	7.000	5.737	5.711	5.372	5.070
17	5.894	5.462	6.337	6.171	5.764	6.688	5.812	6.990	5.223	5.607	6.134	5.080	5.063	4.736	4.775
18	6.765	5.523	7.148	6.828	6.537	7.077	6.154	7.927	5.223	6.232	7.135	5.846	5.790	5.363	5.336
19	6.893	5.939	7.237	7.046	6.692	7.520	6.542	8.114	5.695	6.486	7.390	5.962	6.001	5.515	5.473
20	6.970	6.047	7.364	7.130	6.755	7.610	6.651	8.191	5.745	6.545	7.300	6.001	6.001	5.630	5.480
21	7.043	6.100	7.420	7.173	6.810	7.640	6.775	8.258	5.796	6.604	7.410	6.147	6.226	5.610	5.533
22	7.124	6.154	7.530	7.205	6.856	7.673	6.853	8.313	5.876	6.584	7.423	6.167	6.206	5.658	5.564
23	7.150	6.200	7.555	7.173	6.874	7.704	6.900	8.335	5.896	6.565	7.437	6.214	6.292	5.674	5.609
24	7.150	6.154	7.593	7.119	6.823	7.724	6.962	8.345	5.826	6.565	7.390	6.107	6.279	5.626	5.624
25	7.150	6.154	7.619	7.130	6.865	7.690	6.931	8.334	5.876	6.565	7.355	6.127	6.239	5.594	5.624
26	7.124	6.047	7.530	7.087	6.837	7.543	6.884	8.291	5.846	6.525	7.300	6.081	6.173	5.578	5.579
27	7.045	5.985	7.302	6.979	6.687	7.432	6.775	8.043	5.775	6.389	6.302	5.962	6.075	5.419	5.336

28	6.125	5.416	6.512	6.104	5.837	6.491	5.983	7.070	5.233	5.510	6.312	5.233	5.314	4.927	5.094
29	7.062	5.739	7.428	6.893	6.737	7.197	6.604	8.160	5.414	6.329	7.135	5.922	6.075	5.594	5.594
30	7.175	5.970	7.686	7.130	6.892	7.520	6.806	8.357	5.206	6.643	7.231	6.028	6.147	5.685	5.685
31	7.252	5.903	7.631	7.216	6.974	7.626	6.884	8.456	5.926	6.721	7.300	6.134	6.239	5.849	5.791
32	7.329	6.047	7.746	7.216	7.044	7.604	6.915	8.577	5.936	6.700	7.368	6.214	6.305	5.912	5.852
33	7.355	6.108	7.860	7.240	7.137	7.759	6.946	8.654	6.027	6.919	7.423	6.293	6.358	5.944	5.867
34	7.329	6.108	7.860	7.291	7.174	7.820	7.009	8.699	6.098	6.779	7.465	6.280	6.371	5.992	5.867
35	7.252	6.139	7.937	7.302	7.156	7.830	7.024	8.677	6.037	6.760	7.492	6.306	6.399	6.055	5.852
36	7.227	6.154	7.937	7.270	7.107	7.704	7.040	8.670	6.107	6.740	7.500	6.240	6.371	6.089	5.776
37	7.207	6.139	7.873	7.216	7.065	7.756	7.009	8.566	6.037	6.682	7.396	6.147	6.305	5.933	5.700
38	7.022	6.093	7.631	7.033	6.865	7.603	6.869	8.324	5.896	6.486	6.998	6.028	6.094	5.642	5.276
39	6.304	5.477	6.856	6.171	6.110	6.578	6.045	7.420	5.223	5.568	6.477	5.313	5.400	5.181	5.200
40	7.252	5.985	7.746	7.005	7.010	6.457	6.720	8.500	5.565	6.447	7.451	6.055	6.239	5.830	5.670
41	7.457	6.277	7.899	7.302	7.156	7.350	6.977	8.677	5.986	6.662	7.670	6.253	6.371	5.992	5.791
42	7.631	6.431	7.949	7.388	7.228	7.997	7.036	8.765	6.097	6.760	7.739	6.346	6.464	6.135	5.867
43	7.713	6.539	8.073	7.431	7.319	8.121	7.195	8.875	6.147	6.877	7.794	6.505	6.570	6.182	5.927
44	7.816	6.600	8.077	7.442	7.365	8.160	7.242	8.930	6.187	6.877	7.835	6.571	6.623	6.182	5.958
45	7.842	6.600	8.140	7.496	7.419	8.212	7.257	8.996	6.238	6.916	7.835	6.545	6.670	6.230	5.958
46	7.842	6.616	8.204	7.496	7.383	8.206	7.288	8.952	6.258	6.955	7.808	6.545	6.609	6.198	5.927
47	7.739	6.585	8.204	7.474	7.319	8.150	7.319	8.875	6.248	6.986	7.794	6.465	6.543	6.135	5.932
48	7.552	6.508	8.140	7.420	7.246	8.070	7.257	8.787	6.207	6.916	7.670	6.412	6.451	5.944	5.776
49	7.303	6.354	7.345	7.205	7.070	7.792	7.117	8.500	6.087	6.682	7.000	6.240	6.213	5.578	5.412
50	6.509	5.539	6.995	6.333	6.246	6.613	6.200	7.574	5.273	5.744	6.306	5.459	5.539	5.229	5.291
51	7.300	6.139	7.975	7.280	7.107	7.532	6.902	8.610	5.796	6.721	7.629	6.161	6.226	5.042	5.670
52	7.406	6.277	8.000	7.399	7.128	7.793	7.040	8.643	6.067	6.897	7.739	6.167	6.279	5.630	5.670
53	7.303	6.231	7.971	7.410	7.065	7.761	6.977	8.566	6.104	6.935	7.753	6.031	6.200	5.515	5.473
54	7.124	6.100	7.733	7.313	6.930	7.689	6.838	8.379	6.037	6.958	7.657	5.975	6.067	5.302	5.321
55	6.791	5.893	7.415	7.130	6.622	7.406	6.573	8.114	5.896	6.643	7.396	5.777	5.790	5.070	5.083
56	6.355	5.570	6.983	6.828	6.355	7.025	6.154	7.706	5.655	6.291	6.957	5.379	5.393	4.736	4.669
57	5.766	5.096	6.321	6.322	5.846	6.506	5.610	7.089	5.283	5.783	6.298	4.942	4.878	4.275	4.184
58	4.997	4.477	5.444	5.633	5.146	5.775	4.925	6.240	4.721	5.000	5.379	4.279	4.204	3.655	3.502
59	3.998	3.646	4.308	4.599	4.137	4.751	4.025	5.076	3.998	4.181	4.130	3.445	3.384	2.329	2.683
60	2.742	2.508	3.091	3.209	2.987	3.353	2.732	3.561	2.903	2.313	3.040	2.332	2.274	2.066	2.047
61	3.000	2.954	4.566	3.856	3.964	2.703	3.520	4.807	2.300	1.420	1.670	2.941	2.907	2.336	2.130