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Confirmatory Neutronics Analysis of the AGR-1 Experiment Irradiated in ATR B-10 Position

Gray S. Chang, Misti A. Lillo

January 2003

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ENGINEERING DESIGN FILE

Confirmatory Neutronics Analysis of the AGR-1 Experiment Irradiated in ATR B-10 Position

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A discussion for each revision number is given below.

Revision 1 Summary

This revision addresses the project staff requests for additional data and calculations as well as the correction of typographical errors. All changes are discussed in this summary. Previous calculations and results reported by revision 0 of this EDF are valid and applicable unless noted below.

(Correction) Tables 3, 4, and 7 – The units of mg/m^3 should be Mg/m^3. The units are now shown correctly in the tables. This was a typographical error in the EDF only. Calculations and results were not impacted.

(Correction) Table 4 – The atom densities for the Si and O table entries were switched. The values are now correctly reported. This was a typographical error in the EDF only. The MCNP input model material cards were checked and the correct values were verified as being used in the original analysis. Calculations and results were not impacted.

(Addition) Table 34 – Project staff requested that additional heating rate calculations be performed for the B4C graphite holders vs. EFPDs for 800 EFPDs of irradiation. Thus, the calculated results for B4C heating rates vs. EFPDs were added.

(Update) Table 34 and following tables – Due to addtion of Table 34 in this revision, all table numbers following 34 were incremented as needed.

(Correction) Table 37 – The column entitled Burnup (%FIMA) for 125 EFPDs was off by one node for stack 3 and stack 2. The values are now correctly reported. This was a typographical error in the EDF only. Calculations and results were not impacted.

(Addition) Tables 40, 41, 42 – The AGR-1 project staff requested that finer time intervals be reported for the range of 400-800 EFPDs . Thus, the calculated results for AGR-1 fuel compact projected fission power density and burnup vs. EFPDs for 50 EFPD intervals from 400 EFPDs to 800 EFPDs were added.

The AGR-1 fuel compact projected burnup reaches 22.37% FIMA in capsule 3, stack-1, top fuel

compact of capsule stack (node-25 of stack-1, facing core center towards NW) at 800 EFPDs.

(Update) Table 42 and following tables – Due to the addition of Tables 40, 41, and 42 in this revision, all table numbers following 42 were incremented as needed.

(Addition)Table 47 – The AGR-1 project staff requested that the fast flux and fast fluence be reported for 800 EFPDs. Thus, the calculated results for 50 EFPD time intervals from 700 EFPDs to 800 EFPDs were added. The maximum fast neutron fluence requirement of 5.0×10^{25} n/m^2 is projected to occur after 750 EFPDs of irradiation. At 800 EFPDs, multiple fuel compacts in capsule 3 and capsule 4 exceed the maximum fast neutron fluence requirement of 5.0×10^{25} n/m^2.

Finally, this revised EDF is used to place this document under document control, thus providing a controlled summary of the analysis performance and results, as well as a retrievable record of the review and approval process.

End of Revision 1 Summary

Revision 0 Summary

The confirmatory neutronics analysis for the Advanced Gas Reactor (AGR) capsule assembly AGR-1 has been performed using the computer codes MCNP and ORIGEN2 coupled via the UNIX script MCWO. The confirmatory neutronics analysis evaluated the neutron/gamma heating rates for the AGR-1 capsule assembly structural components, the AGR-1 capsule assembly reactivity worth relative to an aluminum dummy, the peak fuel fission power density of the AGR-1 fuel compacts, the fuel burnup of the AGR-1 fuel compacts, and the fast neutron fluence (E > 0.18MeV) experienced by the AGR-1 fuel compacts. The neutronics model, analysis details, and results are presented in this Engineering Design File (EDF).

For initial conditions (at 0 EFPDs with an East lobe power of 22.47 MW), the projected maximum neutron/gamma heating rate for an AGR-1 capsule assembly structural component was calculated to be 22.33 W/g, occurring in the graphite holder of capsule 5 (bottom 1 inch node). For the peak fuel fission power density condition (at 250 EFPDs with an East lobe power of 37.33 MW), the projected maximum neutron/gamma heating rate was calculated to be 19.19 W/g, occurring in the hafnium shroud of capsule 3 (60° arc facing core center towards SW).

Relative to an aluminum dummy located in the ATR B-10 irradiation position, the AGR-1 capsule

assembly reactivity worths were calculated with a confidence level of 95% (2σ) to be:

-0.033$ ±0.048$ for 0 EFPDs,

0.000$ ±0.045$ for 250 EFPDs, and

-0.043$ ±0.048$ for 250 EFPDs with He-3 replacing He-4 in the capsule assembly.

These reactivity changes are much less than the 0.50$ step insertion limit defined in the ATR UFSAR [SAR-153, Chapter 15.4.5], thus, an aluminum dummy is an acceptable backup experiment for the AGR-1 capsule assembly experiment.

For typical middle of cycle (MOC) operating conditions and nominal lobe powers represented by the requested lobe powers for ATR Cycle 138B (East lobe source power of 22.47 MW), the projected peak fuel fission power density for AGR-1 fuel compacts was calculated to be 132.39 W/cm^3 occurring at 250 EFPDs within capsule 3, stack-1, the third fuel compact from top of capsule stack (node-29 of stack-1, facing core center towards NW).

~~The projected fuel burnup for AGR-1 fuel compacts versus EFPDs from 0 EFPDs to 700 EFPDs was calculated. The AGR-1 fuel compact projected burnup reaches 21.04% FIMA in capsule 3, stack-1, top fuel compact of capsule stack (node-25 of stack-1, facing core center towards NW) at 700 EFPDs.~~

The AGR program requires a minimum fast neutron fluence (E > 0.18 MeV) greater than 1.5×10^{25} n/m^2 (1.5×10^{21} n/cm^2) and a maximum fast neutron fluence of less than 5.0×10^{25} n/m^2. The fast neutron fluence was evaluated for the AGR-1 fuel compacts and the minimum and maximum fast fluence requirements were verified. The minimum fast neutron fluence requirement of greater than 1.5×10^{25} n/m^2 was determined to happen after 450 EFPDs. The last fuel compact to exceed the minimum is projected to occur in capsule 6, stack-2, top fuel compact in capsule stack (node 97 of stack-2, facing away from core center and towards E), at 450 EFPDs with a value of 1.533×10^{25} n/m^2. ~~The maximum fast neutron fluence requirement of less than 5.0×10^{25} n/m^2 will not be exceeded during the analyzed 700 EFPDs. A maximum fast fluence of 4.55×10^{25} n/m^2 for all fuel compacts is projected to occur in capsule 4, stack-3, third fuel compact from the top of capsule stack (node 69 of stack-3, facing core center and towards SW), at 700 EFPDs.~~

Finally, this EDF is used to place this document under document control, thus providing a controlled summary of the analysis performance and results, as well as a retrievable record of the review and approval process of the analysis.

End of Revision 0 Summary

ENGINEERING DESIGN FILE

Confirmatory Neutronics Analysis of the AGR-1
Experiment Irradiated in ATR B-10 Position

EDF No.: 7120 EDF Rev. No.: 1 Project File No.: 23841

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1.0 Introduction

This Engineering Design File (EDF) documents the Advanced Test Reactor (ATR) physics model and confirmatory neutronics analysis for the Advanced Gas Reactor (AGR) capsule assembly experiment, AGR-1, planned for insertion into the ATR B-10 irradiation test position during ATR Cycle 138B. The neutron/gamma heating rates for AGR-1 capsule assembly structural components, AGR-1 capsule assembly reactivity worth relative to an aluminum dummy, AGR-1 fuel compact fission power density and burnup versus Effective Full Power Days (EFPDs), and the AGR-1 fuel compact fast flux (E > 0.18MeV) and fast fluence versus EFPDs have been calculated and are reported herein as requested by AGR-1 project staff [1].

2.0 Assumptions

The assumptions used in this analysis are stated below.

1. The ATR B-10 irradiation position is located between the Northeast (NE) and Southeast (SE) quadrants of the ATR (see Figure 1) which is best represented by the East lobe source power.

2. The East lobe source power is defined as the average of the NE, C and SE lobe powers, E = (NE + C + SE) / 3.

3. If actual cycle lobe powers differ from analyzed cycle lobe powers, analysis results should be scaled using the ratio of the actual East lobe power to the analyzed East lobe power.

4. The heating rates, projected peak fuel fission power density, and projected fuel burnup analyses were performed using typical ATR middle of cycle (MOC) operating conditions. Actual neck shim and outer control shim positions were based upon ATR Surveillance Data Reports for ATR Cycle 136A. Fuel loading and burnup was based upon the Cycle 136A Physics Report [2]. The heating rates, projected peak fuel fission power density, and projected fuel burnup results were normalized using the requested lobe powers for ATR Cycle 138B.

5. The projected peak heating rate analysis was performed using typical PALM cycle operating conditions. Actual neck shim and outer control shim positions were based upon ATR Surveillance Data Reports for ATR Cycle 131B. The fuel loading and burnup was based upon the Cycle 131B Physics Report [3]. The peak heating rate results were normalized using the requested lobe powers for the ATR Cycle 141B.

6. Requested lobe powers for Cycle 138B are 18.0-18.0-24.4-23.0-25.0 MW (NW-NE-C-SW-SE) [4].

7. Requested lobe powers for Cycle 141B are 18.0-18.0-39.0-55.0-55.0 MW (NW-NE-C-SW-SE) [4].

8. Heating rate values reported for AGR-1 capsule assembly within the ATR B-10 position include energy deposition from prompt neutrons, prompt gammas, and delayed fission product gammas.

9. A delayed neutron fraction (β) of 0.0075 [5] was used for ATR reactivity perturbation calculations.

3.0 Capsule Assembly Description

The AGR-1 experiment capsule assembly consists of 6 capsules axially stacked. Each capsule contains a graphite holder with 3 equally spaced fuel compact holder openings (see Figure 2). Each holder opening accommodates 4 axially stacked fuel compacts. Thus, each capsule has 3 stacks x 4 fuel compacts/stack for a total of 12 fuel compacts per capsule. So, within the entire AGR-1 experiment capsule assembly, there are 6 capsules x 12 fuel compacts/capsule for a total of 72 fuel compacts.

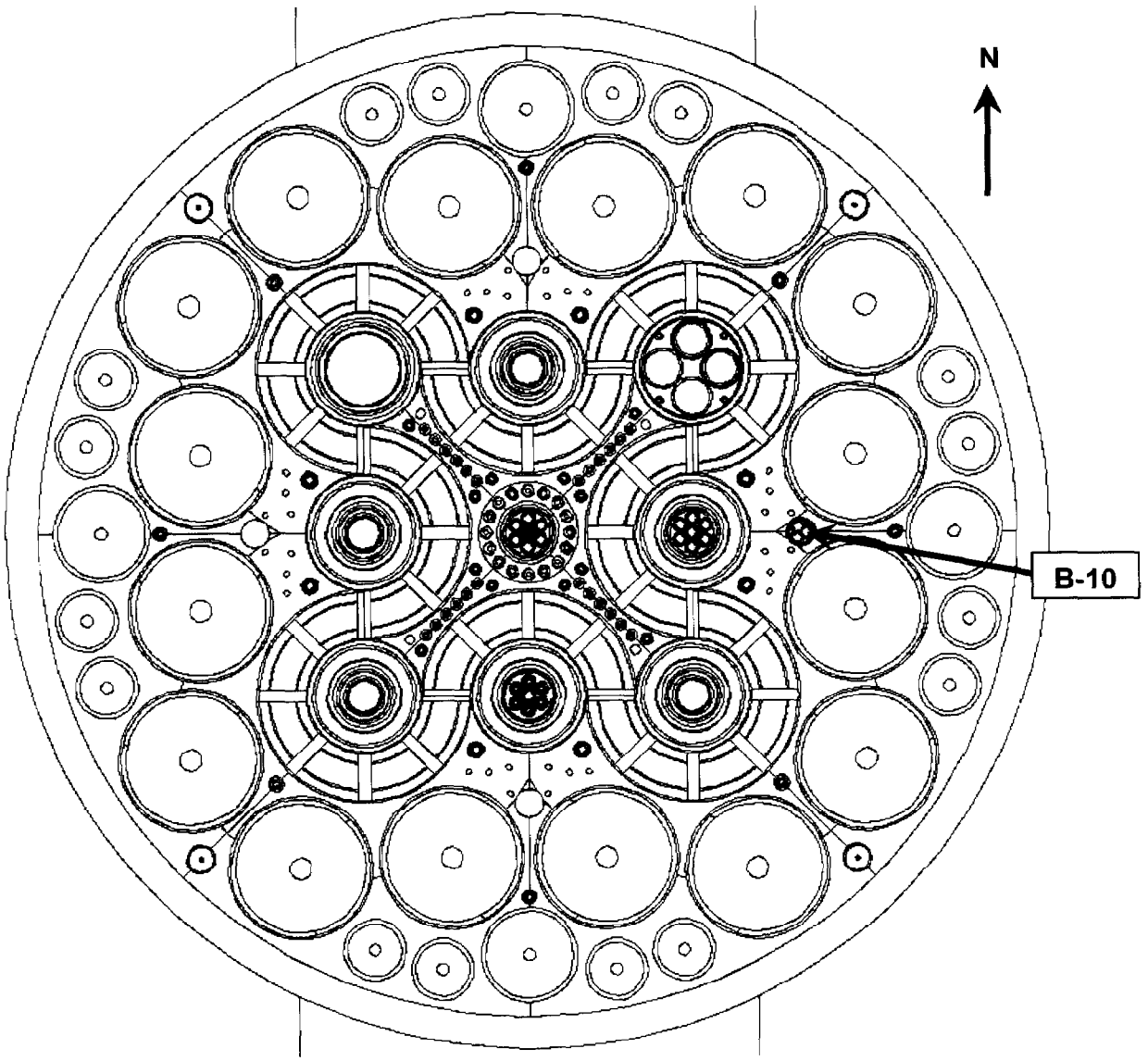


Figure 1. Radial Cross Section View of the ATR Reactor Core, B-10 Irradiation Test Position

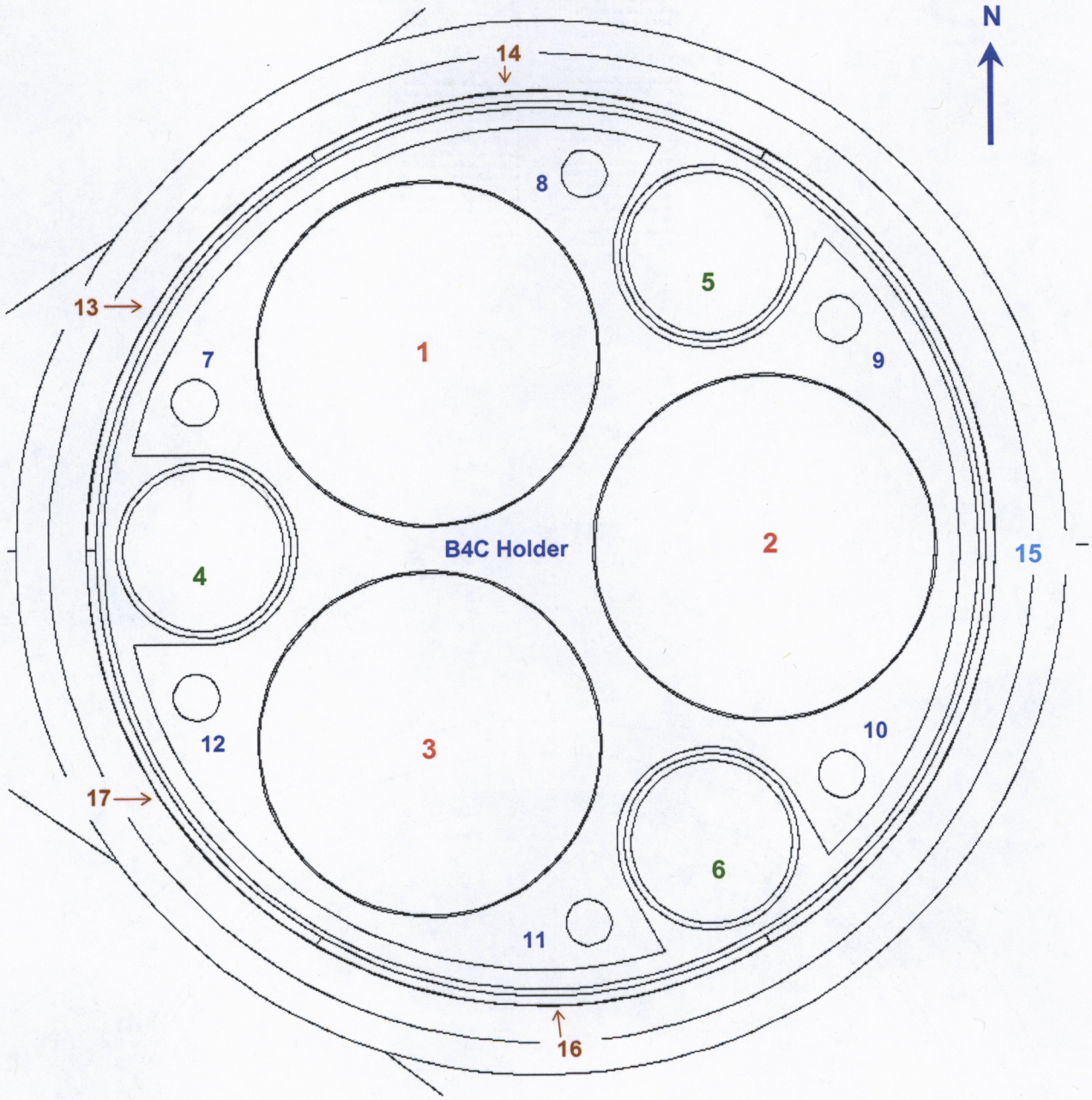


Figure 2. Radial Cross Section View of an AGR-1 Experiment Capsule Assembly, (Components shown include: Graphite Holder, Thru Tubes, Fuel Compacts, SS Sleeve, Hf/SS Shroud, TC and Gas Line Openings, Capsule Body, Gas Gaps, and Water Gap)

Key: Red Numbers – Fuel Compact (1, 2, 3)
Green Numbers – Thru Tube (4, 5, 6)
Blue Numbers – TC and Gas Line (7, 8, 9, 10, 11, 12)
Brown Numbers – Hf Shroud (13, 14, 16, 17)
Turquoise Number – SS Shroud (15)

4.0 Model Description and Data

MCNP [6], a general purpose Monte Carlo N-Particle transport code, was used to model and evaluate the neutron and gamma heating rates of the AGR-1 capsule assembly components as well as the AGR-1 capsule assembly reactivity worth relative to an aluminum dummy. The depletion methodology MCWO, MCNP coupled with ORIGEN2 [7], was used to model and evaluate the depletion and activation of the AGR-1 capsule assembly, providing the fission power density and burnup versus EFPDs for the AGR-1 fuel compacts.

For the AGR-1 confirmatory analysis, the MCNP and ORIGEN2 models were based upon the drawings listed in Table 1, as well as data from experiment designers, vendors, project staff, and project related EDF's. The references for data used in the AGR-1 confirmatory analysis are identified within this document.

Table 1. INL Drawings for the AGR-1 Experiment

INL Drawing	Revision	Drawing Title
DWG-628633	0	ATR Advanced Gas Reactor (AGR) AGR-1 Capsule Details and Assemblies
DWG-628635	2	ATR Advanced Gas Reactor (AGR) AGR-1 Capsule Train Assembly and Details

4.1 Data Libraries

Both the MCNP built-in cross-section data libraries and the JENDL-3.2 cross-section library were used to calculate the neutron and gamma heating rates for AGR-1 assembly structural components as well as the AGR-1 fuel fission density (see Attachment B for a listing of the specific cross-sections used with the MCWO methodology and a justification discussion). The ORIGEN2 libraries ATRXS and HTGRXS were used to calculate the fuel compact and absorber burnup within the AGR-1 capsules.

4.2 Power Data

The neutron/gamma heat generation rates for the AGR-1 capsule assembly structural components were calculated for 0 EFPDs using ATR Cycle 138B requested lobe powers and for 250 EFPDs using ATR Cycle 141B requested lobe powers. The neutron/gamma heat generation rates for the AGR-1 B4C graphite holders vs. EFPDs (25 – 800 EFPDs) were calculated using Cycle 138B requested lobe powers for nominal conditions. The AGR-1 fuel compact projected peak fission power density and projected fuel burnup were calculated using Cycle 138B requested lobe powers for nominal conditions.

The calculated East lobe source power for Cycle 138B is 22.47 MW [(18.0+ 24.4+ 25.0)/ 3] and for Cycle 141B it is 37.33 MW [(18.0+ 39.0+ 55.0)/ 3].

4.3 Fuel Compact Data

The AGR-1 fuel compacts were modeled using data from references [8] and [9]. To simplify the MCNP model geometry, nominal fuel compact dimensions were used. Per reference [8], the fuel compacts placed in capsule 6 (top capsule) and capsule 3 used Baseline data while the fuel compacts placed in capsules 1 (bottom capsule), 2, 4, and 5 used Variant 1 data. Each AGR-1 fuel compact was subdivided into 2 equal-sized cells/nodes. Thus stack-1 is comprised of nodes 1-48 (see Figure 3, which has 8 nodes per capsule times 6 capsules), stack-2 is comprised of nodes 97-144, and stack-3 is comprised of nodes 49-96. These subdivisions were implemented to match the nodalization used by the thermal analysis.

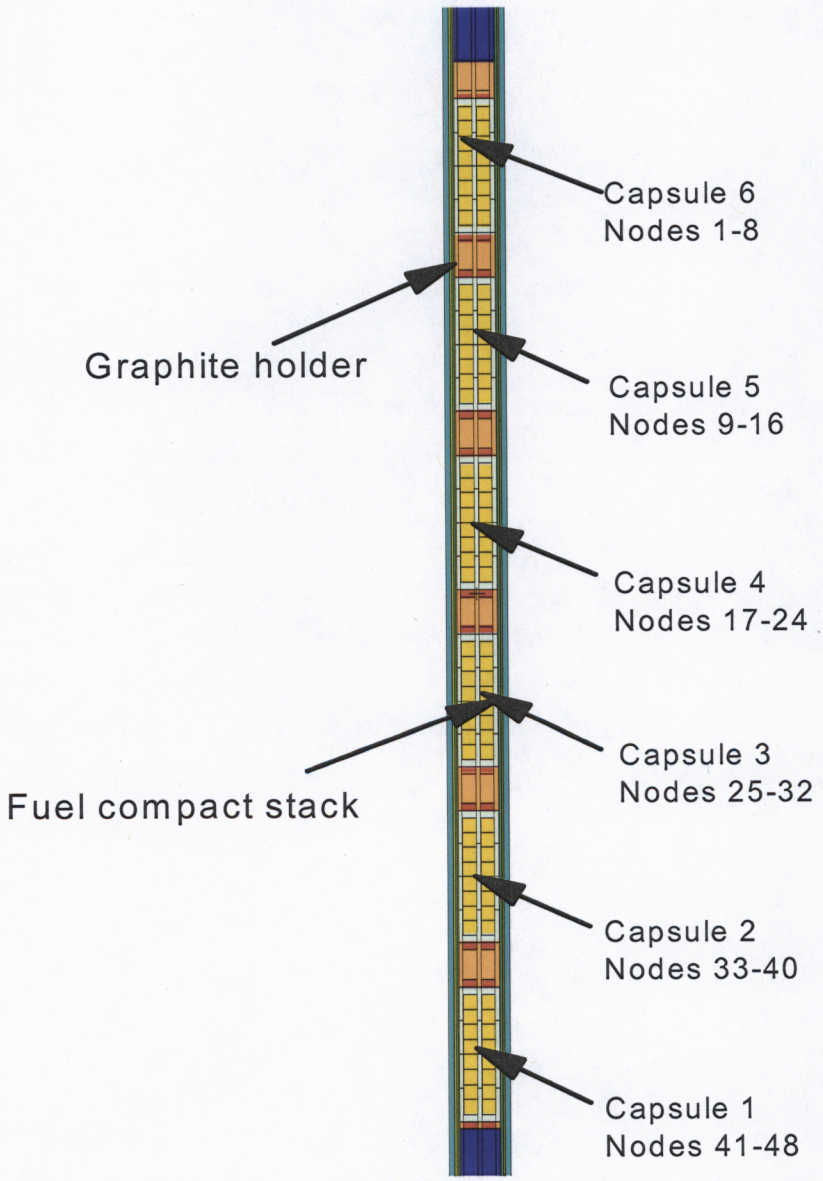


Figure 3. Axial Cross-section View of the 6 Capsules in an AGR-1 Experiment Capsule Assembly

Table 2. AGR-1 Fuel Compact Dimensions [9]

Parameter	Baseline Value	Variant 1 Value
Nominal compact diameter (mm)	12.34	12.34
Nominal compact length (mm)	25.4	25.4

Table 3. AGR-1 Fuel Compact Data [8]

Parameter	Baseline Value	Variant 1 Value
U-235 enrichment (wt %)	19.736	19.736
C/U atomic ratio	0.3253	0.3253
O/U atomic ratio	1.3613	1.3613
Kernel diameter (μm)	349.7	349.7
Buffer thickness (μm)	103.5	102.5
IPyC thickness (μm)	39.4	40.5
SiC thickness (μm)	35.3	35.7
Kernel density (Mg/m^3)	10.924	10.924
SiC density (Mg/m^3)	3.2075	3.206
Compact mass (g)	5.47888	5.3371
U loading (g U/compact)	0.917	0.915
Compact length (mm)	25.066	25.123
Compact diameter (mm)	12.36	12.36
Mol mass U	237.488052	237.4881
Kernel mass (g)	0.000244606	0.000245
Mass U/particle (g/particle)	0.000220731	0.000221
Mass O/particle (g/particle)	2.02439E-05	2.02E-05
Volume SiC/particle (m^3)	4.99472E-11	5.06E-11
Mass Si/particle (g/particle)	0.000112224	0.000114
Number particles/compact	4154.37959	4145.319
Effective compact density (Mg/m^3)	1.821714425	1.770547
Compact weight % U	16.73699734	17.14414
Compact weight % O	1.535004345	1.572345
Compact weight % Si	8.509416675	8.827004
Compact weight % C	73.21858164	72.45651

Table 4. AGR-1 Fuel Compact Material Composition and Atom Density

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (Mg/m^3)	Calculated Weight %	Atom Density (atom/b-cm)
Baseline Fuel Compact	C	12.0107	1.8217	73.2186%	6.68782E-02
	O	15.9994		1.5350%	1.05254E-03
	Si	28.0855		8.5094%	3.32391E-03
	U235	235.0439		3.3032%	1.54177E-04
	U238	238.0508		13.4338%	6.19099E-04
Totals				100.0000%	7.20279E-02
Variant 1 Fuel Compact	C	12.0107	1.7705	72.4565%	6.43232E-02
	O	15.9994		1.57235%	1.04786E-03
	Si	28.0855		8.8270%	3.35112E-03
	U235	235.0439		3.3836%	1.53491E-04
	U238	238.0508		13.7606%	6.16347E-04
Totals				100.0000%	6.94920E-02

4.4 Graphite Holder Data

The AGR-1 fuel compact graphite holders were modeled using data from reference [10] as well as material and element data from standard references (e.g. Chart of the Nuclides, ASTM standards, etc...). Note that the outer radius for each of the six graphite holders is different. The reference drawings have graphite holder dimensions based upon preliminary thermal analysis. The as-built graphite holder outer radii will be determined by the results of the AGR-1 confirmatory thermal analysis. Therefore, based on the six radii given by the reference drawings, an average outer radius for the graphite holders was calculated and used in the MCNP model.

The 5.5 Weight % B4C graphite holders were placed in capsule 6 (top capsule) and capsule 1 (bottom capsule) while the 7 Weight % B4C graphite holders were placed in the remaining four capsules (capsules 2, 3, 4, and 5). Also, to simplify the MCNP model geometry, the radii for the thru tube openings within the graphite holders were modeled using 0.270 in., the same value as the radii for the thru tube openings within the graphite and grafoil spacers.

Table 5. AGR-1 Graphite Holder Dimensions

Item	Outer Diameter (in)	Outer Radius (cm)	Height (in)	Height (cm)	Reference
Capsule 6	1.193	1.515	4.00	10.16	DWG-628635, Item 33, sheet 7
Capsule 5	1.196	1.519	4.00	10.16	DWG-628635, Item 31, sheet 7
Capsule 4	1.201	1.525	4.00	10.16	DWG-628635, Item 32, sheet 7
Capsule 3	1.200	1.524	4.00	10.16	DWG-628635, Item 30, sheet 7
Capsule 2	1.198	1.521	4.00	10.16	DWG-628635, Item 29, sheet 7
Capsule 1	1.189	1.510	4.00	10.16	DWG-628635, Item 28, sheet 7
Capsule Average	1.196	**1.519**	4.00	**10.16**	Calculated
Fuel Compact Opening	0.49083	0.62335	4.00	10.16	DWG-628635, Note 12, sheet 1
Thru Tube Opening (adjusted)	0.270	0.3429	4.00	10.16	DWG-628635 sheet 8
Gas Line Opening	0.0625	0.079375	--	--	DWG-628635, Item 43, sheets 2, 3, 4, 5
Type N 1/16 TC Opening	0.062	0.07874	--	--	DWG-628635, Item 41, sheets 2, 3, 4, 5, [13]
Type N 3/32 TC Opening	0.092	0.11684	--	--	DWG-628635, Item 42, sheets 2, 3, 4, 5, [13]
INL TC Opening	0.062	0.07874	--	--	DWG-628635, Item 44, sheets 2, 3, 4, 5, [13]

Table 6. AGR-1 Graphite Holders Material Composition

5.5 Weight % B4C Graphite Holder Material Composition			
Materials	**Mass (gm)**	**Volume (cc)**	**Density (g/cc)**
B4C	0.05500	0.02183	2.52
B-10	0.00793	--	--
B-11	0.03511	--	--
C	0.01196	--	--
C	0.94500	0.54310	1.74
Total	1.00000	0.56493	**1.77013**

7.0 Weight % B4C Graphite Holder Material			
Materials	**Mass (gm)**	**Volume (cc)**	**Density (g/cc)**
B4C	0.07000	0.02778	2.52
B-10	0.01010	--	--
B-11	0.04469	--	--
C	0.01522	--	--
C	0.93000	0.53448	1.74
Total	1.00000	0.56226	**1.77853**

Table 7. AGR-1 Graphite Holders Atom Density

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (Mg/m^3)	Atom Density (atom/b-cm)
5.5 W% B4C	B-10	10.012937	**1.77013**	8.44623E-04
	B-11	11.0093055		3.39971E-03
	C	12.0107		8.49338E-02
Total				8.91781E-02
7.0 W% B4C	B-10	10.012937	**1.77853**	1.08008E-03
	B-11	11.0093055		4.34744E-03
	C	12.0107		8.42900E-02
Total				8.97175E-02

4.5 Hafnium Shroud Data

The AGR-1 hafnium shroud was modeled using data from reference [11]. Reference [11] discusses the two different lots of hafnium material obtained for use in the AGR-1 shroud. Usage of the two different lots was modeled by placing the Hf 2.35% Zr (Lot # J27P30) in capsules 6, 5, and 4 while the Hf 1.76% Zr (Lot # F18P28) was placed in capsules 3, 2, and 1. Within a capsule, the hafnium shroud occupies a 240° arc with the midpoint facing core center. For the MCNP model, the hafnium shroud is subdivided azimuthally into 4 equal-sized cells/nodes (see Figure 2 for details).

Table 8. AGR-1 Hf Shroud Dimensions

Component	Outer Diameter (in)	Outer Radius (cm)	Inner Diameter (in)	Inner Radius (cm)	Reference
Hf Shroud (240° arc)	1.297	1.64719	1.277	1.62179	DWG-628635, Item 24, sheet 6

Table 9. Hf Shroud Material Density (Calculated) [11]

Zr in Hf (%)	Length (cm)	Width (cm)	Height (cm)	Volume (cc)	Mass (gm)	Density (gm/cc)
2.35%	25.12957	8.13841	0.0259	5.296932	67.878	12.815
1.76%	25.09495	8.0288	0.02638	5.315104	65.17	12.261

Table 10. Hf Shroud Material Composition and Atom Density [11]

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (g/cm^3)	Weight %	Atom Density (atom/b-cm)
Hf 1.76% Zr	H	1.00794	12.261	0.000300%	2.1977E-05
	B-10	10.01294		0.000010%	7.3375E-08
	B-11	11.00931		0.000040%	2.6861E-07
	C	12.0107		0.006900%	4.2420E-05
	N	14.0067		0.002000%	1.0543E-05
	O	15.9994		0.028000%	1.2922E-04
	Mg	24.305		0.001000%	3.0380E-06
	Al	26.98154		0.004100%	1.1220E-05
	Si	28.0855		0.002500%	6.5727E-06
	Ti	47.867		0.003900%	6.0161E-06
	V	50.9415		0.001000%	1.4495E-06
	Cr	51.9961		0.002000%	2.8402E-06
	Mn	54.93805		0.002000%	2.6881E-06
	Fe	55.845		0.022500%	2.9750E-05
	Co	58.9332		0.000500%	6.2647E-07
	Ni	58.6934		0.002500%	3.1451E-06
	Cu	63.546		0.002500%	2.9050E-06
	Zr	91.224		1.760000%	1.4246E-03
	Nb	92.90638		0.005000%	3.9738E-06
	Mo	95.94		0.001000%	7.6964E-07
	Cd	112.411		0.000200%	1.3137E-07
	Sn	118.71		0.001000%	6.2201E-07
	Hf	178.49		98.139450%	4.0599E-02
	Ta	180.9479		0.010000%	4.0807E-06
	W	183.84		0.001000%	4.0165E-07
	Pb	207.2		0.000500%	1.7818E-07
	U235	235.0439		0.000001%	2.2619E-10
	U238	238.0508		0.000099%	3.0795E-08
Total				100.000%	4.2309E-02

Table 10. Hf Shroud Material Composition and Atom Density [11] (continued)

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (g/cm^3)	Weight %	Atom Density (atom/b-cm)
	H	1.00794		0.000300%	2.2968E-05
	B-10	10.01294		0.000010%	7.6684E-08
	B-11	11.00931		0.000040%	2.8073E-07
	C	12.0107		0.006900%	4.4333E-05
	N	14.0067		0.002000%	1.1019E-05
	O	15.9994		0.028000%	1.3505E-04
	Mg	24.305		0.001000%	3.1750E-06
	Al	26.98154		0.004100%	1.1726E-05
	Si	28.0855		0.002500%	6.8692E-06
	Ti	47.867		0.003900%	6.2874E-06
	V	50.9415		0.001000%	1.5149E-06
	Cr	51.9961		0.002000%	2.9683E-06
	Mn	54.93805		0.002000%	2.8093E-06
Hf	Fe	55.845	**12.815**	0.022500%	3.1092E-05
2.35% Zr	Co	58.9332		0.000500%	6.5472E-07
	Ni	58.6934		0.002500%	3.2870E-06
	Cu	63.546		0.002500%	3.0360E-06
	Zr	91.224		2.350000%	1.9879E-03
	Nb	92.90638		0.005000%	4.1531E-06
	Mo	95.94		0.001000%	8.0435E-07
	Cd	112.411		0.000200%	1.3730E-07
	Sn	118.71		0.001000%	6.5007E-07
	Hf	178.49		97.549450%	4.2175E-02
	Ta	180.9479		0.010000%	4.2647E-06
	W	183.84		0.001000%	4.1976E-07
	Pb	207.2		0.000500%	1.8622E-07
	U-235	235.0439		0.000001%	2.3639E-10
	U-238	238.0508		0.000099%	3.2184E-08
Total				100.000%	4.4461E-02

4.6 Stainless Steel Capsule Component Data

The AGR-1 Stainless Steel (SS) capsule components include the SS shroud (Figure 2, number 15), SS sleeve, SS capsule body, SS capsule top heads, and SS capsule bottoms. These components were modeled using 316 stainless steel material.

Table 11. AGR-1 SS Component Dimensions

Component	Outer Diameter (in)	Outer Radius (cm)	Inner Diameter (in)	Inner Radius (cm)	Reference
SS Shroud (120° arc)	1.297	1.64719	1.277	1.62179	DWG-628635, Item 23, sheet 6
SS Sleeve	1.277	1.62179	1.250	1.58750	DWG-628635, Item 22, sheet 8
SS Capsule Body	1.406	1.78562	1.298	1.64846	DWG-628635, Item 16, sheet 7
SS Capsule Top Head	1.406	1.78562	--	--	DWG-628635, Items 18, 19, 20, 21, sheet 8
SS Capsule Bottom	1.406	1.78562	--	--	DWG-628635, Item 16, sheet 7

4.7 Graphite and Grafoil Spacer Data

The AGR-1 graphite and grafoil spacers were modeled using data from reference [12]. For the MCNP model, the graphite and grafoil spacer pairs were combined together at the top of each capsule and at the bottom of each capsule. There is a region between the graphite and grafoil spacer pairs that contains helium gas, which was also combined with the graphite and grafoil spacer pairs. Note the outer radius of the combined spacer was adjusted to 1.519 cm to match the graphite holder outer radius, simplifying the MCNP model geometry. The ratio of the actual volumes each component was used when calculating the atom density for the combined component.

Table 12. AGR-1 Graphite/Grafoil Spacer Dimensions

Component	Outer Diameter (in)	Outer Radius (cm)	Inner Diameter (in)	Inner Radius (cm)	Height (in)	Height (cm)	Reference
Top							
Graphite Spacer	1.180	1.49860	0.250	0.31750	0.2100	0.5334	DWG-628635, Item 35, sheet 8
Grafoil Spacer	1.175	1.49225	0.125	0.15875	0.0630	0.16002	DWG-628635, Item 38, sheet 7
Bottom							
Graphite Spacer	1.180	1.49860	0.250	0.31750	0.2100	0.5334	DWG-628635, Item 36, sheet 8
Grafoil Spacer	1.175	1.49225	--	--	0.0630	0.16002	DWG-628635, Item 39, sheet 8
Model Dimensions							
Top							
Graphite/Grafoil/He Spacer Combined	--	1.519	--	--	--	0.86868	
Bottom							
Graphite/Grafoil/He Spacer Combined	--	1.519	--	--	--	0.69342	

Table 13. AGR-1 Graphite/Grafoil Volume, Mass, and Density [12]

Component	Area* (cm^2)	Height (cm)	Volume (cc)	Percent of MCNP Volume	Density (g/cc)	Calculated Mass (gm)
Upper						
Grafoil	5.5652	0.16002	0.89054	25.06%	1.12	0.9974
Spacer Wall	0.7275	0.5334	0.38805	39.15%	1.71	2.3786
Spacer Floor	4.6455	0.2159	1.00296			
Helium (calculated)			1.27181	35.79%	--	
Total			3.55336	100.00%	--	
Lower						
Grafoil	5.9484	0.16002	0.95186	26.79%	1.12	1.06609
Spacer Wall	0.8397	0.5334	0.44790	41.82%	1.71	2.54086
Spacer Floor	4.8077	0.2159	1.03798			
Helium (calculated)			1.11562	31.40%	--	
Total			3.55336	100.00%	--	
MCNP (Graphite/Grafoil/He)	5.1244	0.69342	3.55336	100.00%	--	

* Area calculated using Autocad.

Table 14. AGR-1 Combined Graphite/Grafoil and He Atom Density

Material	Isotope/ Element	Percent of MCNP Volume	Constituent Atom Density (atom/b-cm)	Combined Atom Density (atom/b-cm)
Upper Combined Spacer				
Grafoil	C (Natural)	25.06%	1.4074E-02	4.7638E-02
Graphite Spacer		39.15%	3.3564E-02	
He	He	35.79%	3.5792E-05	--
Lower Combined Spacer				
Grafoil	C (Natural)	26.79%	1.5043E-02	5.0896E-02
Graphite Spacer		41.82%	3.5853E-02	
He	He	31.40%	3.1396E-05	--

4.8 Thermocouple Data

The AGR-1 thermocouples (TCs) were modeled using the data from references [13], [14], [15], and [16]. Within the Type-N TC's the nicrosil and nisil wires were combined in order to simplify the MCNP model geometry. Except for the combined nicrosil/nisil wires, the TCs were explicitly modeled within the graphite holder regions.

Table 15. AGR-1 Thermocouple Material Composition and Atom Density

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (g/cm^3)	Weight %	Atom Density (atom/b-cm)
Inconnel 600 Sheath	C	12.0107	**8.47**	0.031%	1.3165E-04
	Al	26.98154		0.120%	2.2686E-04
	Si	28.0855		0.250%	4.5404E-04
	S	32.065		0.002%	3.1815E-06
	Ti	47.867		0.220%	2.3443E-04
	Cr	51.9961		16.260%	1.5951E-02
	Mn	54.93805		0.840%	7.7990E-04
	Fe	55.845		7.150%	6.5306E-03
	Co	58.9332		0.025%	2.1638E-05
	Ni	58.6934		75.082%	6.5250E-02
	Cu	63.546		0.020%	1.6054E-05
Total				100.000%	8.9600E-02
MgO Insulation	B-10	10.01294	**3.3**	0.0003%	5.9244E-07
	B-11	11.00931		0.0012%	2.1688E-06
	O	15.9994		39.6914%	4.9301E-02
	Mg	24.305		60.2354%	4.9252E-02
	Al	26.98154		0.0159%	1.1694E-05
	Si	28.0855		0.0047%	3.3075E-06
	Ca	40.078		0.0286%	1.4175E-05
	Fe	55.845		0.0210%	7.4670E-06
	Cd	112.411		0.0015%	2.6518E-07
Total				100.0000%	9.8593E-02
Nicrosil NP Wire	Si	28.0855	**8.5**	1.40%	2.5516E-03
	Cr	51.9961		14.20%	1.3979E-02
	Ni	58.6934		84.40%	7.3608E-02
Total				100.00%	9.0139E-02
Nicrosil NN Wire	Mg	24.305	**8.55**	0.10%	2.1185E-04
	Si	28.0855		4.40%	8.0665E-03
	Ni	58.6934		95.50%	8.3778E-02
Total				100.00%	9.2057E-02
Nicrosil/Nisil Combined Wire	Mg	--	--	--	1.0592E-23
	Si	--		--	4.2155E-03
	Cr	--		--	7.6296E-03
	Ni				7.8649E-02
Total					9.0600E-02

Table 15. AGR-1 Thermocouple Material Composition and Atom Density (continued)

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (g/cm^3)	Weight %	Atom Density (atom/b-cm)
Molybdenum ASTM B387 Type 361 Sheath	Na	22.98977	**10.14**	0.0001%	2.6562E-07
	Al	26.98154		0.0005%	1.1316E-06
	Si	28.0855		0.0050%	1.0871E-05
	K	39.0983		0.0007%	1.0933E-06
	Cr	51.9961		0.0001%	1.1744E-07
	Fe	55.845		0.0040%	4.3739E-06
	Ni	58.6934		0.0030%	3.1212E-06
	Cu	63.546		0.0001%	9.6095E-08
	Mo	95.94		99.9845%	6.3639E-02
	W	183.84		0.0020%	6.6432E-07
Total				100.0000%	6.3661E-02
Al2O3 Insulation	O	15.9994	**3.89**	47.1000%	6.8963E-02
	Na-23	22.98977		0.1338%	1.3633E-04
	Al	26.98154		52.6075%	4.5675E-02
	Si	28.0855		0.0748%	6.2382E-05
	Fe	55.845		0.0839%	3.5208E-05
Total				100.0000%	1.1487E-01
Nb1%Zr Sheath	H	1.00794	**8.57**	0.0003%	1.5361E-05
	C	12.0107		0.0040%	1.7188E-05
	N	14.0067		0.0070%	2.5793E-05
	O	15.9994		0.0105%	3.3870E-05
	Si	28.0855		0.0050%	9.1880E-06
	Fe	55.845		0.0040%	3.6966E-06
	Ni	58.6934		0.0020%	1.7586E-06
	Zr	91.224		1.0650%	6.0252E-04
	Nb	92.90638		98.3912%	5.4657E-02
	Mo	95.94		0.0030%	1.6138E-06
	Hf	178.49		0.0050%	1.4457E-06
	Ta	180.9479		0.0200%	5.7044E-06
	W	183.84		0.0030%	8.4220E-07
Total				100.0000%	5.5514E-02
Hf 2.35% Zr Insulation	C	12.0107	**9.05**	0.0003%	1.3613E-06
	O	15.9994		15.1407%	5.1575E-02
	Al	26.98154		0.0036%	7.2717E-06
	Si	28.0855		0.0045%	8.7323E-06
	Ti	47.867		0.0024%	2.7326E-06
	Fe	55.845		0.0036%	3.5133E-06
	Zr	91.224		0.3900%	2.3300E-04
	Hf	178.49		84.4549%	2.5788E-02
Total				100.0000%	7.7619E-02

Table 15. AGR-1 Thermocouple Material Composition and Atom Density (continued)

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (g/cm^3)	Weight %	Atom Density (atom/b-cm)
Molybdenum ASTM B387 Type 361 Wire	C	12.0107	**10.14**	0.0010%	5.0842E-06
	O	15.9994		0.0190%	7.2517E-05
	Na	22.98977		0.0011%	2.9218E-06
	Mg	24.305		0.0005%	1.2562E-06
	Al	26.98154		0.0095%	2.1500E-05
	Si	28.0855		0.0290%	6.3053E-05
	K	39.0983		0.0117%	1.8273E-05
	Ca	40.078		0.0012%	1.8284E-06
	Ti	47.867		0.0005%	6.3786E-07
	Cr	51.9961		0.0010%	1.1744E-06
	Mn	54.93805		0.0005%	5.5576E-07
	Fe	55.845		0.0018%	1.9682E-06
	Co	58.9332		0.0001%	1.0362E-07
	Ni	58.6934		0.0010%	1.0404E-06
	Cu	63.546		0.0010%	9.6095E-07
	Zr	91.224		0.0010%	6.6939E-07
	Mo	95.94		99.9036%	6.3587E-02
	W	183.84		0.0165%	5.4807E-06
Total				100.0000%	6.3786E-02
Nb1%Zr Wire	H	1.00794	**8.57**	1.5361E-05	2.7635E-04
	C	12.0107		1.1725E-05	2.1093E-04
	N	14.0067		1.1177E-05	2.0107E-04
	O	15.9994		2.7956E-05	5.0294E-04
	Si	28.0855		9.1880E-06	1.6529E-04
	Ti	47.867		4.3128E-06	7.7588E-05
	Fe	55.845		3.2346E-06	5.8191E-05
	Ni	58.6934		2.4244E-06	4.3615E-05
	Zr	91.224		5.6332E-10	1.0134E-08
	Nb	92.90638		5.5464E-02	9.9780E-01
	Mo	95.94		1.6138E-06	2.9033E-05
	Hf	178.49		1.4457E-06	2.6009E-05
	Ta	180.9479		3.2841E-05	5.9082E-04
	W	183.84		8.4220E-07	1.5151E-05
Total				100.00%	5.5586E-02
Tantalum	C	12.0107	**16.654**	0.0350%	2.9226E-04
	N	14.0067		0.0200%	1.4321E-04
	O	15.9994		0.1413%	8.8543E-04
	Si	28.0855		0.0225%	8.0347E-05
	Ti	47.867		0.0053%	1.1000E-05
	Fe	55.845		0.0175%	3.1428E-05
	Ni	58.6934		0.0075%	1.2816E-05
	Nb	92.90638		0.0450%	4.8578E-05
	Mo	95.94		0.0140%	1.4635E-05
	Ta	180.9479		99.6775%	5.5248E-02
	W	183.84		0.0145%	7.9104E-06
Total				100.00%	5.6775E-02

Table 16. AGR-1 Thermocouple Dimensions [13]

Component	Outer Diameter (in)	Outer Radius (cm)	Inner Diameter (in)	Inner Radius (cm)
Type N (1/16")				
Nisil Wire	0.010	0.01270	--	--
Nicrosil Wire	0.010	0.01270	--	--
MgO Insulation	0.042	0.05334	0.01	0.01270
Inconnel Sheath	0.062	0.07874	0.042	0.05334
Model Dimensions				
Nisil/Nicrosil Wire (combined) [a]	--	0.01796	--	--
MgO Insulation (adjusted) [b]	--	0.05334	--	0.01796
Type N (3/32")				
Nisil Wire	0.015	0.01905	--	--
Nicrosil Wire	0.015	0.01905	--	--
Al_2O_3 Insulation	0.056	0.07112	0.015	0.01905
Moly Sheath	0.092	0.11684	0.056	0.07112
Model Dimensions				
Nisil/Nicrosil Wire (combined) [a]	--	0.02694	--	--
Al_2O_3 Insulation (adjusted) [b]	--	0.7112	--	0.02694
INL (1/16")				
Tantalum	0.025	0.03175	0.015	0.01905
Moly Wire	0.0092	0.011684	--	--
Nb1Zr Wire	0.0083	0.010541	--	--
HfO2 Insulation	0.0417	0.052959	--	--
Nb1Zr Sheath	0.0620	0.07874	0.0417	0.052959
Model Dimensions				
Tantalum [c]	0.0092	0.011684	--	--
	0.0083	0.010541	--	--

a) Calculated to preserve equivalent volumes.
b) Adjusted to accommodate combined wires.
c) Tantalum was modeled using the outer radii for the corresponding wire. Lengths were calculated using equivalent volumes.

4.9 Molybdenum Thru Tube Data

The AGR-1 molybdenum thru tubes (TTs) were modeled using the following data as well as material data from standard references.

Table 17. AGR-1 Molybdenum Thru Tube Material Composition and Atom Density

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (g/cm^3)	Weight %	Atom Density (atom/b-cm)
Molybdenum ASTM 387 Type 361	Na	22.98977	10.14	0.0001%	2.6562E-07
	Al	26.98154		0.0005%	1.1316E-06
	Si	28.0855		0.0050%	1.0871E-05
	K	39.0983		0.0007%	1.0933E-06
	Cr	51.9961		0.0001%	1.1744E-07
	Fe	55.845		0.0040%	4.3739E-06
	Ni	58.6934		0.0030%	3.1212E-06
	Cu	63.546		0.0001%	9.6095E-08
	Mo	95.94		99.9845%	6.3639E-02
	W	183.84		0.0020%	6.6432E-07
Total				100.0000%	6.3661E-02

Table 18. AGR-1 Molybdenum Thru Tube Dimensions

Component	Outer Diameter (in)	Outer Radius (cm)	Inner Diameter (in)	Inner Radius (cm)
Molybdenum Thru Tube	0.25000	0.31750	0.2300	0.29210

4.10 Niobium Gas Line Data

The gas lines are 99.8% pure niobium and were modeled using the following data as well as material and element data from standard references.

Table 19. AGR-1 Nb Gas Lines Atom Density

Material	Isotope/ Element	Atomic Weight (g/mole)	Material Density (g/cm^3)	Atom Density (atom/b-cm)
Nb Gas Lines	Nb	92.90638	**8.57**	5.55490E-02

Table 20. AGR-1 Nb Gas Lines Dimensions

Component	Outer Diameter (in)	Outer Radius (cm)	Inner Diameter (in)	Inner Radius (cm)	Reference
Niobium Gas Line (In/Out)	0.0625	0.07938	0.0425	0.05398	DWG-628635 Item 43, Sheet 1

4.11 Thru Tube Contents Data

The thru tubes provide space for threading thermocouples and gas lines through the capsule assembly. To simplify the MCNP model geometry, the gas lines and TCs modeled within the thru tubes and the large gas spaces between capsules were combined together, like-to-like. The materials were explicitly modeled, but equivalent material volumes and equivalent material masses were calculated. The number and type of TC's and number of gas lines used to calculate the equivalent volumes for the MCNP model of the AGR-1 capsule assembly are given in Table 21 and Table 22.

Table 21. Number and Type of TCs and Gas Lines within Capsules and Thru Tubes[14]

Capsule Position	Component	No. Within Capsule	No. Within Thru Tubes			
			TT1	TT2	TT3	TT Total
6 (Top)	gas line	2	10	--	--	10
	Type N (1/16")	--	--	5	--	5
	INL TC (1/16")	2	--	3	6	9
	Type N (3/32")	3	--	--	--	--
5	gas line	2	8	--	--	8
	Type N (1/16")	1	--	4	--	4
	INL TC (1/16")	2	--	2	5	7
	Type N (3/32")	--	--	--	--	--
4	gas line	2	6	--	--	6
	Type N (1/16")	1	--	3	--	3
	INL TC (1/16")	2	--	2	3	5
	Type N (3/32")	--	--	--	--	--
3	gas line	2	4	--	--	4
	Type N (1/16")	1	--	2	--	2
	INL TC (1/16")	2	--	1	2	3
	Type N (3/32")	--	--	--	--	--
2	gas line	2	2	--	--	2
	Type N (1/16")	1	--	1	--	1
	INL TC (1/16")	2	--	--	1	1
	Type N (3/32")	--	--	--	--	--
1 (Bottom)	gas line	1	--	--	--	--
	Type N (1/16")	1	--	--	--	--
	INL TC (1/16")	1	--	--	--	--
	Type N (3/32")	--	--	--	--	--

Table 22. Number of TCs & Gas Lines per Thru Tube (Equivalent Volumes Modeled)

Capsule	TT1 No. of Gas Lines	TT2 No. of INL SPC-775 TCs (1/16")	TT2 No. of Type-N TCs (1/16")	TT3 No. of INL SPC-775 TCs (1/16")	TT3 No. of Type-N TCs (1/16")
6	10	3	3 + 2 = 5	6	-
5	8	2	2 + 2 = 4	5	--
4	6	2	2 + 1 = 3	3	--
3	4	1	2	2	--
3	2	--	1	1	--

4.12 Other AGR-1 Capsule Assembly Component Data

The remaining capsule assembly components for the AGR-1 capsule assembly were modeled using the data and dimensions presented below. Note, the outer radii for the SS capsule train end, SS surrounding lower graphite spacer, and SS cap below the lower graphite spacer were adjusted from 1.78181 cm to 1.78562 cm, to coincide with the outer radii for the SS capsule bodies, again to simplify the MCNP model geometry. The SS components were modeled using 316 stainless and the lower graphite spacer was modeled using graphite grade H-451.

Table 23. Other AGR-1 Component Dimensions

Component	Outer Diameter (in)	Outer Radius (cm)	Inner Diameter (in)	Inner Radius (cm)	Reference
Lower Graphite Spacer @ AGR Assembly Bottom	1.280	1.62560	--	--	DWG-628633, Detail 11
SS surrounding Lower Graphite Spacer	1.4060	1.78562	1.180	1.49860	DWG-628633, Detail 12 & DWG-623635, Item 16, Sheet 7
SS Cap below Lower Graphite Spacer	1.4060	1.78562	--	--	DWG-628633, Detail 12 & DWG-623635, Item 16, Sheet 7
SS Capsule Train End	1.4060	1.78562	1.180	1.49860	DWG-628633, Detail 12 & DWG-623635, Item 16, Sheet 7
Water inside Assembly Bottom (Capsule Train End)	1.180	1.49860	--	--	DWG-628633, Detail 12
Gas Region above Assembly	1.4060	1.78562	--	--	DWG-628635, Item 16, Sheet 7
Water surrounding AGR Assembly (within B-10 Position)	--	1.9050*	1.4060	1.78562	DWG-628635, Item 16, Sheet 7

*Note - This is the outer radius for the ATR B-10 Irradiation Test Position.

4.13 MCNP Capsule Details

The AGR-1 capsule assembly was modeled as explicitly as possible. The numbering scheme used to designate component positions is shown in Figure 4. An X-Y cross-sectional view created using the MCNP geometry model for each capsule and the gas region above that capsule is shown by Figure 5 through Figure 10.

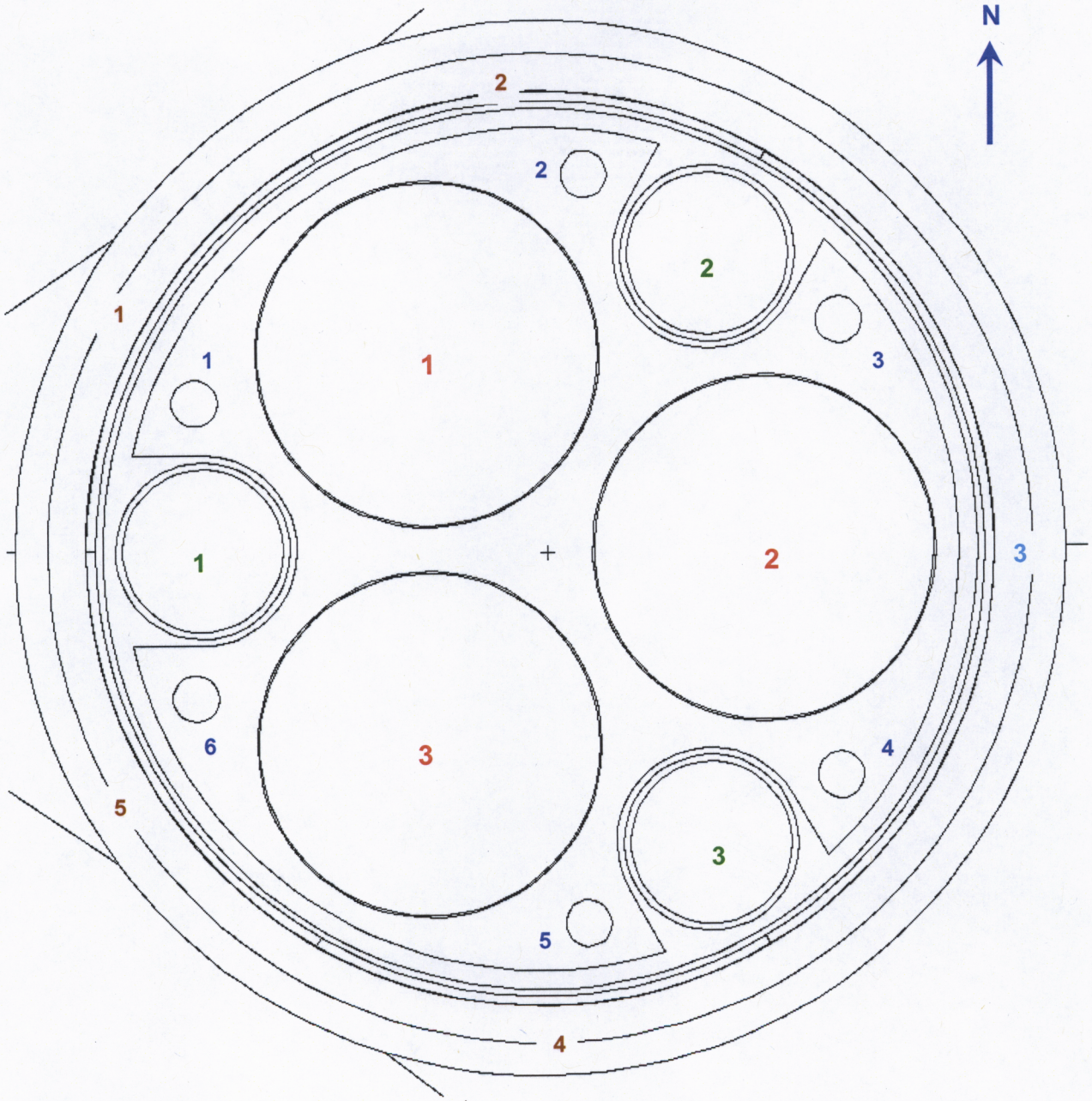
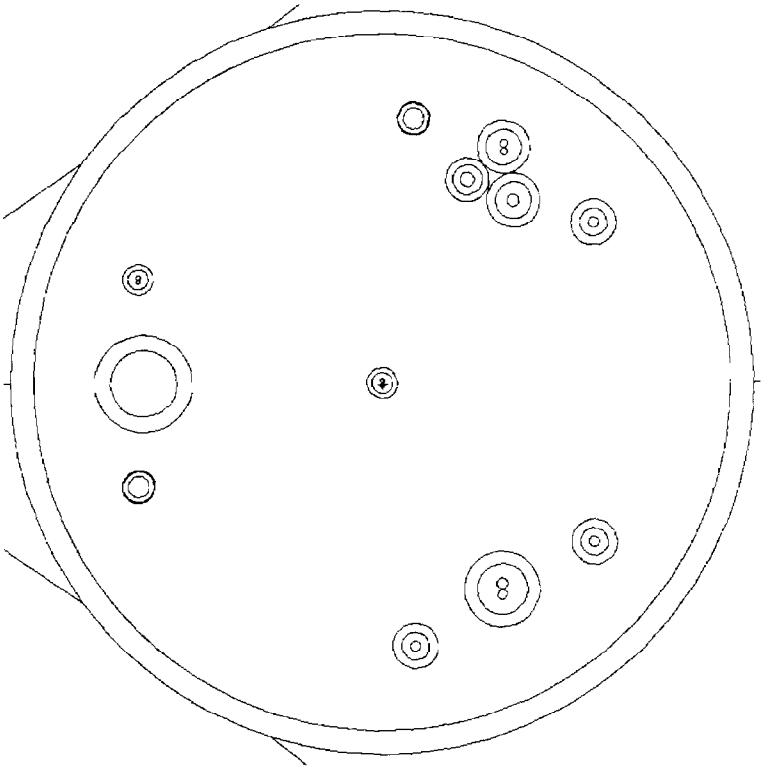


Figure 4. MCNP X-Y Cross Section of a Generic AGR-1 Experiment Capsule Assembly. (Components shown include: Graphite Holder, Thru Tubes, Fuel Compacts, SS Sleeve, Hf/SS Shroud, TC and Gas Line Openings, Capsule Body, Gas Gaps, and Water Gap)

Key: Red Numbers – Fuel Compact Position Designation (1, 2, 3)
Green Numbers – Thru Tube Position Designation (1, 2, 3)
Blue Numbers – TC and Gas Line Position Designation (1, 2, 3, 4, 5, 6)
Brown Numbers – Hf Shroud Position Designation (1, 2, 4, 5)
Turquoise Number – SS Shroud Position Designation (3)

Gas Region with Gas Lines and TCs



N

Region with Capsule Body, Shroud, Sleeve, B4C, Fuel Compacts,
Thru Tubes, Gas Lines and TCs

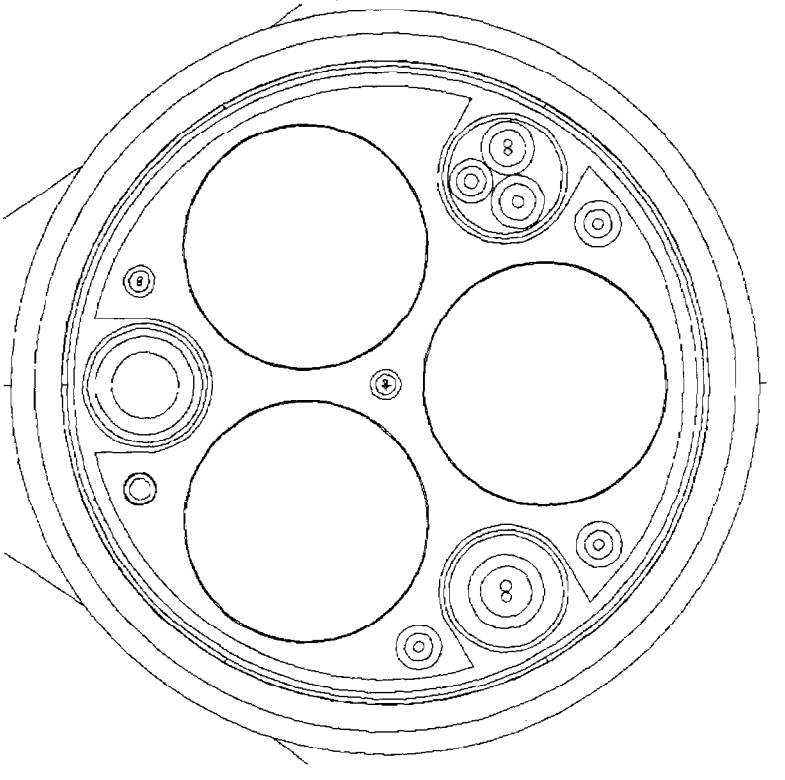


Figure 5. MCNP X-Y Cross Section Views of Gas Region above AGR-1 Capsule 6 and B4C Region within Capsule 6

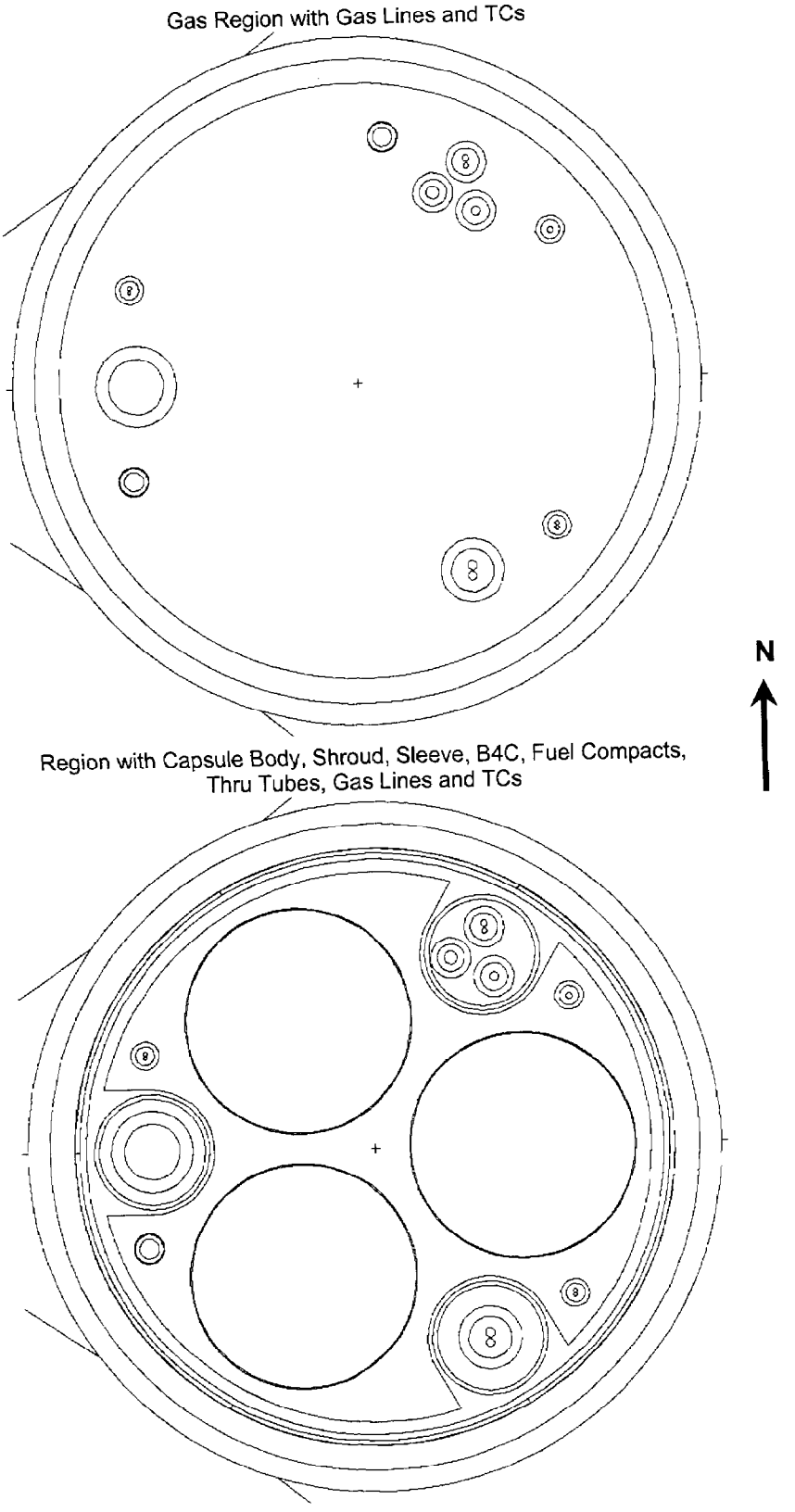


Figure 6. **MCNP X-Y Cross Section Views of Gas Region above AGR-1 Capsule 5 and B4C Region within Capsule 5**

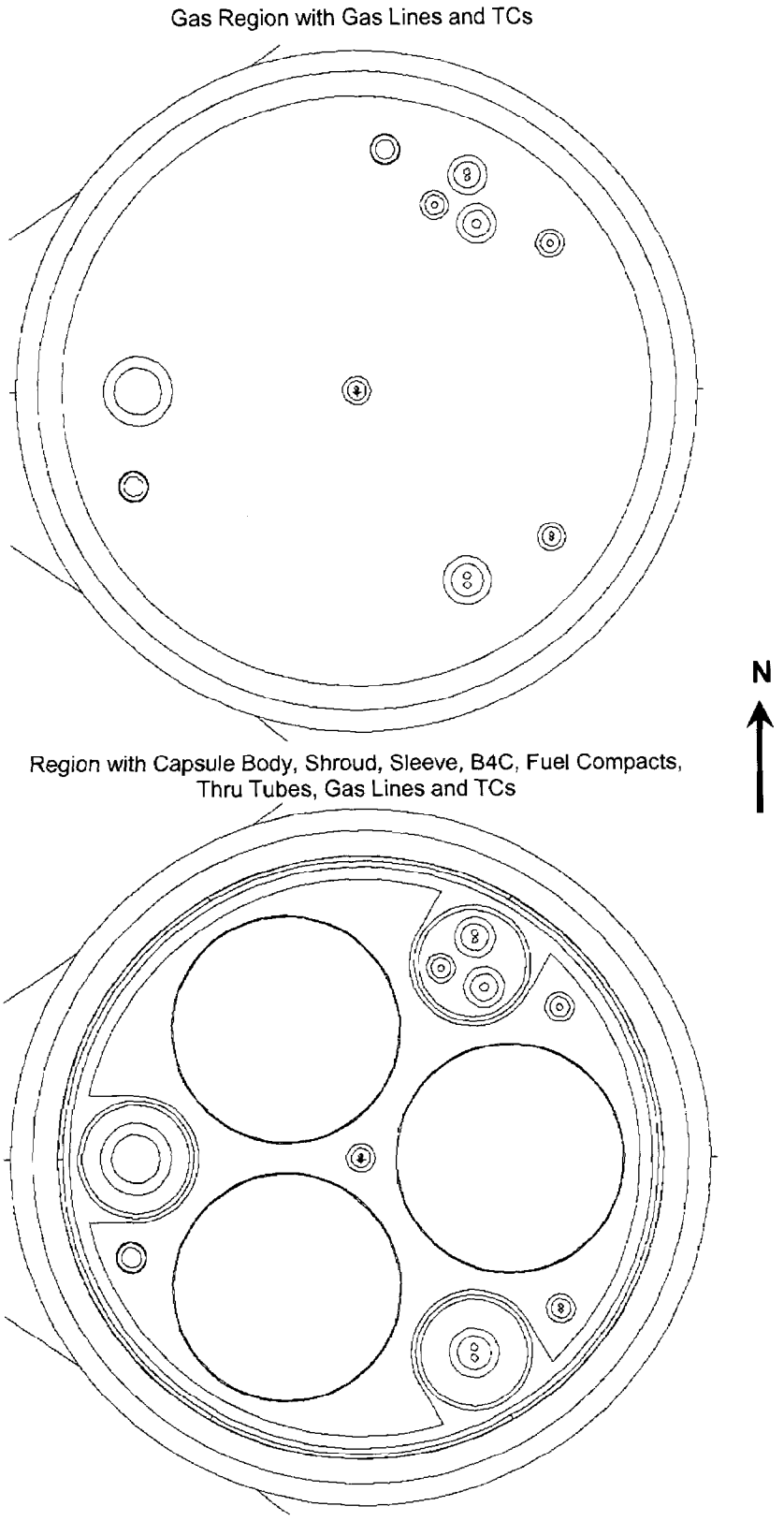
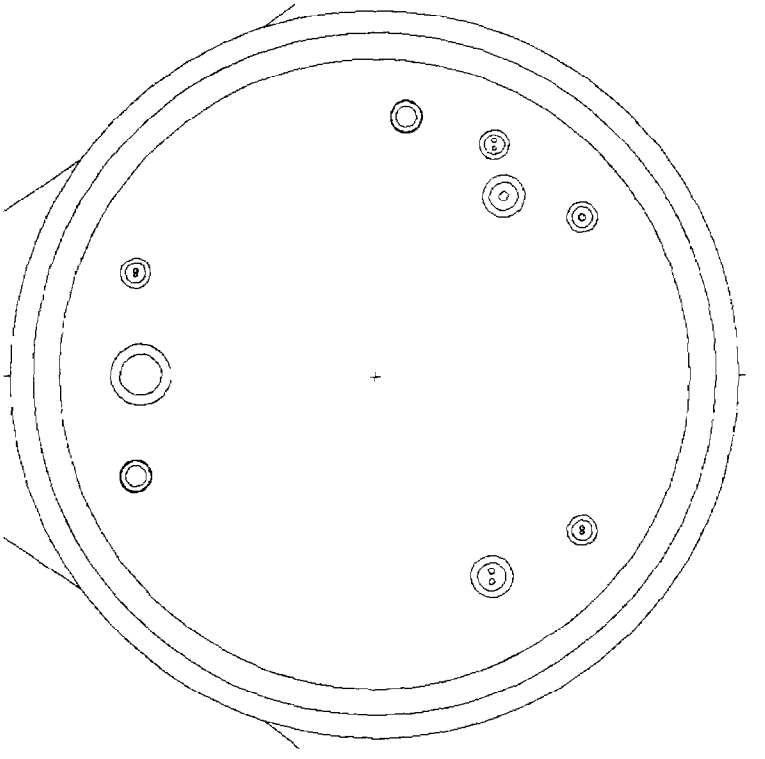


Figure 7. MCNP X-Y Cross Section Views of Gas Region above AGR-1 Capsule 4 and B4C Region within Capsule 4

Gas Region with Gas Lines and TCs



N

Region with Capsule Body, Shroud, Sleeve, B4C, Fuel Compacts,
Thru Tubes, Gas Lines and TCs

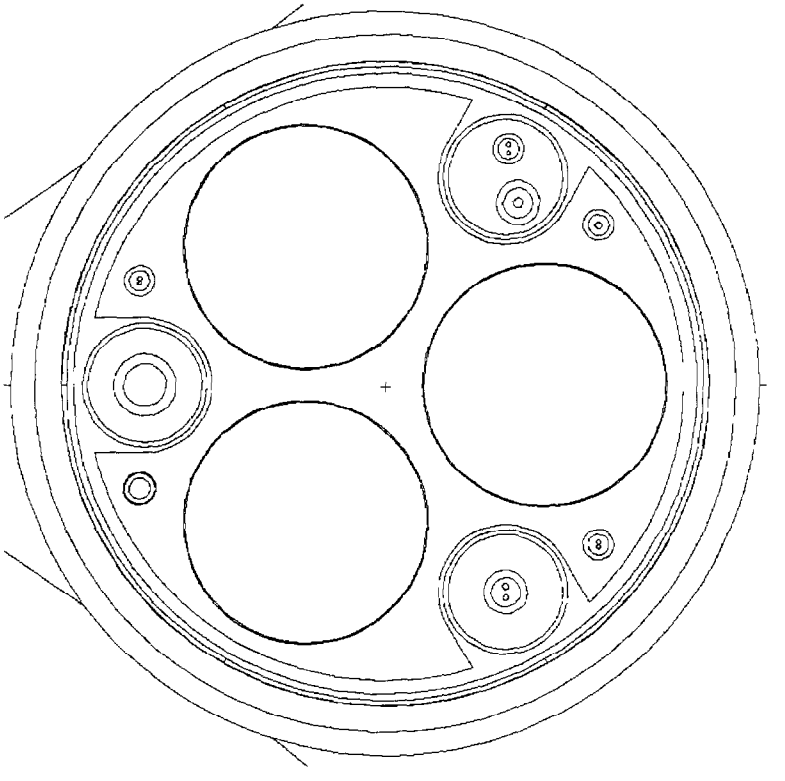
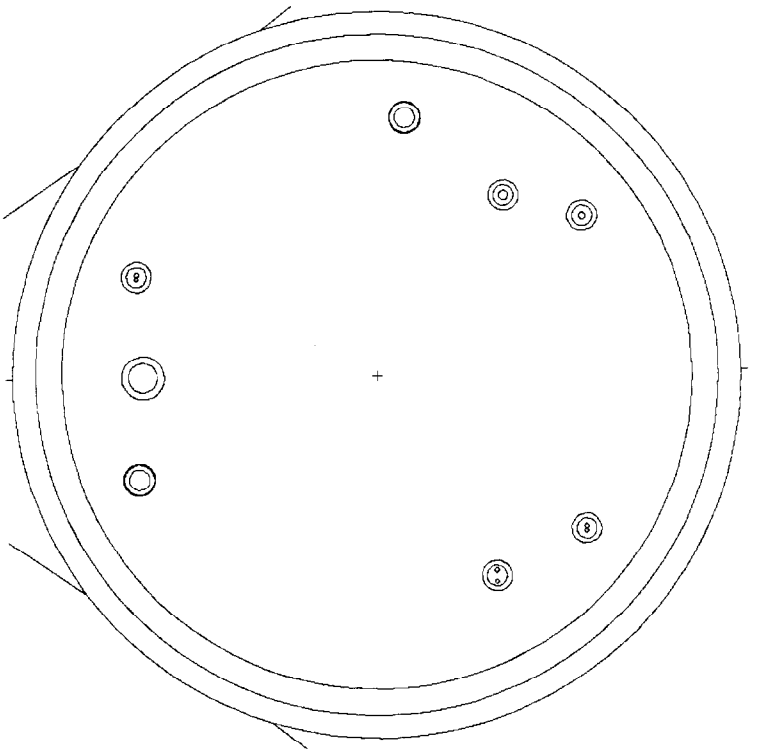


Figure 8. MCNP X-Y Cross Section Views of Gas Region above AGR-1 Capsule 3 and B4C Region within Capsule 3

Gas Region with Gas Lines and TCs



N

Region with Capsule Body, Shroud, Sleeve, B4C, Fuel Compacts,
Thru Tubes, Gas Lines and TCs

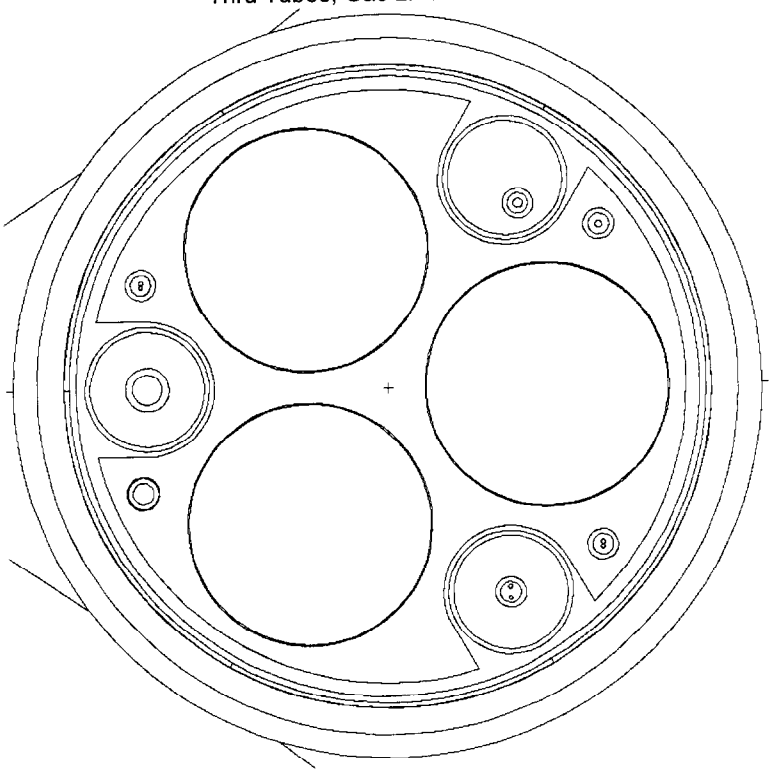


Figure 9. MCNP X-Y Cross Section Views of Gas Region above AGR-1 Capsule 2 and B4C Region within Capsule 2

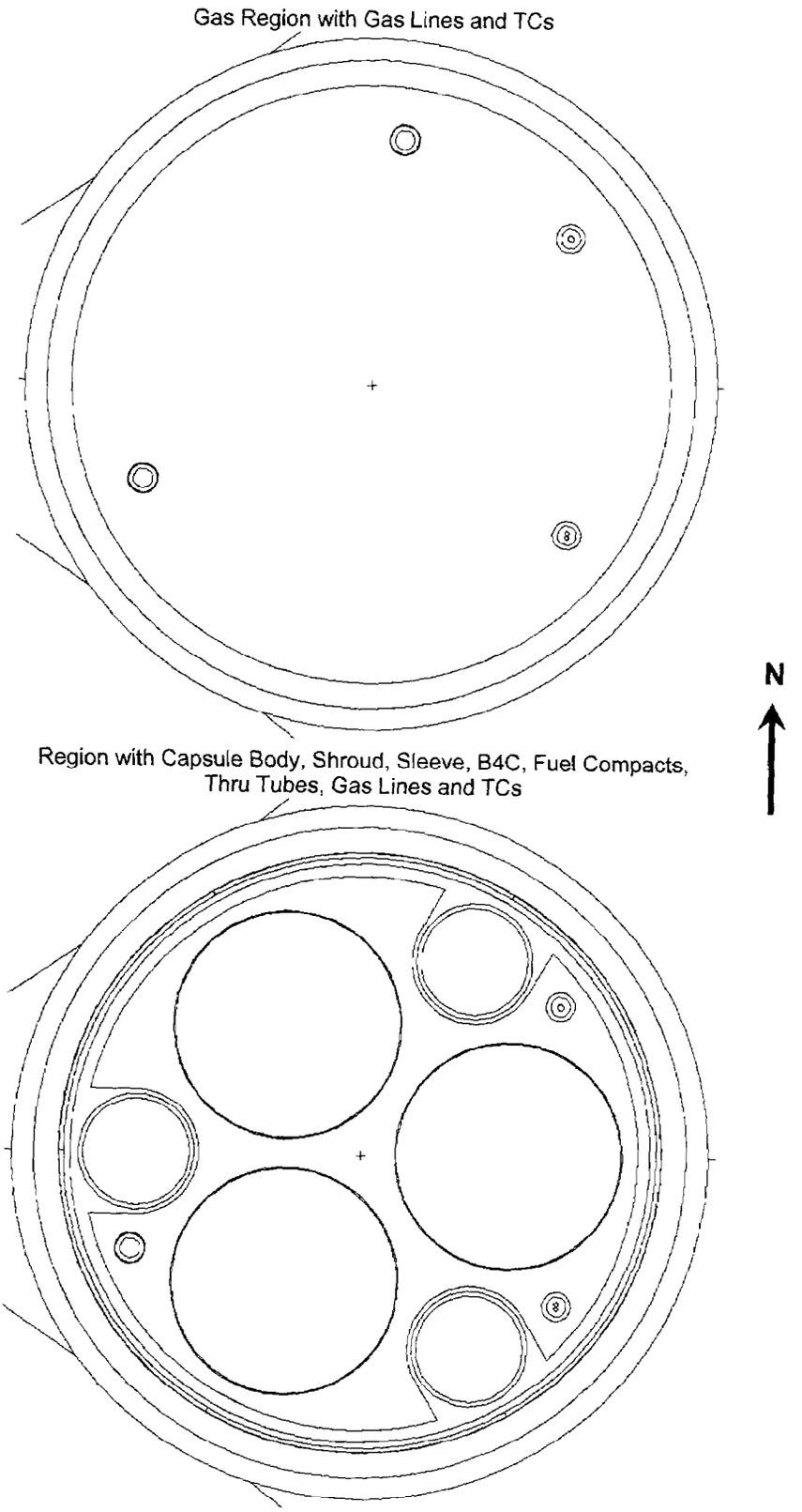


Figure 10. MCNP X-Y Cross Section Views of Gas Region above AGR-1 Capsule 1 and B4C Region within Capsule 1

5.0 Analysis and Calculations

MCNP was used to calculate the AGR-1 capsule assembly structural components neutron fission and gamma heating rates as well as the AGR-1 capsule assembly reactivity worth relative to an aluminum dummy. The depletion methodology MCWO (using ORIGEN2) was used to calculate the AGR-1 fuel compact and absorber depletion/burnup behaviors versus EFPD's for the ATR B-10 position.

MCNP reports tally results normalized per source particle. The flux tallies have units of neutrons/cm^2 per fission neutron and the heating tallies have units of MeV/gm per fission neutron or per delayed fission photon. Additionally, the MCNP tally results must be scaled to reactor operating conditions. The following normalization factors were used to scale the MCNP-calculated flux tallies and heating tallies reported by this EDF.

Neutron Flux Normalization Factor

Note, the MCNP f4 tally has units of 1/cm^2 per source neutron.

$$\left(\frac{fission\ neutrons}{fission}\right)\left(\frac{fission}{MeV}\right)\left(\frac{MeV}{MW_{core\ power}-s}\right) = Flux\ Normalizaiton$$

$$\left(\frac{2.43\ fission\ neutrons}{fission}\right)\left(\frac{fission}{200\ MeV}\right)\left(\frac{6.24146\times10^{18}\ MeV}{MW_{core\ power}-s}\right) = 7.583\times10^{16}\frac{fission\ neutrons}{MW_{core\ power}-s}$$

Neutron/Gamma Heating Normalization Factor

Note, the MCNP f6 tally has units of MeV/g per source neutron.

$$\left(\frac{fission\ neutrons}{MW-s}\right)\left(\frac{W-s}{MeV}\right) = Heat\ Normalization$$

$$\left(\frac{7.583\times10^{16}\ fission\ neutrons}{MW_{core\ power}-s}\right)\left(\frac{1.60219\times10^{-13}W-s}{MeV}\right) = 1.215\times10^{4}\ \frac{fission\ neutrons-W}{MW_{core\ power}-MeV}$$

Delayed Fission Product Gamma Heating Normalization Factor

Note, the MCNP f6 tally has units of MeV/g per source photon.

$$\left(\frac{delayed\ fission\ photons}{fission}\right)\left(\frac{fission}{MeV}\right)\left(\frac{MeV}{MW_{core\ power}-s}\right)\left(\frac{W-s}{MeV}\right)=Heat\ Normalizaiton$$

$$\left(\frac{8.9603\ delayed\ fission\ photons}{fission}\right)\left(\frac{fission}{200\ MeV}\right)\left(\frac{6.24146\times10^{18}\ MeV}{MW_{core\ power}-s}\right)\left(\frac{1.60219\times10^{-13}W-s}{MeV}\right)=$$

$$4.48015\times10^{4}\frac{delyed\ fission\ photons-W}{MW_{core\ power}-MeV}$$

MCNP kcode calculations were performed to evaluate the AGR-1 capsule assembly reactivity worth. Each kcode calculation used 25000 source histories per cycle and 900 cycles. The kcode card used for the calculations follows.

```
kcode  25000  1.01  5  90
```

A good indicator of fuel burnup is the Fissions per Initial heavy Metal Atom (FIMA). This is simply the ratio of the number of fissions that have occurred in the fuel to the initial (zero burnup) inventory of heavy metal atoms (uranium plus plutonium) in the fuel. A FIMA value is determined as part of the normal PIE burnup determination procedure. Based upon an effective energy release of 204.55 MeV per fission, atomic mass of initial heavy metal (total uranium atomic mass is 237.46 g atoms/mole for a fuel enrichment of 19.736% U-235) the burnup (GWd/t) can be obtained by multiplying the % FIMA by the conversion factor 9.6.

% FIMA to GWd/ton Conversion Factor

$$(\%\ FIMA)\left(\frac{g}{ton}\right)\left(\frac{mole}{g\cdot atoms}\right)\left(\frac{atoms}{mole}\right)\left(\frac{MeV}{fission}\right)\left(\frac{W\cdot\sec}{MeV}\right)\left(\frac{day}{\sec}\right)\left(\frac{GW}{W}\right)=FIMA\frac{GW\cdot day}{ton\cdot fission}$$

$$\left(\frac{FIMA}{100}\right)\left(\frac{1.0\times10^{6}g}{ton}\right)\left(\frac{mole}{237.46\ g\cdot atoms}\right)\left(\frac{6.02214\times10^{23}atoms}{mole}\right)\left(\frac{204.55\ MeV}{fission}\right)$$

$$\left(\frac{1.60219\times10^{-13}W\cdot\sec}{MeV}\right)\left(\frac{1\ day}{86400\ \sec}\right)\left(\frac{1\ GW}{1\times10^{9}\ W}\right)=FIMA\cdot9.6\frac{GW\cdot day}{ton\cdot fission}$$

6.0 Software

The three computer codes (MCNP, MCWO, and ORIGEN2) used to perform this confirmatory analysis are listed as verified and validated (V&V'd) software in the INL Enterprise Architecture Repository and are accepted as qualified scientific and engineering analysis software.

Table 24. INL Qualified Analysis Software Version and Tracking Number

Code Name	Version	V&V Tracking Number
MCNP	5 (Release 1.30)	171103, 198740
MCWO	0	149879
ORIGEN2	2.1	64556

MCNP has been verified for use at the INL by running the 42 sample problems transmitted on the Radiation Safety Information Computational Center (RSICC) installation CD and verifying the results against the standard results provided on the CD.

MCWO has been verified at the INL by benchmarking calculated flux magnitudes with measured flux levels for several experiments in several test positions in the ATR core [17], [18], [19]. Additionally, MCWO and the ATR core model have been benchmarked for heat rate evaluations by comparing the measured temperatures to predicted temperatures in various ATR experiments [20].

The following computer configurations were used to perform the MCNP, MCWO, and ORIGEN2 calculations reported by this EDF.

Table 25. Computer Configurations for INL Qualified MCNP5 installations.

Computer System Name	Computer Model	Processor	Operating System	Property Number
goughd2	Dell Precision 670	Dual Intel Xeon	Windows XP	382130
panda2	Dell Precision 670	Dual Intel Xeon	Windows XP	378377
OZONE	230 Sun Microsystems V20z nodes, two AMD Opteron Model 248 CPUs (2.2GHz) per node, 4GB RAM per node.	AMD Opteron	Mandrake Linux 10.0, gcc version 3.3.2-6.1 mdk, kernel version 2.6.3-11 mdksmp	N/A

Table 26. Computer Configurations for INL Qualified MCWO/ORIGEN2 installations.

Computer System Name	Computer Model	Processor	Operating System	Property Number
panda2	Dell Precision 670	Dual Intel Xeon	Windows XP	378377

7.0 Data Retention

The input, output, and data files generated to support this analysis and EDF will be recorded to a CD or DVD and stored within the project file.

8.0 Results and Conclusions

8.1 Projected Neutron/Gamma Heating Rates

The projected neutron/gamma heating rates for the AGR-1 capsule assembly structural components are tabulated in Table 27 through Table 32, and the material densities are summarized in Table 33. For BOL conditions (0 EFPDs and normalized to Cycle 138B total core power of 108.4 MW) the maximum neutron/gamma heating rate was calculated to be 22.33 W/g for the graphite holder of capsule 5 (bottom 1 inch node). For the projected peak fuel fission power density condition (250 EFPDs and normalized to Cycle 141B total core power of 185.0 MW), the maximum neutron/gamma heating rate was calculated to be 19.19 W/g for the hafnium shroud of capsule 3 (hafnium position 5, facing core center towards SW, see Figure 2, number 17).

Project staff requested that additional projected neutron/gamma heating rate calculations for the B4C graphite holders vs. EFPDs be performed. These additional calculations determined the projected neutron/gamma heating rates for 800 EFPDs of irradiation in 25 day intervals. The heating rate results for the B4C graphite holders vs. EFPDs are tabulated in Table 34 of this document.

Table 27. Neutron/Gamma Heating Rates for Other AGR-1 Components/Regions (0 EFPDs)

Other AGR-1 Components/Regions	Neutron/ Gamma Heating (W/g)
Lower Graphite Spacer @ AGR Assembly Bottom	1.62
SS around Lower Graphite Spacer	1.98
SS Cap below Lower Graphite Spacer	1.80
SS @ Assembly Bottom (Capsule Train End)	1.50
Water within Assembly Bottom (Capsule Train End)	1.83
Gas Region above Assembly	1.71
SS AGR Capsule Body (All 6 Capsules)	2.77
Water surrounding AGR Capsule Bodies*	3.87

* Includes Delayed Fission Product Gamma

Table 28. Neutron/Gamma Heating Rates for Other AGR-1 Components/Regions (250 EFPDs)

Other AGR-1 Components/Regions	Neutron/ Gamma Heating (W/g)
Lower Graphite Spacer @ AGR Assembly Bottom	2.78
SS around Lower Graphite Spacer	3.33
SS Cap below Lower Graphite Spacer	3.08
SS @ Assembly Bottom (Capsule Train End)	2.52
Water within Assembly Bottom (Capsule Train End)	3.08
Gas Region above Assembly	2.88
SS AGR Capsule Body (All 6 Capsules)	4.76
Water surrounding AGR Capsule Bodies *	6.55

* Includes Delayed Fission Product Gamma

Table 29. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (0 EFPDs)

Capsule 6 - top	Neutron/ Gamma Heating (W/g)	Capsule 5	Neutron/ Gamma Heating (W/g)
SS Capsule Top Head	1.61	SS Capsule Top Head	2.27
Graphite/Grafoil Spacer Top	1.57	Graphite/Grafoil Spacer Top	2.23
Graphite Holder (5.5% B4C)*	--	Graphite Holder (7.0% B4C)*	--
*0.0" - 0.5" node (Top)**	13.37	*0.0" - 1.0" node (Top)**	18.25
*0.5" - 1.0" node**	11.47	*1.0" - 2.0" node**	16.60
*1.0" - 2.0" node**	11.46	*2.0" - 3.5" node**	17.55
*2.0" to 4.0" (Bottom)**	13.65	*3.5" - 4.0" node (Bottom)**	22.33
Graphite/Grafoil Spacer Bottom	2.06	Graphite/Grafoil Spacer Bottom	2.49
SS Capsule Bottom	2.21	SS Capsule Bottom	2.69
SS Sleeve	2.02	SS Sleeve	2.64
Hf Shroud*	--	Hf Shroud*	--
*Position 1 (60 degree arc)**	7.38	*Position 1 (60 degree arc)**	9.72
*Position 2 (60 degree arc)**	5.81	*Position 2 (60 degree arc)**	7.73
*Position 4 (60 degree arc)**	5.74	*Position 4 (60 degree arc)**	7.60
*Position 5 (60 degree arc)**	7.50	*Position 5 (60 degree arc)**	9.87
SS Shroud (120 degree arc)	1.62	SS Shroud (120 degree arc)	2.13
Molybdenum Thru Tube 1 (TT1)	2.61	Molybdenum Thru Tube 1 (TT1)	3.41
Molybdenum Thru Tube 2 (TT2)	2.18	Molybdenum Thru Tube 2 (TT2)	2.83
Molybdenum Thru Tube 3 (TT3)	2.18	Molybdenum Thru Tube 3 (TT3)	2.87
TT1 Contents - 10 Nb Gas Lines	2.02	TT1 Contents - 8 Nb Gas Lines	3.17
TT2 Contents - 3 T-50's & 5 T-N's (1/16")	--	TT2 Contents - 2 T-50's & 4 T-N's (1/16")	--
T-50 Mo Wires	1.89	*T-50 Mo Wires*	2.91
T-50 Nb1Zr Wires	1.85	*T-50 Nb1Zr Wires*	2.93
T-50 HfO2 insulation	2.66	*T-50 HfO2 insulation*	4.10
T-50 Nb1Zr Sheaths	1.90	*T-50 Nb1Zr Sheaths*	2.77
T-N (1/16") Nicrosil/Nisil Wires	1.63	*T-N (1/16") Nicrosil/Nisil Wires*	2.40
T-N (1/16") MgO insulation	1.42	*T-N (1/16") MgO insulation*	2.23
T-N (1/16") Inconnel Sheath	1.64	*T-N (1/16") Inconnel Sheath*	2.40
TT3 Contents - 6 T-50's	--	TT3 Contents - 5 T-50's	--
T-50 Mo Wires	1.82	T-50 Mo Wires	2.78
T-50 Nb1Zr Wires	1.84	T-50 Nb1Zr Wires	2.75
T-50 HfO2 insulation	2.59	T-50 HfO2 insulation	4.02
T-50 Nb1Zr Sheaths	1.88	T-50 Nb1Zr Sheaths	2.76

* Includes Delayed Fission Product Gamma

Table 29. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (0 EFPDs)

Capsule 6 - top	Neutron/ Gamma Heating (W/g)	Capsule 5	Neutron/ Gamma Heating (W/g)
B4C Opening - Center	--	B4C Opening - Center	--
T-50 Nb1Zr Sheath	2.16	Nothing	--
T-50 HfO2 Insulation	3.15		--
T-50 Mo Wires	2.20		--
T-50 Nb Wires	2.15		--
T-50 Ta barrier	3.65		--
B4C Opening - 1	--	B4C Opening - 1	--
T-50 Nb1Zr Sheath	2.44	T-50 Nb1Zr Sheath	3.46
T-50 HfO2 Insulation	3.58	T-50 HfO2 Insulation	5.12
T-50 Mo Wires	2.47	T-50 Mo Wires	3.39
T-50 Nb Wires	2.50	T-50 Nb Wires	3.51
T-50 Ta barrier	3.68	T-50 Ta barrier	6.22
B4C Opening - 2	--	B4C Opening - 2	--
Nb Gas Line (Out)	2.63	Nb Gas Line (Out)	2.94
B4C Opening - 3	--	B4C Opening - 3	--
T-N (3/32") Moly Sheath	1.77	T-N (1/16") Inconnel Sheath	2.23
T-N (3/32") Al2O3 Insulation	1.36	T-N (1/16") MgO Insulation	2.01
T-N (3/32") Nicrosil/Nisil Wires	1.50	T-N (1/16") Nicrosil/Nisil Wires	2.30
B4C Opening - 4	--	B4C Opening - 4	--
T-N (3/32")	--	T-50 Nb1Zr Sheath	2.65
T-N (3/32") Moly Sheath	1.79	T-50 HfO2 Insulation	3.82
T-N (3/32") Al2O3 Insulation	1.40	T-50 Mo Wires	2.69
T-N (3/32") Nicrosil/Nisil Wires	1.49	T-50 Nb Wires	2.72
	--	T-50 Ta barrier	4.37
B4C Opening - 5	--	B4C Opening - 5	--
T-N (3/32") Moly Sheath	2.03	Nothing	--
T-N (3/32") Al2O3 Insulation	1.58		--
T-N (3/32") Nicrosil/Nisil Wires	1.78		--
B4C Opening - 6	--	B4C Opening - 6	--
Nb Gas Line (In)	2.11	Nb Gas Line (In)	3.43

* Includes Delayed Fission Product Gamma

Table 29. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (0 EFPDs) (continued)

Capsule 4	Neutron/ Gamma Heating (W/g)	Capsule 3	Neutron/ Gamma Heating (W/g)
SS Capsule Top Head	2.69	SS Capsule Top Head	2.84
Graphite/Grafoil Spacer Top	2.61	Graphite/Grafoil Spacer Top	2.74
Graphite Holder (7.0% B4C)*	--	Graphite Holder (7.0% B4C)*	--
*0.0" - 1.0" node (Top)**	21.39	*0.0" - 1.0" node (Top)**	22.25
*1.0" - 2.0" node**	18.65	*1.0" - 2.0" node**	19.32
*2.0" - 3.0" node**	19.02	*2.0" - 3.0" node**	19.15
*3.0" - 4.0" node(Bottom)**	21.50	*3.0" - 4.0" node (Bottom)**	21.92
Graphite/Grafoil Spacer Bottom	2.67	Graphite/Grafoil Spacer Bottom	2.64
SS Capsule Bottom	2.85	SS Capsule Bottom	2.82
SS Sleeve	2.96	SS Sleeve	3.01
Hf Shroud*	--	Hf Shroud*	--
*Position 1 (60 degree arc)**	10.85	*Position 1 (60 degree arc)**	11.20
*Position 2 (60 degree arc)**	8.52	*Position 2 (60 degree arc)**	8.81
*Position 4 (60 degree arc)**	8.51	*Position 4 (60 degree arc)**	8.74
*Position 5 (60 degree arc)**	11.09	*Position 5 (60 degree arc)**	11.31
SS Shroud (120 degree arc)	2.39	SS Shroud (120 degree arc)	2.41
Molybdenum Thru Tube 1 (TT1)	3.84	Molybdenum Thru Tube 1 (TT1)	3.92
Molybdenum Thru Tube 2 (TT2)	3.20	Molybdenum Thru Tube 2 (TT2)	3.31
Molybdenum Thru Tube 3 (TT3)	3.22	Molybdenum Thru Tube 3 (TT3)	3.27
TT1 Contents - 6 Nb Gas Lines	3.57	TT1 Contents - 4 Nb Gas Lines	3.66
TT2 Contents - 2 T-50's & 3 T-N's (1/16")	--	TT2 Contents - 2 T-50's & 4 T-N's (1/16")	--
T-50 Mo Wires	3.25	*T-50 Mo Wires*	3.28
T-50 Nb1Zr Wires	3.07	*T-50 Nb1Zr Wires*	3.38
T-50 HfO2 insulation	4.65	*T-50 HfO2 insulation*	4.82
T-50 Nb1Zr Sheaths	3.12	*T-50 Nb1Zr Sheaths*	3.27
T-N (1/16") Nicrosil/Nisil Wires	2.77	*T-N (1/16") Nicrosil/Nisil Wires*	2.70
T-N (1/16") MgO insulation	2.52	*T-N (1/16") MgO insulation*	2.47
T-N (1/16") Inconnel Sheath	2.70	*T-N (1/16") Inconnel Sheath*	2.69
TT3 Contents - 3 T-50's	--	TT3 Contents - 5 T-50's	--
T-50 Mo Wires	3.28	T-50 Mo Wires	3.31
T-50 Nb1Zr Wires	3.20	T-50 Nb1Zr Wires	3.30
T-50 HfO2 insulation	4.54	T-50 HfO2 insulation	4.70
T-50 Nb1Zr Sheaths	3.13	T-50 Nb1Zr Sheaths	3.20

* Includes Delayed Fission Product Gamma

Table 29. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (0 EFPDs) (continued)

Capsule 4	Neutron/ Gamma Heating (W/g)	Capsule 3	Neutron/ Gamma Heating (W/g)
B4C Opening - Center	--	B4C Opening - Center	--
T-50 Nb1Zr Sheath	3.53	Nothing	--
T-50 HfO2 Insulation	5.11		--
T-50 Mo Wires	3.67		--
T-50 Nb Wires	3.64		--
T-50 Ta barrier	5.72		--
B4C Opening - 1	--	B4C Opening - 1	--
Nothing	--	T-50 Nb1Zr Sheath	4.21
	--	T-50 HfO2 Insulation	6.17
	--	T-50 Mo Wires	4.27
	--	T-50 Nb Wires	4.20
	--	T-50 Ta barrier	5.17
B4C Opening - 2	--	B4C Opening - 2	--
Nb Gas Line (Out)	3.43	Nb Gas Line (Out)	3.66
B4C Opening - 3	--	B4C Opening - 3	--
T-N (1/16") Moly Sheath	2.46	T-N (1/16") Inconnel Sheath	2.62
T-N (1/16") MgO Insulation	2.27	T-N (1/16") MgO Insulation	2.35
T-N (1/16") Nicrosil/Nisil Wires	2.47	T-N (1/16") Nicrosil/Nisil Wires	2.73
B4C Opening - 4	--	B4C Opening - 4	--
T-50 Nb1Zr Sheath	3.08	T-50 Nb1Zr Sheath	3.14
T-50 HfO2 Insulation	4.48	T-50 HfO2 Insulation	4.68
T-50 Mo Wires	3.14	T-50 Mo Wires	3.21
T-50 Nb Wires	3.07	T-50 Nb Wires	3.37
T-50 Ta barrier	4.45	T-50 Ta barrier	7.21
B4C Opening – 5	--	B4C Opening - 5	--
Nothing	--	Nothing	--
	--		--
	--		--
B4C Opening - 6	--	B4C Opening - 6	--
Nb Gas Line (In)	3.92	Nb Gas Line (In)	4.03

* Includes Delayed Fission Product Gamma

Table 29. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (0 EFPDs) (continued)

Capsule 2	Neutron/ Gamma Heating (W/g)	Capsule 1 - bottom	Neutron/ Gamma Heating (W/g)
SS Capsule Top Head	2.76	SS Capsule Top Head	2.41
Graphite/Grafoil Spacer Top	2.59	Graphite/Grafoil Spacer Top	2.20
Graphite Holder (7.0% B4C)*	--	Graphite Holder (5.5% B4C)*	--
*0.0" - 1.0" node (Top)**	21.71	*0.0" - 1.0" node (Top)**	17.22
*1.0" - 2.0" node**	18.23	*1.0" - 2.0" node**	14.07
*2.0" - 3.0" node**	17.93	*2.0" - 4.0" node (Bottom)**	13.91
*3.0" - 4.0" node (Bottom)**	19.92		--
Graphite/Grafoil Spacer Bottom	2.37	Graphite/Grafoil Spacer Bottom	1.82
SS Capsule Bottom	2.46	SS Capsule Bottom	1.89
SS Sleeve	2.78	SS Sleeve	2.27
Hf Shroud*	--	Hf Shroud*	--
*Position 1 (60 degree arc)**	10.35	*Position 1 (60 degree arc)**	8.27
*Position 2 (60 degree arc)**	8.22	*Position 2 (60 degree arc)**	6.61
*Position 4 (60 degree arc)**	8.15	*Position 4 (60 degree arc)**	6.59
*Position 5 (60 degree arc)**	10.47	*Position 5 (60 degree arc)**	8.58
SS Shroud (120 degree arc)	2.26	SS Shroud (120 degree arc)	1.83
Molybdenum Thru Tube 1 (TT1)	3.65	Molybdenum Thru Tube 1 (TT1)	3.02
Molybdenum Thru Tube 2 (TT2)	3.09	Molybdenum Thru Tube 2 (TT2)	2.51
Molybdenum Thru Tube 3 (TT3)	3.10	Molybdenum Thru Tube 3 (TT3)	2.51
TT1 Contents - 2 Nb Gas Lines	3.44	TT1 Contents - Nothing	--
TT2 Contents – 1 T-N (1/16")	--	TT2 Contents - Nothing	--
	--		--
	--		--
	--		--
	--		--
T-N (1/16") Nicrosil/Nisil Wires	2.55		--
T-N (1/16") MgO insulation	2.33		--
T-N (1/16") Inconnel Sheath	2.55		--
TT3 Contents - 1 T-50	--	TT3 Contents - Nothing	--
T-50 Mo Wires	3.24		--
T-50 Nb1Zr Wires	3.17		--
T-50 HfO2 insulation	4.59		--
T-50 Nb1Zr Sheaths	3.06		--

* Includes Delayed Fission Product Gamma

Table 29. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (0 EFPDs) (continued)

Capsule 2	Neutron/ Gamma Heating (W/g)	Capsule 1 - bottom	Neutron/ Gamma Heating (W/g)
B4C Opening - Center	--	B4C Opening - Center	--
Nothing	--	Nothing	--
	--		--
	--		--
	--		--
	--		--
B4C Opening - 1	--	B4C Opening - 1	--
T-50 Nb1Zr Sheath	3.90	Nothing	--
T-50 HfO2 Insulation	5.83		--
T-50 Mo Wires	4.12		--
T-50 Nb Wires	4.20		--
T-50 Ta barrier	6.38		--
B4C Opening - 2	--	B4C Opening - 2	--
Nb Gas Line (Out)	3.53	Nb Gas Line (Out)	3.12
B4C Opening - 3	--	B4C Opening - 3	--
T-N (1/16") Moly Sheath	2.50	T-N (1/16") Inconnel Sheath	2.24
T-N (1/16") MgO Insulation	2.29	T-N (1/16") MgO Insulation	2.00
T-N (1/16") Nicrosil/Nisil Wires	2.53	T-N (1/16") Nicrosil/Nisil Wires	2.19
B4C Opening - 4	--	B4C Opening - 4	--
T-50 Nb1Zr Sheath	3.07	T-50 Nb1Zr Sheath	2.69
T-50 HfO2 Insulation	4.49	T-50 HfO2 Insulation	3.97
T-50 Mo Wires	3.17	T-50 Mo Wires	2.91
T-50 Nb Wires	2.92	T-50 Nb Wires	2.62
T-50 Ta barrier	4.71	T-50 Ta barrier	5.51
B4C Opening – 5	--	B4C Opening - 5	--
Nothing	--	Nothing	--
	--		--
	--		--
B4C Opening - 6	--	B4C Opening - 6	--
Nb Gas Line (In)	3.76	Nb Gas Line (In)	3.19

* Includes Delayed Fission Product Gamma

Table 30. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (250 EFPDs)

Capsule 6 - top	Neutron/ Gamma Heating (W/g)	Capsule 5	Neutron/ Gamma Heating (W/g)
SS Capsule Top Head	2.70	SS Capsule Top Head	3.94
Graphite/Grafoil Spacer Top	2.70	Graphite/Grafoil Spacer Top	3.77
Graphite Holder (5.5% B4C)*	--	Graphite Holder (7.0% B4C)*	--
*0.0" - 0.5" node (Top)**	8.57	*0.0" - 1.0" node (Top)**	10.13
*0.5" - 1.0" node**	9.62	*1.0" - 2.0" node**	11.35
*1.0" - 2.0" node**	10.16	*2.0" - 3.5" node**	10.90
*2.0" to 4.0" (Bottom)**	11.95	*3.5" - 4.0" nod e(Bottom)**	8.21
Graphite/Grafoil Spacer Bottom	3.49	Graphite/Grafoil Spacer Bottom	4.24
SS Capsule Bottom	3.78	SS Capsule Bottom	4.64
SS Sleeve	3.49	SS Sleeve	4.58
Hf Shroud*	--	Hf Shroud*	--
*Position 1 (60 degree arc)**	11.85	*Position 1 (60 degree arc)**	15.44
*Position 2 (60 degree arc)**	9.13	*Position 2 (60 degree arc)**	11.94
*Position 4 (60 degree arc)**	10.38	*Position 4 (60 degree arc)**	13.72
*Position 5 (60 degree arc)**	13.09	*Position 5 (60 degree arc)**	17.01
SS Shroud (120 degree arc)	2.84	SS Shroud (120 degree arc)	3.79
Molybdenum Thru Tube 1 (TT1)	4.45	Molybdenum Thru Tube 1 (TT1)	5.75
Molybdenum Thru Tube 2 (TT2)	3.67	Molybdenum Thru Tube 2 (TT2)	4.84
Molybdenum Thru Tube 3 (TT3)	3.90	Molybdenum Thru Tube 3 (TT3)	5.12
TT1 Contents - 10 Nb Gas Lines	3.42	TT1 Contents - 8 Nb Gas Lines	5.36
TT2 Contents - 3 T-50's & 5 T-N's (1/16")	--	TT2 Contents - 2 T-50's & 4 T-N's (1/16")	--
T-50 Mo Wires	3.08	*T-50 Mo Wires*	5.08
T-50 Nb1Zr Wires	3.12	*T-50 Nb1Zr Wires*	4.87
T-50 HfO2 insulation	4.43	*T-50 HfO2 insulation*	6.98
T-50 Nb1Zr Sheaths	3.14	*T-50 Nb1Zr Sheaths*	4.79
T-N (1/16") Nicrosil/Nisil Wires	2.68	*T-N (1/16") Nicrosil/Nisil Wires*	4.16
T-N (1/16") MgO insulation	2.37	*T-N (1/16") MgO insulation*	3.81
T-N (1/16") Inconnel Sheath	2.72	*T-N (1/16") Inconnel Sheath*	4.12
TT3 Contents - 6 T-50's	--	TT3 Contents - 5 T-50's	--
T-50 Mo Wires	3.25	T-50 Mo Wires	5.46
T-50 Nb1Zr Wires	3.32	T-50 Nb1Zr Wires	5.30
T-50 HfO2 insulation	4.58	T-50 HfO2 insulation	7.48
T-50 Nb1Zr Sheaths	3.28	T-50 Nb1Zr Sheaths	5.13

* Includes Delayed Fission Product Gamma

Table 30. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (250 EFPDs)

Capsule 6 - top	Neutron/ Gamma Heating (W/g)	Capsule 5	Neutron/ Gamma Heating (W/g)
B4C Opening - Center	--	B4C Opening - Center	--
T-50 Nb1Zr Sheath	3.64	Nothing	--
T-50 HfO2 Insulation	5.27		--
T-50 Mo Wires	3.28		--
T-50 Nb Wires	4.12		--
T-50 Ta barrier	4.40		--
B4C Opening - 1	--	B4C Opening - 1	--
T-50 Nb1Zr Sheath	3.97	T-50 Nb1Zr Sheath	5.83
T-50 HfO2 Insulation	5.81	T-50 HfO2 Insulation	8.56
T-50 Mo Wires	3.88	T-50 Mo Wires	6.06
T-50 Nb Wires	3.99	T-50 Nb Wires	5.94
T-50 Ta barrier	7.95	T-50 Ta barrier	12.13
B4C Opening - 2	--	B4C Opening - 2	--
Nb Gas Line (Out)	4.39	Nb Gas Line (Out)	5.00
B4C Opening - 3	--	B4C Opening - 3	--
T-N (3/32") Moly Sheath	2.86	T-N (1/16") Inconnel Sheath	3.69
T-N (3/32") Al2O3 Insulation	2.17	T-N (1/16") MgO Insulation	3.38
T-N (3/32") Nicrosil/Nisil Wires	2.36	T-N (1/16") Nicrosil/Nisil Wires	3.71
B4C Opening - 4	--	B4C Opening - 4	--
T-N (3/32")	--	T-50 Nb1Zr Sheath	4.76
T-N (3/32") Moly Sheath	3.09	T-50 HfO2 Insulation	6.99
T-N (3/32") Al2O3 Insulation	2.41	T-50 Mo Wires	5.04
T-N (3/32") Nicrosil/Nisil Wires	2.56	T-50 Nb Wires	5.26
	--	T-50 Ta barrier	9.28
B4C Opening - 5	--	B4C Opening - 5	--
T-N (3/32") Moly Sheath	3.49	Nothing	--
T-N (3/32") Al2O3 Insulation	2.61		--
T-N (3/32") Nicrosil/Nisil Wires	3.03		--
B4C Opening - 6	--	B4C Opening - 6	--
Nb Gas Line (In)	3.22	Nb Gas Line (In)	5.90

* Includes Delayed Fission Product Gamma

Table 30. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (250 EFPDs) (continued)

Capsule 4	Neutron/ Gamma Heating (W/g)	Capsule 3	Neutron/ Gamma Heating (W/g)
SS Capsule Top Head	4.64	SS Capsule Top Head	4.87
Graphite/Grafoil Spacer Top	4.42	Graphite/Grafoil Spacer Top	4.67
Graphite Holder (7.0% B4C)*	--	Graphite Holder (7.0% B4C)*	--
*0.0" - 1.0" node (Top)**	8.70	*0.0" - 1.0" node (Top)**	8.62
*1.0" - 2.0" node**	10.13	*1.0" - 2.0" node**	10.14
*2.0" - 3.0" node**	10.19	*2.0" - 3.0" node**	10.11
*3.0" - 4.0" node (Bottom)**	8.53	*3.0" - 4.0" node (Bottom)**	8.32
Graphite/Grafoil Spacer Bottom	4.51	Graphite/Grafoil Spacer Bottom	4.51
SS Capsule Bottom	4.88	SS Capsule Bottom	4.87
SS Sleeve	5.08	SS Sleeve	5.17
Hf Shroud*	--	Hf Shroud*	--
*Position 1 (60 degree arc)**	17.06	*Position 1 (60 degree arc)**	17.54
*Position 2 (60 degree arc)**	13.11	*Position 2 (60 degree arc)**	13.62
*Position 4 (60 degree arc)**	15.29	*Position 4 (60 degree arc)**	15.67
*Position 5 (60 degree arc)**	18.78	***Position 5 (60 degree arc)****	19.19
SS Shroud (120 degree arc)	4.23	SS Shroud (120 degree arc)	4.28
Molybdenum Thru Tube 1 (TT1)	6.47	Molybdenum Thru Tube 1 (TT1)	6.61
Molybdenum Thru Tube 2 (TT2)	5.38	Molybdenum Thru Tube 2 (TT2)	5.52
Molybdenum Thru Tube 3 (TT3)	5.77	Molybdenum Thru Tube 3 (TT3)	5.91
TT1 Contents - 6 Nb Gas Lines	5.98	TT1 Contents - 4 Nb Gas Lines	6.20
TT2 Contents - 2 T-50's & 3 T-N's (1/16")	--	TT2 Contents - 2 T-50's & 4 T-N's (1/16")	--
T-50 Mo Wires	5.60	*T-50 Mo Wires*	5.78
T-50 Nb1Zr Wires	5.62	*T-50 Nb1Zr Wires*	5.91
T-50 HfO2 insulation	7.94	*T-50 HfO2 insulation*	8.16
T-50 Nb1Zr Sheaths	5.32	*T-50 Nb1Zr Sheaths*	5.60
T-N (1/16") Nicrosil/Nisil Wires	4.63	*T-N (1/16") Nicrosil/Nisil Wires*	4.72
T-N (1/16") MgO insulation	4.28	*T-N (1/16") MgO insulation*	4.30
T-N (1/16") Inconnel Sheath	4.60	*T-N (1/16") Inconnel Sheath*	4.61
TT3 Contents - 3 T-50's	--	TT3 Contents - 5 T-50's	--
T-50 Mo Wires	6.02	T-50 Mo Wires	6.14
T-50 Nb1Zr Wires	6.04	T-50 Nb1Zr Wires	6.23
T-50 HfO2 insulation	8.51	T-50 HfO2 insulation	8.72
T-50 Nb1Zr Sheaths	5.80	T-50 Nb1Zr Sheaths	5.96

* Includes Delayed Fission Product Gamma

Table 30. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (250 EFPDs) (continued)

Capsule 4	Neutron/ Gamma Heating (W/g)	Capsule 3	Neutron/ Gamma Heating (W/g)
B4C Opening - Center	--	B4C Opening - Center	--
T-50 Nb1Zr Sheath	6.20	Nothing	--
T-50 HfO2 Insulation	8.93		--
T-50 Mo Wires	5.98		--
T-50 Nb Wires	6.10		--
T-50 Ta barrier	9.73		--
B4C Opening - 1	--	B4C Opening - 1	--
Nothing	--	T-50 Nb1Zr Sheath	7.13
	--	T-50 HfO2 Insulation	10.35
	--	T-50 Mo Wires	6.95
	--	T-50 Nb Wires	7.39
	--	T-50 Ta barrier	11.75
B4C Opening - 2	--	B4C Opening - 2	--
Nb Gas Line (Out)	5.76	Nb Gas Line (Out)	6.01
B4C Opening - 3	--	B4C Opening - 3	--
T-N (1/16") Moly Sheath	4.30	T-N (1/16") Inconnel Sheath	4.52
T-N (1/16") MgO Insulation	3.88	T-N (1/16") MgO Insulation	4.05
T-N (1/16") Nicrosil/Nisil Wires	4.22	T-N (1/16") Nicrosil/Nisil Wires	4.58
B4C Opening - 4	--	B4C Opening - 4	--
T-50 Nb1Zr Sheath	5.52	T-50 Nb1Zr Sheath	5.87
T-50 HfO2 Insulation	8.06	T-50 HfO2 Insulation	8.70
T-50 Mo Wires	5.74	T-50 Mo Wires	5.96
T-50 Nb Wires	5.28	T-50 Nb Wires	6.11
T-50 Ta barrier	10.89	T-50 Ta barrier	14.02
B4C Opening – 5	--	B4C Opening - 5	--
Nothing	--	Nothing	--
	--		--
	--		--
B4C Opening - 6	--	B4C Opening - 6	--
Nb Gas Line (In)	6.59	Nb Gas Line (In)	--

* Includes Delayed Fission Product Gamma

Table 30. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (250 EFPDs) (continued)

Capsule 2	Neutron/ Gamma Heating (W/g)	Capsule 1 - bottom	Neutron/ Gamma Heating (W/g)
SS Capsule Top Head	4.79	SS Capsule Top Head	4.22
Graphite/Grafoil Spacer Top	4.47	Graphite/Grafoil Spacer Top	3.82
Graphite Holder (7.0% B4C)*	--	Graphite Holder (5.5% B4C)*	--
*0.0" - 1.0" node (Top)**	8.47	*0.0" - 1.0" node (Top)**	7.49
*1.0" - 2.0" node**	10.40	*1.0" - 2.0" node**	8.84
*2.0" - 3.0" node**	10.69	*2.0" - 4.0" node (Bottom)**	8.83
*3.0" - 4.0" node (Bottom)**	9.06		--
Graphite/Grafoil Spacer Bottom	4.08	Graphite/Grafoil Spacer Bottom	3.10
SS Capsule Bottom	4.34	SS Capsule Bottom	3.25
SS Sleeve	4.85	SS Sleeve	3.97
Hf Shroud*	--	Hf Shroud*	--
*Position 1 (60 degree arc)**	16.48	*Position 1 (60 degree arc)**	13.39
*Position 2 (60 degree arc)**	12.78	*Position 2 (60 degree arc)**	10.48
*Position 4 (60 degree arc)**	14.81	*Position 4 (60 degree arc)**	12.03
*Position 5 (60 degree arc)**	18.07	*Position 5 (60 degree arc)**	14.84
SS Shroud (120 degree arc)	4.03	SS Shroud (120 degree arc)	3.26
Molybdenum Thru Tube 1 (TT1)	6.25	Molybdenum Thru Tube 1 (TT1)	5.17
Molybdenum Thru Tube 2 (TT2)	5.18	Molybdenum Thru Tube 2 (TT2)	4.24
Molybdenum Thru Tube 3 (TT3)	5.52	Molybdenum Thru Tube 3 (TT3)	4.48
TT1 Contents - 2 Nb Gas Lines	5.97	TT1 Contents - Nothing	--
TT2 Contents – 1 T-N (1/16")	--	TT2 Contents - Nothing	--
	--		--
	--		--
	--		--
	--		--
T-N (1/16") Nicrosil/Nisil Wires	4.35		--
T-N (1/16") MgO insulation	4.07		--
T-N (1/16") Inconnel Sheath	4.31		--
TT3 Contents - 1 T-50	--	TT3 Contents - Nothing	--
T-50 Mo Wires	5.96		--
T-50 Nb1Zr Wires	5.87		--
T-50 HfO2 insulation	8.30		--
T-50 Nb1Zr Sheaths	5.54		--

* Includes Delayed Fission Product Gamma

Table 30. MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (250 EFPDs) (continued)

Capsule 2	Neutron/ Gamma Heating (W/g)	Capsule 1 - bottom	Neutron/ Gamma Heating (W/g)
B4C Opening - Center	--	B4C Opening - Center	--
Nothing	--	Nothing	--
	--		--
	--		--
	--		--
	--		--
B4C Opening - 1	--	B4C Opening - 1	--
T-50 Nb1Zr Sheath	6.80	Nothing	--
T-50 HfO2 Insulation	9.85		--
T-50 Mo Wires	6.77		--
T-50 Nb Wires	6.76		--
T-50 Ta barrier	11.81		--
B4C Opening - 2	--	B4C Opening - 2	--
Nb Gas Line (Out)	5.71	Nb Gas Line (Out)	5.23
B4C Opening - 3	--	B4C Opening - 3	--
T-N (1/16") Moly Sheath	4.49	T-N (1/16") Inconnel Sheath	3.69
T-N (1/16") MgO Insulation	4.03	T-N (1/16") MgO Insulation	3.38
T-N (1/16") Nicrosil/Nisil Wires	4.69	T-N (1/16") Nicrosil/Nisil Wires	3.79
B4C Opening - 4	--	B4C Opening - 4	--
T-50 Nb1Zr Sheath	5.48	T-50 Nb1Zr Sheath	4.92
T-50 HfO2 Insulation	7.99	T-50 HfO2 Insulation	7.11
T-50 Mo Wires	5.59	T-50 Mo Wires	4.71
T-50 Nb Wires	5.68	T-50 Nb Wires	4.99
T-50 Ta barrier	7.19	T-50 Ta barrier	10.70
B4C Opening – 5	--	B4C Opening - 5	--
Nothing	--	Nothing	--
	--		--
	--		--
B4C Opening - 6	--	B4C Opening - 6	--
Nb Gas Line (In)	6.37	Nb Gas Line (In)	5.32

* Includes Delayed Fission Product Gamma

Table 31. Maximum MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (0 EFPDs)

AGR-1 Component	Maximum MCNP-Calculated Neutron/Gamma Heating Rates (W/g)
SS Capsule Top Head	2.84
Graphite/Grafoil Spacer Top	2.74
Graphite Holder	
(5.5% B4C)	17.22
(7.0% B4C)	22.33
Graphite/Grafoil Spacer Bottom	2.67
SS Capsule Bottom	2.85
SS Sleeve	3.01
Hf Shroud	
Position 1 (60 degree arc)	11.20
Position 2 (60 degree arc)	8.81
Position 4 (60 degree arc)	8.74
Position 5 (60 degree arc)	11.31
SS Shroud (120 degree arc)	2.41
Molybdenum TT1	3.92
Molybdenum TT2	3.31
Molybdenum TT3	3.27
Type-N TC (3/32")	
T-N (3/32") Moly Sheath	2.03
T-N (3/32") Al2O3 Insulation	1.58
T-N (3/32") Nicrosil/Nisil Wires	1.78
Type-N TC (1/16")	
T-N (1/16") Inconnel Sheath	2.62
T-N (1/16") MgO Insulation	2.35
T-N (1/16") Nicrosil/Nisil Wires	2.73
INL TC	
T-50 Nb1Zr Sheath	4.21
T-50 HfO2 Insulation	6.17
T-50 Mo Wires	4.27
T-50 Nb Wires	4.20
T-50 Ta barrier	7.21
Nb Gas Lines	4.03

Table 32. Maximum MCNP-Calculated Neutron/Gamma Heating Rates for AGR-1 Capsule Assembly Components (250 EFPDs)

AGR-1 Component	Maximum MCNP-Calculated Neutron/Gamma Heating Rates (W/g)
SS Capsule Top Head	4.87
Graphite/Grafoil Spacer Top	4.67
Graphite Holder	
(5.5% B4C)	11.95
(7.0% B4C)	11.35
Graphite/Grafoil Spacer Bottom	4.51
SS Capsule Bottom	4.88
SS Sleeve	5.17
Hf Shroud	
Position 1 (60 degree arc)	17.54
Position 2 (60 degree arc)	13.62
Position 4 (60 degree arc)	15.67
Position 5 (60 degree arc)	19.19
SS Shroud (120 degree arc)	4.28
Molybdenum TT1	6.61
Molybdenum TT2	5.52
Molybdenum TT3	5.91
Type-N TC (3/32")	
T-N (3/32") Moly Sheath	3.49
T-N (3/32") Al2O3 Insulation	2.61
T-N (3/32") Nicrosil/Nisil Wires	3.03
Type-N TC (1/16")	
T-N (1/16") Inconnel Sheath	4.52
T-N (1/16") MgO Insulation	4.05
T-N (1/16") Nicrosil/Nisil Wires	4.69
INL TC	
T-50 Nb1Zr Sheath	7.13
T-50 HfO2 Insulation	10.35
T-50 Mo Wires	6.95
T-50 Nb Wires	7.39
T-50 Ta barrier	14.02
Nb Gas Lines	6.67

Table 33. MCNP Calculated Density for AGR-1 Capsule Assembly Components (0 EFPDs)

AGR-1 Component	MCNP Calculated Density (g/cc)	Applicability
SS Capsule Top Head	8.09551	All Capsules
Graphite/Grafoil Spacer Top	0.950378	All Capsules
Graphite Holder	--	
(5.5% B4C)	1.77021	(Capsules 6, 1)
(7.0% B4C)	1.77861	(Capsules 5, 4, 3, 2)
Graphite/Grafoil Spacer Bottom	1.01533	All Capsules
SS Capsule Bottom	8.09551	All Capsules
SS Sleeve	8.09551	All Capsules
Hf Shroud	--	
Position 1 (60 degree arc)	12.8143	(Capsules 6, 5, 4)
Position 2 (60 degree arc)	12.8143	(Capsules 6, 5, 4)
Position 4 (60 degree arc)	12.8143	(Capsules 6, 5, 4)
Position 5 (60 degree arc)	12.8143	(Capsules 6, 5, 4)
Position 1 (60 degree arc)	12.2609	(Capsules 3, 2, 1)
Position 2 (60 degree arc)	12.2609	(Capsules 3, 2, 1)
Position 4 (60 degree arc)	12.2609	(Capsules 3, 2, 1)
Position 5 (60 degree arc)	12.2609	(Capsules 3, 2, 1)
SS Shroud (120 degree arc)	8.09551	All Capsules
Molybdenum TT1	10.139	All Capsules
Molybdenum TT2	10.139	All Capsules
Molybdenum TT3	10.139	All Capsules
Type-N TC (3/32")	--	
T-N (3/32") Moly Sheath	10.1392	All Capsules
T-N (3/32") Al2O3 Insulation	3.88953	All Capsules
T-N (3/32") Nicrosil/Nisil Wires	8.52514	All Capsules
Type-N TC (1/16")	--	
T-N (1/16") Inconnel Sheath	8.47016	All Capsules
T-N (1/16") MgO Insulation	3.29969	All Capsules
T-N (1/16") Nicrosil/Nisil Wires	8.52514	All Capsules
INL TC	--	
T-50 Nb1Zr Sheath	8.58074	All Capsules
T-50 HfO2 Insulation	9.04968	All Capsules
T-50 Mo Wires	10.1392	All Capsules
T-50 Nb Wires	8.57014	All Capsules
T-50 Ta barrier	16.6543	All Capsules
Nb Gas Lines	8.56994	All Capsules
He	0.0008304	All Capsules
Water	0.99819	All Capsules
SS Capsule Body	8.09551	All Capsules

Table 34. AGR-1 B4C Graphite HolderProjected Neutron/Gamma Heating Rates vs. EFPD (25-300 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

	EFPDs	25	50	75	100	125	150	175	200	225	250	275	300
Capsule	Relative Cell Position	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)
Capsule 6	0.0" to 0.5" (Top)	13.29	12.67	12.01	11.30	10.52	9.66	11.36	7.87	7.01	6.14	5.34	4.62
5.5% B4C	0.5" to 1.0"	11.34	11.04	10.72	10.32	9.91	9.40	11.08	8.13	7.50	6.80	6.06	5.34
	1.0" to 2.0"	11.31	10.98	10.72	10.35	9.96	9.52	10.71	8.41	7.78	7.10	6.37	5.64
	2.0" to 4.0" (Bottom)	14.53	14.12	13.72	13.23	12.68	12.03	8.78	10.50	9.61	8.61	7.56	6.51
Capsule 5	0.0" to 0.5" (Top)	18.24	17.55	16.75	15.83	14.78	13.57	8.82	10.74	9.22	7.71	6.35	5.19
7.0% B4C	0.5" to 1.0"	16.56	16.11	15.66	15.09	14.38	13.59	9.02	11.47	10.11	8.64	7.22	5.90
	1.0" to 2.0"	17.48	17.03	16.54	15.91	15.12	14.13	11.34	11.58	10.05	8.46	6.94	5.62
	2.0" to 4.0" (Bottom)	22.12	20.85	19.42	17.83	16.05	14.03	12.24	9.85	7.97	6.36	5.13	4.28
Capsule 4	0.0" to 0.5" (Top)	21.32	20.36	19.35	18.00	16.47	14.67	12.65	10.60	8.58	6.82	5.45	4.50
7.0% B4C	0.5" to 1.0"	18.54	18.02	17.46	16.70	15.78	14.62	12.99	11.63	9.86	8.00	6.39	5.13
	1.0" to 2.0"	18.84	18.37	17.80	17.03	16.12	14.92	11.93	11.81	9.99	8.07	6.43	5.15
	2.0" to 4.0" (Bottom)	21.33	20.43	19.34	17.97	16.49	14.62	12.73	10.45	8.42	6.65	5.32	4.41
Capsule 3	0.0" to 0.5" (Top)	22.03	21.04	19.84	18.44	16.78	14.89	13.28	10.58	8.50	6.72	5.37	4.46
7.0% B4C	0.5" to 1.0"	19.29	18.76	18.14	17.34	16.38	15.17	13.53	11.96	10.02	8.08	6.42	5.17
	1.0" to 2.0"	19.09	18.54	17.94	17.15	16.23	15.10	12.62	11.99	10.11	8.18	6.46	5.16
	2.0" to 4.0" (Bottom)	21.76	20.80	19.71	18.30	16.77	14.86	12.75	10.52	8.42	6.61	5.27	4.38
Capsule 2	0.0" to 0.5" (Top)	21.59	20.61	19.47	18.08	16.52	14.61	13.68	10.41	8.39	6.62	5.29	4.39
7.0% B4C	0.5" to 1.0"	18.27	17.78	17.19	16.47	15.66	14.54	13.71	11.71	10.00	8.21	6.58	5.28
	1.0" to 2.0"	17.77	17.38	16.88	16.18	15.44	14.42	12.74	11.81	10.19	8.42	6.79	5.42
	2.0" to 4.0" (Bottom)	19.71	18.99	18.09	17.00	15.71	14.20	12.57	10.68	8.84	7.12	5.69	4.62
Capsule 1	0.0" to 1.0" (Top)	17.00	16.12	15.18	14.06	12.80	11.36	13.30	8.34	6.92	5.66	4.67	3.94
5.5% B4C	1.0" to 2.0"	14.07	13.65	13.17	12.59	11.94	11.08	13.26	9.08	7.89	6.67	5.58	4.62
	2.0" to 4.0" (Bottom)	13.88	13.38	12.85	12.24	11.54	10.71	12.52	8.73	7.67	6.56	5.55	4.65

Table 34. AGR-1 B4C Graphite HolderProjected Neutron/Gamma Heating Rates vs. EFPD (25-300 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

	EFPDs	325	350	375	400	425	450	475	500	525	550	575	600
Capsule	Relative Cell Position	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)
Capsule 6	0.0" to 0.5" (Top)	3.99	3.46	3.05	2.74	2.49	2.31	2.19	2.11	2.05	2.00	1.97	1.95
5.5% B4C	0.5" to 1.0"	4.65	4.05	3.53	3.11	2.79	2.55	2.38	2.26	2.18	2.12	2.08	2.05
	1.0" to 2.0"	4.92	4.26	3.72	3.26	2.92	2.67	2.49	2.37	2.28	2.23	2.19	2.16
	2.0" to 4.0" (Bottom)	5.53	4.67	3.98	3.45	3.07	2.80	2.62	2.51	2.43	2.39	2.36	2.33
Capsule 5	0.0" to 0.5" (Top)	4.32	3.71	3.32	3.07	2.93	2.84	2.79	2.76	2.74	2.72	2.71	2.71
7.0% B4C	0.5" to 1.0"	4.85	4.07	3.56	3.24	3.06	2.95	2.89	2.85	2.83	2.81	2.80	2.79
	1.0" to 2.0"	4.64	3.94	3.51	3.25	3.11	3.02	2.97	2.94	2.92	2.91	2.90	2.89
	2.0" to 4.0" (Bottom)	3.74	3.41	3.22	3.12	3.06	3.03	3.01	2.99	2.98	2.97	2.97	2.96
Capsule 4	0.0" to 0.5" (Top)	3.91	3.58	3.39	3.29	3.23	3.20	3.17	3.16	3.15	3.14	3.14	3.13
7.0% B4C	0.5" to 1.0"	4.30	3.78	3.49	3.34	3.26	3.21	3.18	3.16	3.15	3.14	3.13	3.12
	1.0" to 2.0"	4.32	3.81	3.52	3.38	3.29	3.25	3.22	3.20	3.19	3.17	3.17	3.16
	2.0" to 4.0" (Bottom)	3.87	3.56	3.40	3.31	3.26	3.23	3.21	3.20	3.19	3.18	3.18	3.17
Capsule 3	0.0" to 0.5" (Top)	3.92	3.62	3.46	3.37	3.32	3.29	3.27	3.26	3.25	3.25	3.24	3.23
7.0% B4C	0.5" to 1.0"	4.35	3.86	3.59	3.45	3.37	3.32	3.30	3.28	3.27	3.26	3.25	3.25
	1.0" to 2.0"	4.32	3.83	3.55	3.40	3.32	3.28	3.25	3.24	3.23	3.22	3.21	3.21
	2.0" to 4.0" (Bottom)	3.86	3.57	3.41	3.33	3.28	3.25	3.24	3.23	3.22	3.21	3.20	3.20
Capsule 2	0.0" to 0.5" (Top)	3.84	3.52	3.35	3.26	3.21	3.18	3.16	3.15	3.14	3.13	3.12	3.11
7.0% B4C	0.5" to 1.0"	4.37	3.79	3.47	3.29	3.19	3.14	3.10	3.08	3.07	3.06	3.05	3.05
	1.0" to 2.0"	4.43	3.80	3.44	3.23	3.12	3.06	3.03	3.01	2.99	2.98	2.97	2.97
	2.0" to 4.0" (Bottom)	3.92	3.49	3.25	3.11	3.04	3.00	2.97	2.96	2.94	2.93	2.93	2.92
Capsule 1	0.0" to 1.0" (Top)	3.45	3.13	2.95	2.83	2.76	2.72	2.69	2.68	2.66	2.65	2.65	2.64
5.5% B4C	1.0" to 2.0"	3.91	3.39	3.06	2.85	2.72	2.64	2.59	2.56	2.54	2.52	2.51	2.50
	2.0" to 4.0" (Bottom)	3.93	3.39	3.02	2.77	2.61	2.50	2.44	2.39	2.37	2.35	2.34	2.33

Table 34. AGR-1 B4C Graphite HolderProjected Neutron/Gamma Heating Rates vs. EFPD (25-300 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

	EFPDs	625	650	675	700	725	750	775	800
Capsule	Relative Cell Position	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)	Total Heating (W/g)
Capsule 6 5.5% B4C	0.0" to 0.5" (Top)	1.94	1.92	1.91	1.91	1.90	1.90	1.89	1.89
	0.5" to 1.0"	2.04	2.02	2.01	2.00	2.00	1.99	1.99	1.98
	1.0" to 2.0"	2.15	2.13	2.12	2.12	2.11	2.10	2.10	2.09
	2.0" to 4.0" (Bottom)	2.32	2.31	2.30	2.29	2.29	2.29	2.28	2.28
Capsule 5 7.0% B4C	0.0" to 0.5" (Top)	2.70	2.69	2.69	2.68	2.68	2.68	2.67	2.67
	0.5" to 1.0"	2.79	2.78	2.78	2.77	2.77	2.76	2.76	2.76
	1.0" to 2.0"	2.88	2.88	2.87	2.86	2.86	2.86	2.85	2.85
	2.0" to 4.0" (Bottom)	2.96	2.95	2.95	2.94	2.94	2.94	2.94	2.93
Capsule 4 7.0% B4C	0.0" to 0.5" (Top)	3.13	3.12	3.11	3.11	3.11	3.10	3.10	3.10
	0.5" to 1.0"	3.12	3.11	3.11	3.10	3.10	3.09	3.09	3.09
	1.0" to 2.0"	3.15	3.15	3.14	3.13	3.13	3.13	3.12	3.12
	2.0" to 4.0" (Bottom)	3.17	3.16	3.16	3.15	3.15	3.15	3.14	3.14
Capsule 3 7.0% B4C	0.0" to 0.5" (Top)	3.23	3.23	3.22	3.21	3.21	3.21	3.20	3.20
	0.5" to 1.0"	3.24	3.23	3.23	3.22	3.22	3.22	3.21	3.21
	1.0" to 2.0"	3.20	3.19	3.19	3.18	3.18	3.18	3.17	3.17
	2.0" to 4.0" (Bottom)	3.19	3.19	3.18	3.18	3.18	3.17	3.17	3.17
Capsule 2 7.0% B4C	0.0" to 0.5" (Top)	3.11	3.10	3.10	3.09	3.09	3.09	3.08	3.08
	0.5" to 1.0"	3.04	3.04	3.03	3.03	3.02	3.02	3.02	3.02
	1.0" to 2.0"	2.96	2.95	2.95	2.95	2.94	2.94	2.94	2.94
	2.0" to 4.0" (Bottom)	2.92	2.91	2.91	2.90	2.90	2.90	2.90	2.89
Capsule 1 5.5% B4C	0.0" to 1.0" (Top)	2.64	2.63	2.63	2.62	2.62	2.62	2.61	2.61
	1.0" to 2.0"	2.50	2.49	2.49	2.49	2.48	2.48	2.47	2.47
	2.0" to 4.0" (Bottom)	2.32	2.32	2.31	2.31	2.30	2.30	2.30	2.29

8.2 Reactivity Perturbation

Evaluations were performed to verify that the AGR-1 capsule assembly could be replaced by the standard aluminum dummy without exceeding the core reactivity perturbation limit of 0.50$ [ATR UFSAR, SAR-153, Chapter 15.4.5].

Using the validated ATR full core model (see Attachment J), a number of MCNP calculations were performed to support safety evaluations of reactivity variations within the ATR B-10 position for the AGR-1 assembly. For the reference case, an Al-dummy in the B-10 position, MCNP calculated K_{eff} to be 1.00194(±0.00018). For case-A, beginning of AGR-1 irradiation (0 EFPDs), case-B, projected peak fission density (250 EFPDs), and case-C, projected peak fission density (250 EFPDs) with He-3 replacing He-4 within the capsule assembly, MCNP calculated the final K_{eff} to be 1.00169 (±0.00018), 1.00194 (±0.00018), and 1.00162 (±0.00017), respectively. The reactivity worth in dollars was calculated using the given equation and value for β (the delayed neutron fraction β = 0.0075 [5]).

$$\rho\$ = \ell n\left(\frac{K_{Case\ A,\ B,\ or\ C}}{K_{\mathrm{Re}\,ference\ Case}}\right)/\beta$$

Table 35. MCNP-Calculated K_{eff} for AGR-1 Experiment Assembly

Case Description	K_{eff}	K_{eff} Error (σ)	Aluminum Relative Reactivity Worth ($)
Actual ATR Critical Condition	1.000000	--	--
Reference Case – Al dummy in B-10	1.001940	±0.00018	0.0000 ±0.048
Case-A (AGR-1 in B-10, 0 EFPDs)	1.001690	±0.00018	-0.0333 ±0.048
Case-B (AGR-1 in B-10, 250 EFPDs)	1.001940	±0.00017	0.0000 ±0.045
Case-C (AGR-1 in B-10, 250 EFPDs w/He-3)	1.001620	±0.00018	-0.0426 ±0.048

The calculated reactivity worth (ρ$) for case-A is -0.033$, case-B is 0.000$, and case-C is -0.043$. Using the calculated error band (0.00018), the calculated AGR-1 experiment reactivity insertion ($\rho_{2\sigma}$$) within a 95% confidence level (2σ) relative to ATR actual critical conditions (1.0000) was calculated as follows.

$$\rho_{+2\sigma}\$ = \ell n\left(\frac{1.0000 + 2\times 0.00018}{1.0000}\right)/0.0075 = 0.048\$$$

$$\rho_{-2\sigma}\$ = \ell n\left(\frac{1.0000 - 2\times 0.00018}{1.0000}\right)/0.0075 = -0.048\$$$

The AGR-1 capsule assembly reactivity worths relative to an aluminum dummy were calculated to be:

-0.033$ ±0.048$ (0 EFPDs),

0.000$ ±0.045$ (250 EFPDs), and

-0.043$ ±0.048$ (250 EFPDs w/He-3 replacint He-4 in the capsule assembly.

These reactivity changes are much less than the 0.50$ step insertion limit defined in the ATR UFSAR [SAR-153, Chapter 15.4.5], thus, an aluminum dummy is an acceptable backup for the AGR-1 capsule assembly.

8.3 Projected Fuel Compact Fission Power Density and Fuel Burnup

The MCWO-calculated projected fuel fission power density (W/cm^3) and burnup (% FIMA and GWd/t) were evaluated from 0 EFPDs to 800 EFPDs for nominal MOC operating conditions (OSCC positions at 96.0°- 84.8°- 82.1°- 85.5° for NE-NW-SE-SW, respectively). The MCWO-calculated results are plotted in Figure 11 through Figure 16. The numerical data for 0 EFPDs through 800 EFPDs is tabulated in Table 36 through Table 42.

The AGR-1 fuel compact projected peak fuel fission power density of 132.39 W/cm^3 occurred in capsule 3, stack-1, third fuel compact from the top (node-29 of stack-1, facing core center towards NW) at 250 EFPDs.

The AGR-1 fuel compact projected burnup reaches 22.37% FIMA (214.75 GWd/t) in capsule 3, stack-1, top fuel compact of capsule stack (node-25 of stack-1, facing core center towards NW) at 800 EFPDs.

8.4 Projected Fuel Compact Fast Flux and Fast Fluence

The AGR program requires a minimum fast neutron fluence (E > 0.18 MeV) of greater than 1.5x10^{25} n/m^2 (1.5x10^{21} n/cm^2) and a maximum fast neutron fluence of less than 5.0x10^{25} n/m^2 (5.0x10^{21} n/cm^2) [9]. The fast neutron fluence minimum and maximum requirements within the AGR-1 fuel compacts were evaluated using MCNP. The MCNP-calculated projected fast neutron fluence (E > 0.18 MeV) versus EFPDs are plotted in Figure 17 through Figure 19. The numerical data for fast neutron flux and fast neutron fluence are tabulated in Table 43 through Table 47.

The minimum fast neutron fluence requirement of greater than 1.5x10^{25} n/m^2 for all AGR-1 fuel compacts was determined to happen after 450 EFPDs. The last fuel compact to exceed the minimum is projected to occur in capsule 6, stack-2, top fuel compact of capsule stack (node 97 of stack-2, facing away from core center and towards E), at 450 EFPDs with a value of 1.533x10^{25} n/m^2 (1.533x10^{21} n/cm^2).

The maximum fast neutron fluence requirement of 5.0x10^{25} n/m^2 (5.0x10^{21} n/cm^2) is projected to occur after 750 EFPDs of irradiation. At 800 EFPDs, multiple fuel compacts in capsule 3 and capsule 4 will exceed 5.0x10^{25} n/m^2.

Figure 11. AGR-1 Fuel Compact Stack 1 Fission Power Density vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

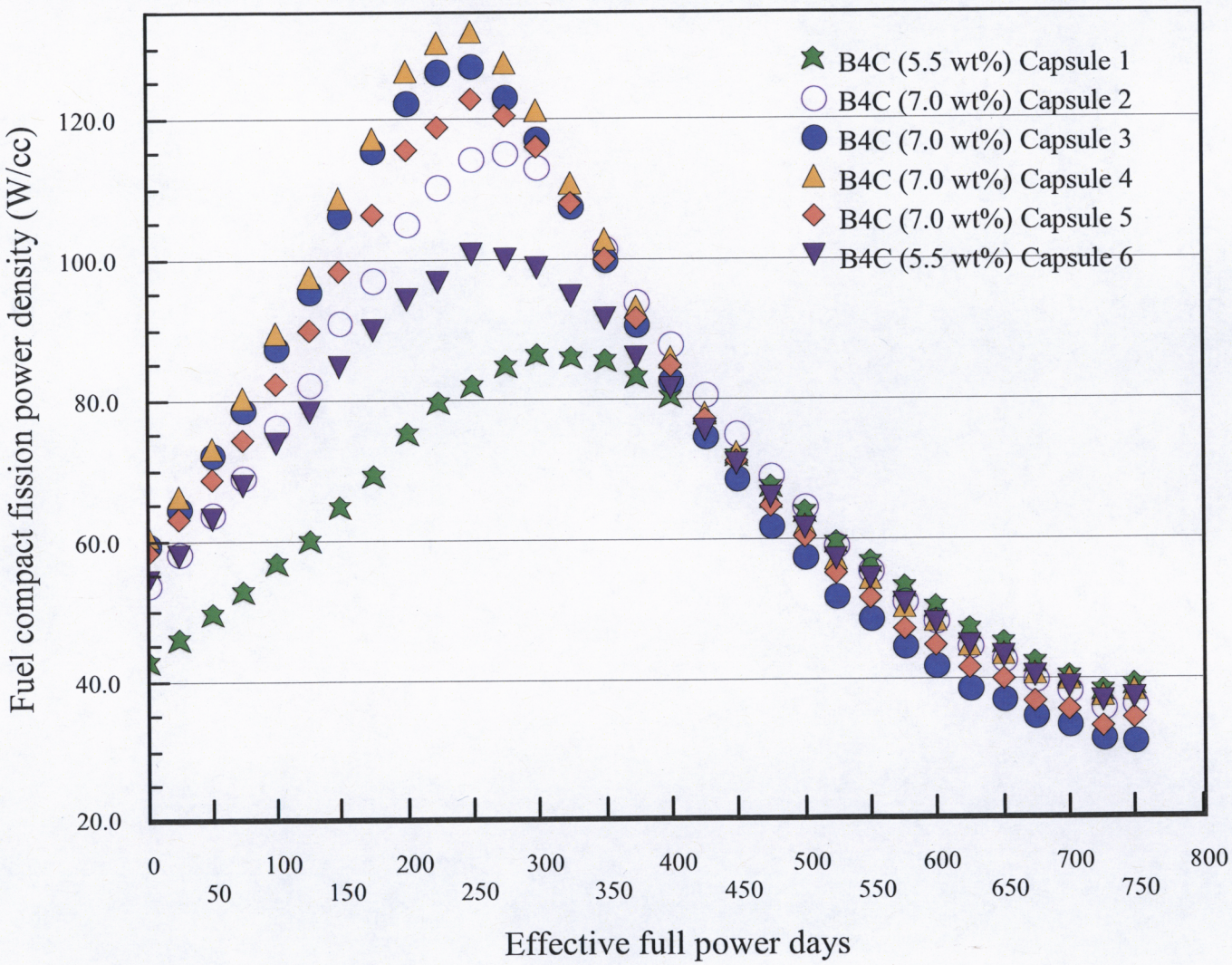


Figure 12. AGR-1 Fuel Compact Stack 2 Fission Power Density vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

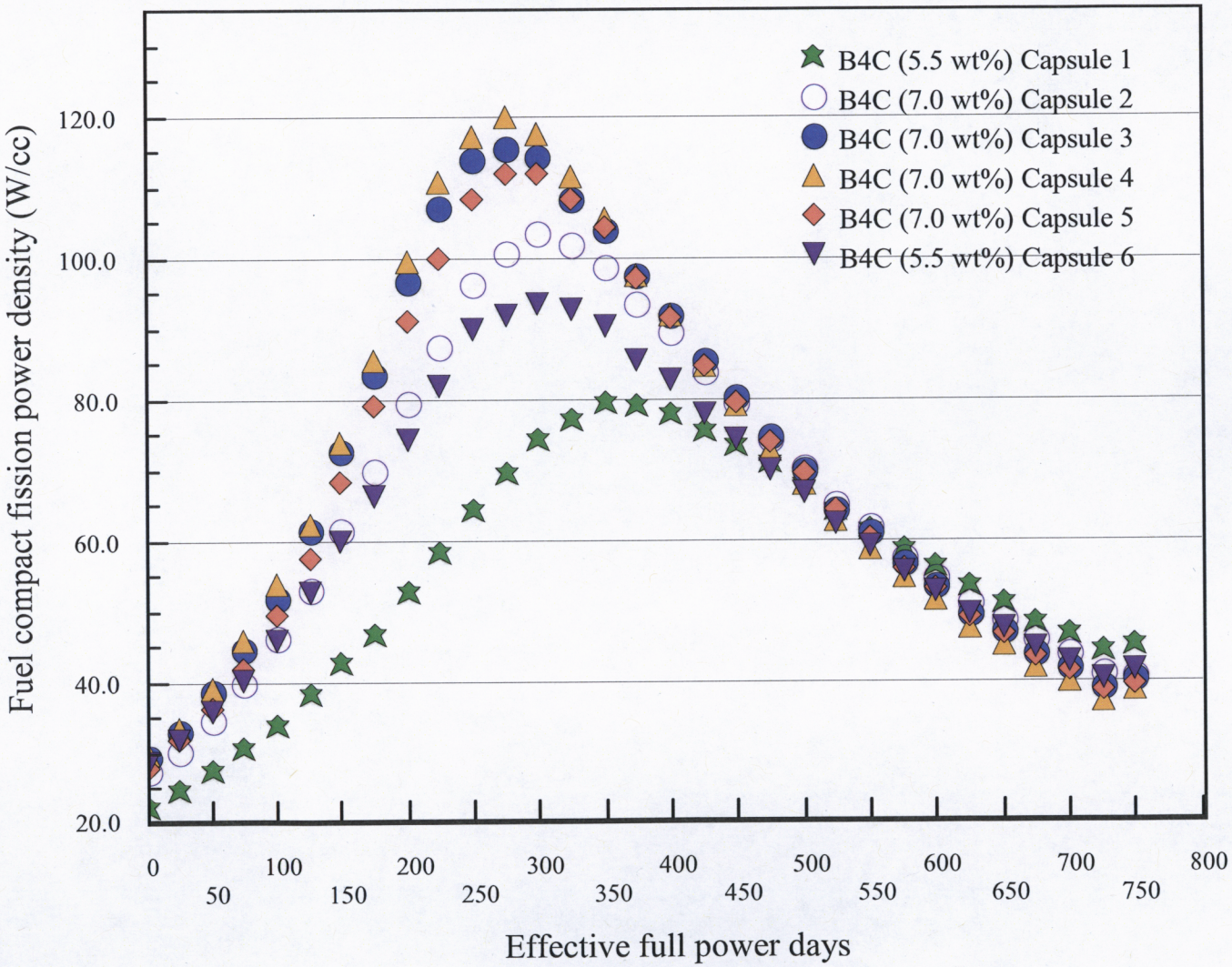


Figure 13. AGR-1 Fuel Compact Stack 3 Fission Power Density vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

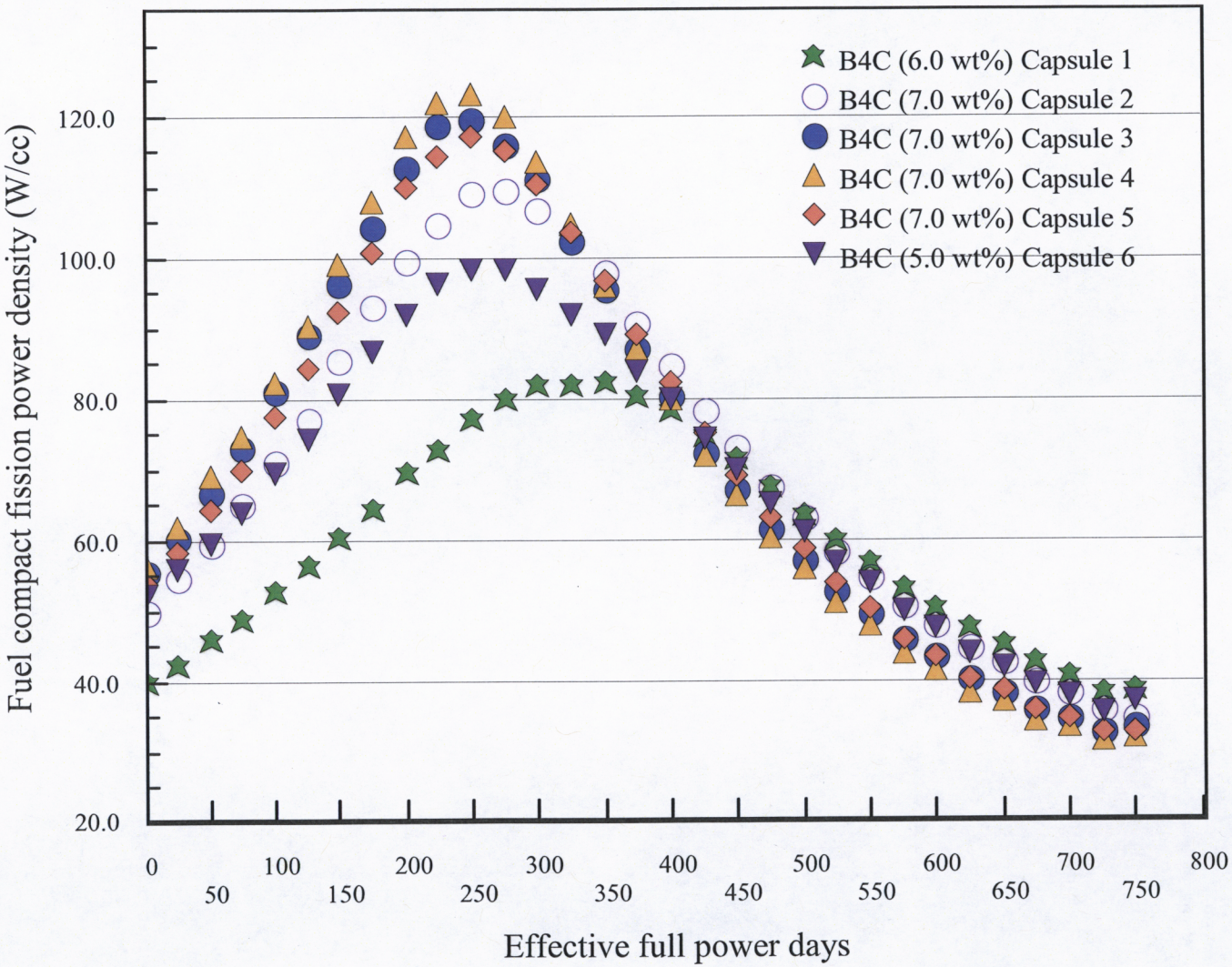


Figure 14. AGR-1 Fuel Compact Stack 1 Burnup vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

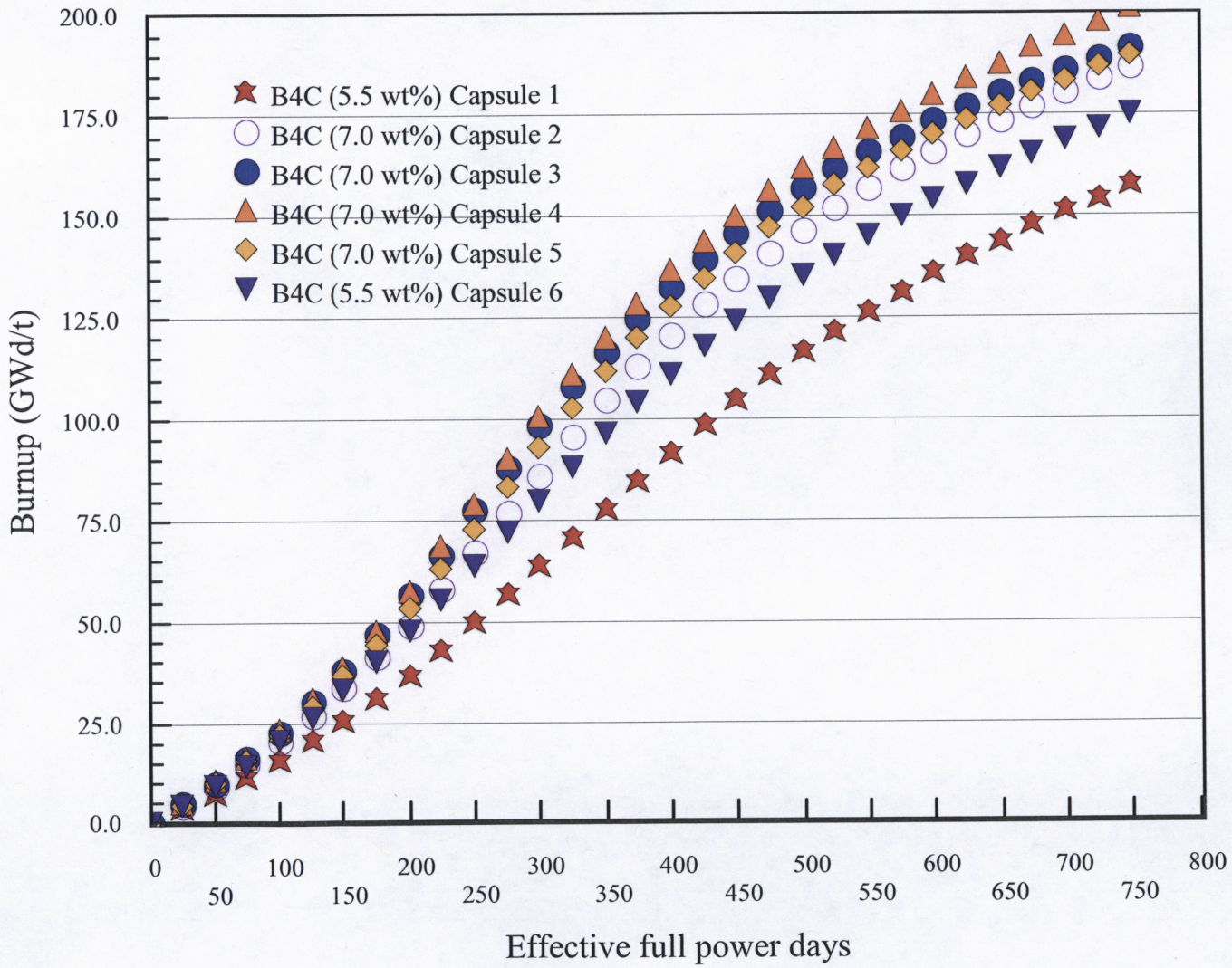


Figure 15. AGR-1 Fuel Compact Stack 2 Burnup vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

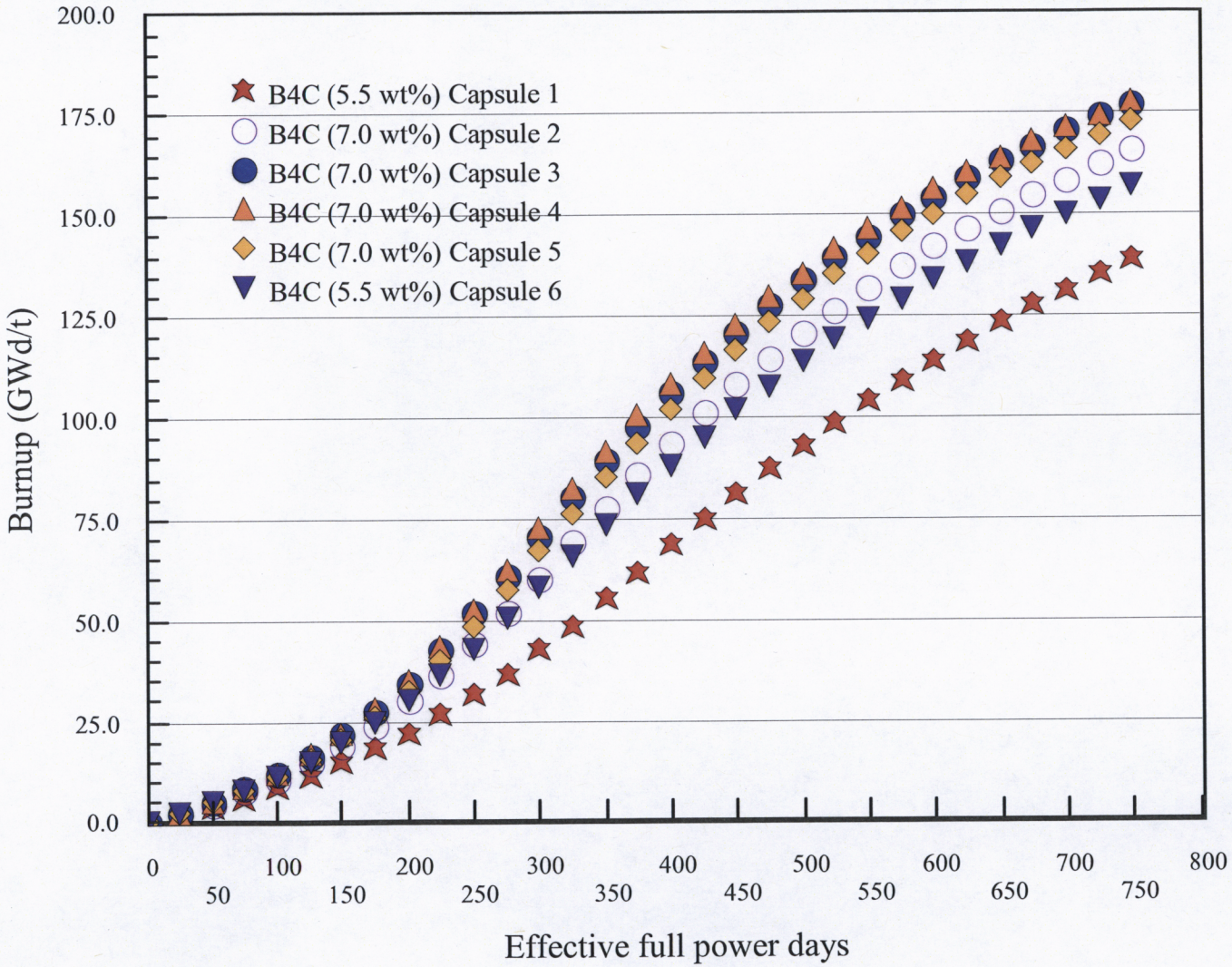


Figure 16. AGR-1 Fuel Compact Stack 3 Burnup vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

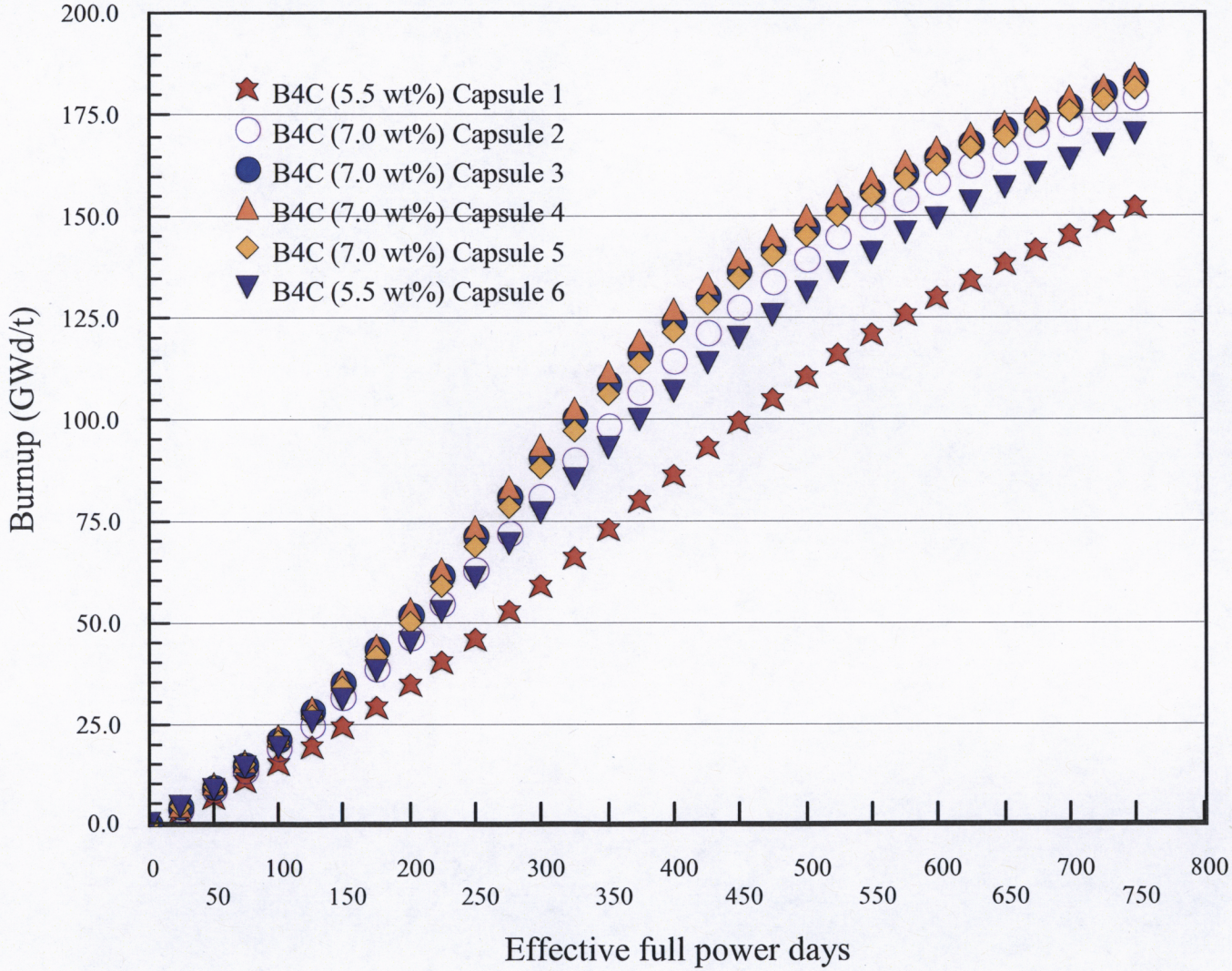


Figure 17. AGR-1 Fuel Compact Stack 1 Fast Fluence (> 0.18MeV) vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

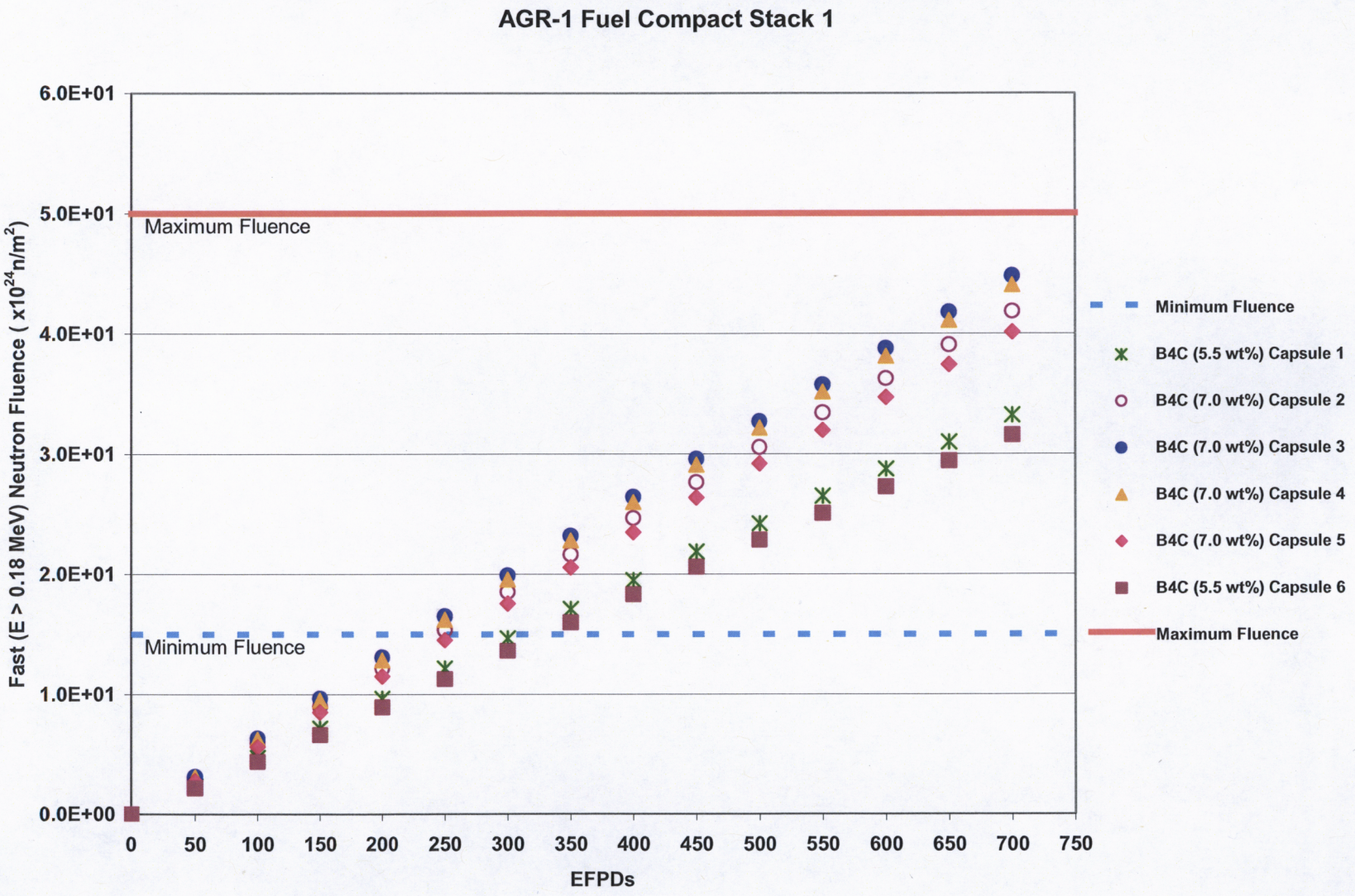


Figure 18. AGR-1 Fuel Compact Stack 2 Fast Fluence (> 0.18MeV) vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

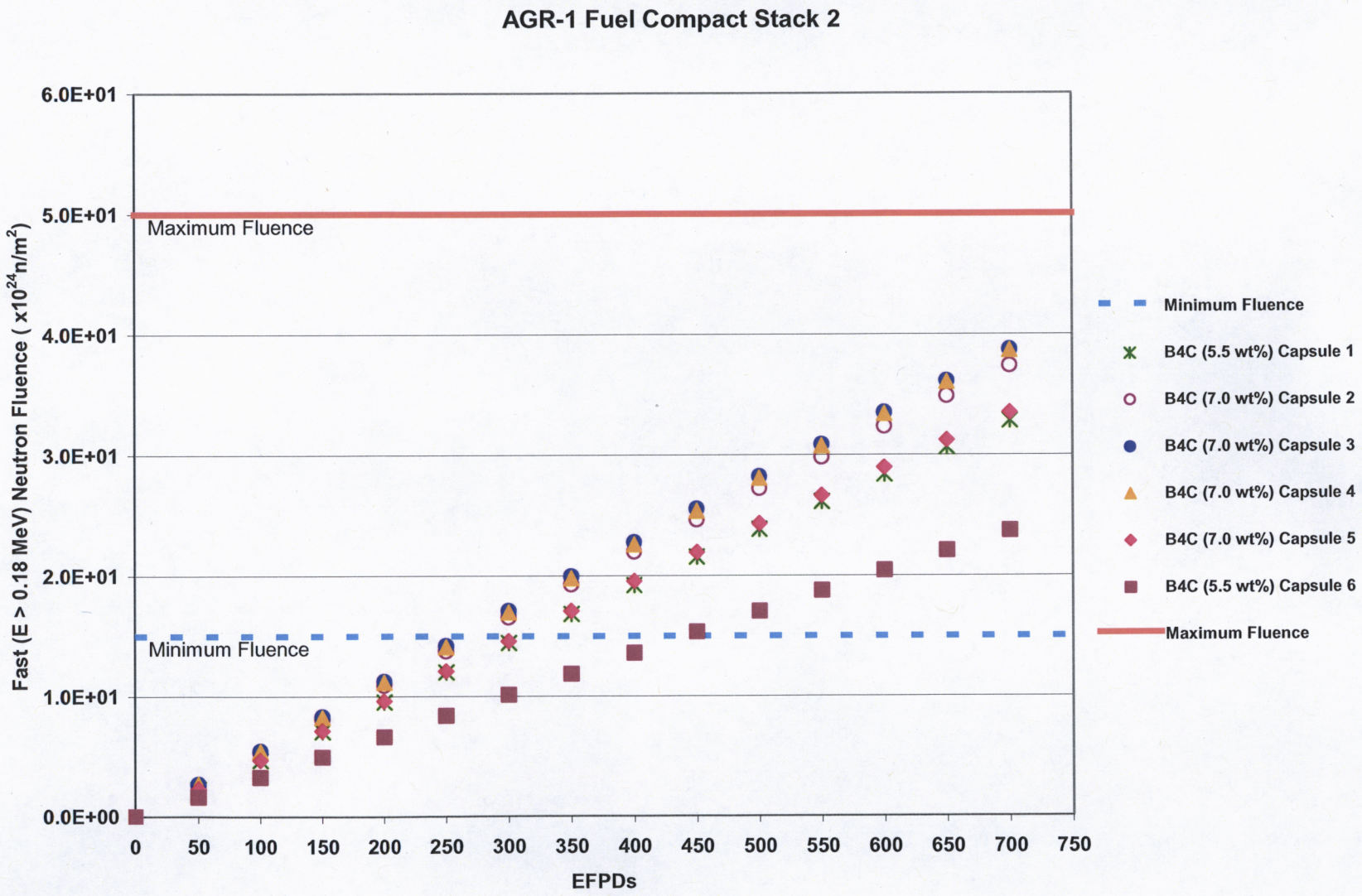


Figure 19. AGR-1 Fuel Compact Stack 3 Fast Fluence (> 0.18MeV) vs. EFPD (19.7% U-235 enrichment and nominal MOC conditions)

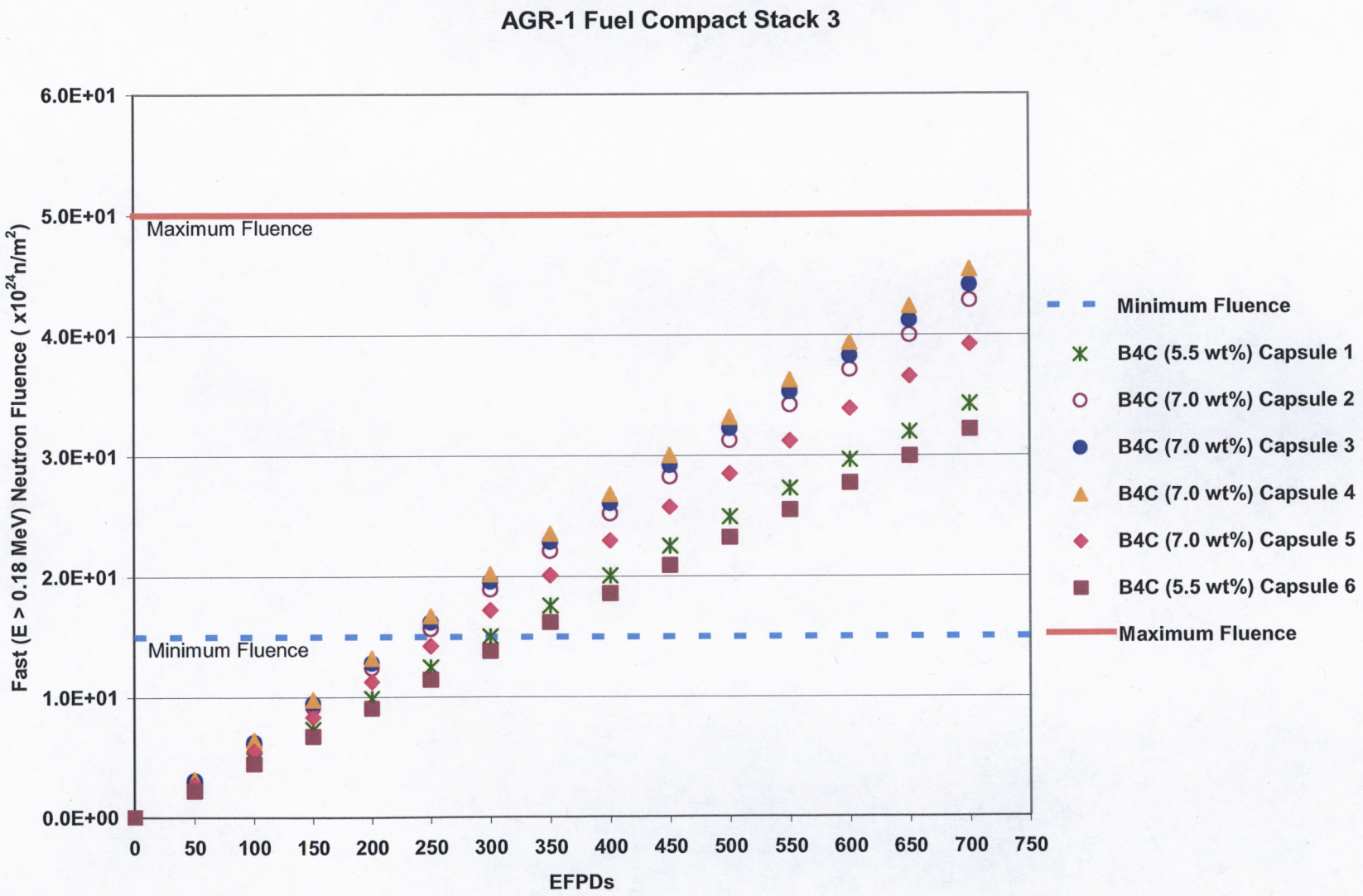


Table 36. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (0-75 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	0 EFPDs		25 EFPDs		50 EFPDs		75 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-1									
Node-1	16.25	57.04	0.00	59.00	0.49	61.03	1.01	63.40	1.54
Node-2	15.75	45.11	0.00	47.21	0.39	50.26	0.80	53.15	1.24
Node-3	15.25	44.71	0.00	47.23	0.39	49.70	0.80	52.76	1.23
Node-4	14.75	44.19	0.00	46.64	0.38	49.52	0.79	52.55	1.22
Node-5	14.50	42.59	0.00	46.02	0.37	49.45	0.77	52.72	1.20
Node-6	14.25	42.28	0.00	44.85	0.37	48.61	0.76	52.20	1.18
Node-7	13.75	47.28	0.00	50.30	0.41	54.18	0.85	57.14	1.32
Node-8	13.25	67.17	0.00	69.44	0.58	72.17	1.19	73.74	1.81
Node-9	10.25	72.20	0.00	75.36	0.63	79.82	1.28	83.81	1.97
Node-10	9.75	54.96	0.00	58.66	0.48	64.09	0.99	70.01	1.54
Node-11	9.25	54.81	0.00	59.05	0.48	63.66	0.99	69.07	1.54
Node-12	8.75	54.33	0.00	59.04	0.47	64.66	0.98	69.99	1.54
Node-13	8.50	53.74	0.00	58.29	0.47	64.07	0.97	68.89	1.53
Node-14	8.25	57.30	0.00	61.54	0.50	67.37	1.03	73.02	1.62
Node-15	7.75	61.85	0.00	66.26	0.54	71.82	1.11	78.06	1.74
Node-16	7.25	84.21	0.00	88.89	0.73	93.86	1.50	98.94	2.32
Node-17	4.25	85.04	0.00	89.83	0.74	95.30	1.52	100.79	2.34
Node-18	3.75	63.61	0.00	69.12	0.55	76.24	1.15	83.85	1.81
Node-19	3.25	61.31	0.00	66.31	0.53	73.64	1.11	79.57	1.75
Node-20	2.75	61.20	0.00	66.88	0.53	73.63	1.11	81.09	1.75
Node-21	2.50	59.54	0.00	64.74	0.52	72.11	1.08	78.78	1.70
Node-22	2.25	62.39	0.00	68.64	0.54	75.88	1.14	81.92	1.80
Node-23	1.75	66.41	0.00	72.84	0.58	80.35	1.21	88.26	1.91
Node-24	1.25	88.17	0.00	92.38	0.77	97.63	1.57	102.42	2.41
Node-25	-1.75	87.71	0.00	92.74	0.76	97.94	1.57	104.83	2.42
Node-26	-2.25	68.41	0.00	74.54	0.59	82.49	1.24	90.56	1.96
Node-27	-2.75	64.13	0.00	69.54	0.56	76.13	1.16	82.47	1.82
Node-28	-3.25	61.74	0.00	66.92	0.54	73.32	1.12	80.91	1.75
Node-29	-3.50	60.74	0.00	66.12	0.53	72.93	1.10	80.36	1.73
Node-30	-3.75	62.82	0.00	68.03	0.55	74.90	1.14	82.67	1.79
Node-31	-4.25	66.90	0.00	73.10	0.58	81.60	1.21	89.66	1.92
Node-32	-4.75	89.56	0.00	94.29	0.78	99.91	1.60	104.77	2.46
Node-33	-7.75	87.05	0.00	90.23	0.76	96.52	1.54	100.82	2.38
Node-34	-8.25	64.59	0.00	71.23	0.56	77.34	1.18	85.06	1.85
Node-35	-8.75	62.75	0.00	68.29	0.54	74.47	1.14	81.87	1.78
Node-36	-9.25	60.39	0.00	66.16	0.52	72.11	1.10	77.80	1.72
Node-37	-9.50	58.10	0.00	63.22	0.50	68.59	1.05	74.26	1.65
Node-38	-9.75	59.64	0.00	64.81	0.52	70.87	1.08	77.44	1.69
Node-39	-10.25	62.99	0.00	68.75	0.55	75.01	1.14	82.11	1.79
Node-40	-10.75	78.86	0.00	83.48	0.68	89.01	1.41	93.85	2.18
Node-41	-13.75	82.92	0.00	87.08	0.72	91.77	1.48	95.51	2.27
Node-42	-14.25	63.12	0.00	67.33	0.55	72.63	1.13	78.72	1.76
Node-43	-14.75	58.66	0.00	62.50	0.51	67.76	1.05	72.36	1.64
Node-44	-15.25	55.82	0.00	59.16	0.48	64.39	1.00	69.05	1.56
Node-45	-15.50	54.30	0.00	57.91	0.47	63.18	0.97	67.87	1.52
Node-46	-15.75	54.32	0.00	57.92	0.47	62.34	0.97	67.02	1.51
Node-47	-16.25	55.27	0.00	58.82	0.48	62.64	0.99	66.63	1.53
Node-48	-16.75	68.55	0.00	71.30	0.59	74.74	1.21	77.18	1.86

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 36. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (0-75 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	0 EFPDs		25 EFPDs		50 EFPDs		75 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-3									
Node-49	16.25	53.56	0.00	55.86	0.46	58.78	0.95	60.80	1.46
Node-50	15.75	44.91	0.00	47.40	0.39	50.05	0.80	52.72	1.24
Node-51	15.25	43.47	0.00	45.95	0.38	48.97	0.78	52.09	1.20
Node-52	14.75	42.78	0.00	45.31	0.37	48.48	0.76	51.16	1.19
Node-53	14.50	39.65	0.00	42.42	0.34	45.88	0.71	48.51	1.11
Node-54	14.25	40.26	0.00	43.33	0.35	46.84	0.73	50.51	1.13
Node-55	13.75	44.96	0.00	48.38	0.39	51.58	0.81	55.08	1.26
Node-56	13.25	63.47	0.00	66.16	0.55	69.09	1.12	71.41	1.72
Node-57	10.25	68.43	0.00	71.13	0.59	74.95	1.21	78.65	1.86
Node-58	9.75	53.47	0.00	57.89	0.46	63.09	0.97	68.30	1.51
Node-59	9.25	50.62	0.00	54.39	0.44	59.14	0.91	64.72	1.42
Node-60	8.75	50.18	0.00	55.10	0.44	60.10	0.91	65.30	1.44
Node-61	8.50	49.89	0.00	54.46	0.43	59.44	0.91	65.19	1.42
Node-62	8.25	53.25	0.00	57.74	0.46	62.53	0.96	68.06	1.51
Node-63	7.75	56.11	0.00	60.97	0.49	66.93	1.02	73.79	1.60
Node-64	7.25	75.84	0.00	79.95	0.66	85.44	1.35	90.15	2.09
Node-65	4.25	80.87	0.00	84.95	0.70	89.87	1.44	94.88	2.22
Node-66	3.75	59.98	0.00	65.51	0.52	72.90	1.09	79.87	1.72
Node-67	3.25	55.78	0.00	60.89	0.48	68.62	1.01	76.11	1.61
Node-68	2.75	55.14	0.00	60.12	0.48	65.94	1.00	72.49	1.57
Node-69	2.50	55.57	0.00	60.45	0.48	66.85	1.01	73.25	1.59
Node-70	2.25	57.10	0.00	62.55	0.50	68.23	1.04	74.88	1.63
Node-71	1.75	62.11	0.00	66.95	0.54	74.05	1.12	81.46	1.76
Node-72	1.25	83.39	0.00	87.20	0.72	93.46	1.48	98.46	2.29
Node-73	-1.75	83.21	0.00	88.02	0.72	94.98	1.49	100.52	2.31
Node-74	-2.25	60.20	0.00	66.37	0.52	74.90	1.10	82.79	1.75
Node-75	-2.75	59.71	0.00	64.96	0.52	71.45	1.08	77.57	1.70
Node-76	-3.25	56.48	0.00	61.93	0.49	68.20	1.03	75.28	1.62
Node-77	-3.50	56.26	0.00	61.80	0.49	68.96	1.02	74.59	1.62
Node-78	-3.75	59.71	0.00	64.75	0.52	72.02	1.08	78.26	1.71
Node-79	-4.25	62.50	0.00	68.77	0.54	76.45	1.14	84.26	1.80
Node-80	-4.75	82.30	0.00	86.18	0.71	92.38	1.46	97.69	2.26
Node-81	-7.75	80.66	0.00	86.67	0.70	93.01	1.45	98.62	2.26
Node-82	-8.25	61.26	0.00	67.28	0.53	74.52	1.12	82.50	1.76
Node-83	-8.75	57.53	0.00	62.67	0.50	68.33	1.04	74.84	1.64
Node-84	-9.25	54.22	0.00	58.83	0.47	64.77	0.98	70.80	1.54
Node-85	-9.50	53.71	0.00	58.07	0.47	64.42	0.97	69.79	1.53
Node-86	-9.75	53.93	0.00	58.55	0.47	63.64	0.98	69.48	1.53
Node-87	-10.25	55.70	0.00	60.86	0.48	66.97	1.01	73.33	1.59
Node-88	-10.75	75.70	0.00	80.11	0.66	84.49	1.35	89.70	2.09
Node-89	-13.75	77.71	0.00	81.64	0.67	85.93	1.38	89.50	2.13
Node-90	-14.25	58.71	0.00	63.98	0.51	69.55	1.06	75.61	1.67
Node-91	-14.75	54.67	0.00	58.91	0.47	63.81	0.99	68.35	1.54
Node-92	-15.25	52.88	0.00	56.72	0.46	61.00	0.95	65.98	1.48
Node-93	-15.50	52.45	0.00	55.91	0.46	59.55	0.94	63.79	1.46
Node-94	-15.75	50.73	0.00	53.84	0.44	57.87	0.91	62.08	1.41
Node-95	-16.25	53.10	0.00	56.29	0.46	60.85	0.95	64.50	1.48
Node-96	-16.75	67.49	0.00	69.61	0.59	72.21	1.19	74.54	1.82

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 36. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (0-75 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	0 EFPDs		25 EFPDs		50 EFPDs		75 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-2									
Node-97	16.25	35.39	0.00	37.64	0.31	40.34	0.63	42.49	0.98
Node-98	15.75	25.10	0.00	27.30	0.22	30.15	0.45	33.09	0.72
Node-99	15.25	23.50	0.00	25.50	0.20	28.08	0.43	30.36	0.67
Node-100	14.75	23.71	0.00	25.55	0.21	28.20	0.43	30.76	0.67
Node-101	14.50	22.15	0.00	24.65	0.19	27.58	0.41	30.80	0.65
Node-102	14.25	21.94	0.00	24.37	0.19	26.99	0.40	30.27	0.64
Node-103	13.75	24.98	0.00	26.97	0.22	29.95	0.45	32.96	0.71
Node-104	13.25	37.86	0.00	39.75	0.33	43.04	0.67	45.35	1.05
Node-105	10.25	43.29	0.00	46.47	0.38	50.39	0.78	54.91	1.22
Node-106	9.75	28.81	0.00	32.33	0.25	35.73	0.53	40.54	0.84
Node-107	9.25	27.05	0.00	30.68	0.23	34.67	0.50	39.06	0.80
Node-108	8.75	26.94	0.00	30.21	0.23	34.53	0.50	39.51	0.80
Node-109	8.50	27.25	0.00	30.22	0.24	34.70	0.50	39.81	0.80
Node-110	8.25	27.51	0.00	30.72	0.24	34.77	0.51	40.31	0.81
Node-111	7.75	29.91	0.00	33.40	0.26	38.03	0.55	43.71	0.88
Node-112	7.25	48.57	0.00	52.70	0.42	58.16	0.88	63.94	1.38
Node-113	4.25	52.05	0.00	56.05	0.45	61.66	0.94	67.80	1.47
Node-114	3.75	32.64	0.00	37.40	0.28	43.61	0.61	50.21	0.99
Node-115	3.25	30.64	0.00	35.00	0.27	40.40	0.57	46.83	0.92
Node-116	2.75	30.68	0.00	34.70	0.27	40.49	0.57	46.25	0.92
Node-117	2.50	29.43	0.00	33.18	0.26	38.70	0.54	44.75	0.88
Node-118	2.25	30.69	0.00	34.43	0.27	40.20	0.57	45.96	0.91
Node-119	1.75	34.12	0.00	38.73	0.30	45.10	0.63	53.07	1.02
Node-120	1.25	52.54	0.00	56.97	0.46	62.77	0.95	68.53	1.49
Node-121	-1.75	53.32	0.00	57.99	0.46	63.52	0.97	69.72	1.52
Node-122	-2.25	34.49	0.00	38.99	0.30	45.12	0.64	51.44	1.03
Node-123	-2.75	31.63	0.00	35.77	0.27	40.88	0.58	47.27	0.94
Node-124	-3.25	30.42	0.00	34.18	0.26	39.50	0.56	46.12	0.90
Node-125	-3.50	29.68	0.00	33.31	0.26	38.90	0.55	45.80	0.88
Node-126	-3.75	30.41	0.00	34.37	0.26	39.70	0.56	46.57	0.91
Node-127	-4.25	34.57	0.00	39.42	0.30	45.93	0.64	53.28	1.04
Node-128	-4.75	53.05	0.00	57.44	0.46	63.35	0.96	69.77	1.51
Node-129	-7.75	52.30	0.00	57.15	0.45	62.68	0.95	68.42	1.49
Node-130	-8.25	34.75	0.00	39.17	0.30	45.34	0.64	52.18	1.03
Node-131	-8.75	30.54	0.00	34.34	0.26	39.56	0.56	46.32	0.91
Node-132	-9.25	29.72	0.00	33.68	0.26	37.98	0.55	43.98	0.88
Node-133	-9.50	27.96	0.00	31.78	0.24	36.11	0.52	41.82	0.83
Node-134	-9.75	28.65	0.00	31.72	0.25	36.36	0.52	41.48	0.84
Node-135	-10.25	31.59	0.00	35.49	0.27	41.06	0.58	46.97	0.94
Node-136	-10.75	48.90	0.00	51.87	0.42	57.20	0.87	61.98	1.37
Node-137	-13.75	53.75	0.00	57.16	0.47	62.00	0.96	66.85	1.50
Node-138	-14.25	34.79	0.00	39.03	0.30	43.76	0.64	49.07	1.02
Node-139	-14.75	31.96	0.00	35.40	0.28	39.24	0.58	44.01	0.93
Node-140	-15.25	28.89	0.00	32.18	0.25	36.38	0.53	41.84	0.85
Node-141	-15.50	28.51	0.00	31.68	0.25	35.85	0.52	40.40	0.83
Node-142	-15.75	29.15	0.00	32.26	0.25	35.95	0.53	40.26	0.84
Node-143	-16.25	31.43	0.00	34.63	0.27	39.35	0.57	43.73	0.91
Node-144	-16.75	42.77	0.00	45.55	0.37	48.83	0.77	51.56	1.19

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 37. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (100-175 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	100 EFPDs		125 EFPDs		150 EFPDs		175 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-1									
Node-1	16.25	65.48	2.09	67.28	2.65	69.74	3.24	70.77	3.84
Node-2	15.75	57.02	1.70	59.76	2.19	63.04	2.71	65.31	3.26
Node-3	15.25	56.11	1.69	59.31	2.17	63.41	2.69	66.30	3.24
Node-4	14.75	56.24	1.67	58.91	2.16	63.24	2.67	66.18	3.22
Node-5	14.50	56.62	1.66	59.99	2.15	64.83	2.67	69.13	3.23
Node-6	14.25	56.04	1.63	59.71	2.12	65.48	2.64	70.25	3.20
Node-7	13.75	61.40	1.81	65.50	2.35	70.69	2.91	74.42	3.53
Node-8	13.25	76.71	2.45	78.43	3.12	81.72	3.80	83.56	4.51
Node-9	10.25	88.03	2.70	92.00	3.46	96.69	4.26	100.45	5.10
Node-10	9.75	76.05	2.15	82.60	2.81	89.89	3.53	95.27	4.31
Node-11	9.25	75.64	2.14	81.85	2.80	89.09	3.51	96.03	4.28
Node-12	8.75	77.26	2.15	83.26	2.82	90.96	3.55	97.13	4.33
Node-13	8.50	76.46	2.13	82.26	2.79	91.05	3.50	97.26	4.29
Node-14	8.25	79.99	2.25	85.74	2.94	94.14	3.69	100.46	4.50
Node-15	7.75	86.09	2.41	92.62	3.16	101.03	3.96	107.80	4.84
Node-16	7.25	105.78	3.18	110.24	4.09	114.54	5.05	117.29	6.04
Node-17	4.25	107.64	3.22	112.84	4.15	118.60	5.13	122.23	6.16
Node-18	3.75	93.82	2.54	103.32	3.36	112.15	4.25	119.31	5.23
Node-19	3.25	87.95	2.44	95.62	3.20	104.13	4.03	112.58	4.93
Node-20	2.75	89.02	2.45	96.93	3.23	105.29	4.07	115.54	4.98
Node-21	2.50	87.69	2.39	95.34	3.15	106.43	3.98	115.44	4.90
Node-22	2.25	90.93	2.51	98.93	3.30	107.80	4.15	115.12	5.09
Node-23	1.75	96.78	2.67	104.92	3.51	113.83	4.42	119.68	5.41
Node-24	1.25	109.32	3.30	113.89	4.25	121.13	5.24	124.90	6.29
Node-25	-1.75	111.69	3.33	116.79	4.29	123.77	5.31	127.45	6.38
Node-26	-2.25	99.11	2.74	106.67	3.60	115.94	4.53	122.42	5.53
Node-27	-2.75	91.41	2.54	100.52	3.33	108.73	4.20	116.54	5.15
Node-28	-3.25	89.26	2.46	97.20	3.23	106.75	4.07	115.65	5.00
Node-29	-3.50	89.70	2.43	97.68	3.21	108.68	4.06	117.13	5.00
Node-30	-3.75	90.94	2.50	100.25	3.29	110.67	4.16	118.95	5.12
Node-31	-4.25	98.59	2.70	108.41	3.56	115.06	4.50	122.77	5.50
Node-32	-4.75	112.38	3.37	116.89	4.35	121.98	5.36	124.33	6.42
Node-33	-7.75	107.87	3.25	112.85	4.19	118.53	5.17	120.86	6.20
Node-34	-8.25	93.26	2.59	101.44	3.40	111.11	4.28	118.10	5.24
Node-35	-8.75	88.88	2.49	95.62	3.27	103.57	4.09	110.62	4.99
Node-36	-9.25	85.56	2.40	92.26	3.14	100.26	3.94	108.25	4.81
Node-37	-9.50	82.26	2.29	89.87	3.01	98.49	3.79	106.35	4.64
Node-38	-9.75	84.96	2.37	94.00	3.10	101.77	3.92	108.84	4.80
Node-39	-10.25	90.25	2.51	97.06	3.29	104.75	4.13	110.55	5.04
Node-40	-10.75	99.65	3.00	104.91	3.86	110.99	4.77	114.99	5.73
Node-41	-13.75	100.38	3.10	103.67	3.97	107.10	4.87	109.79	5.80
Node-42	-14.25	85.22	2.45	90.58	3.18	97.00	3.97	101.97	4.81
Node-43	-14.75	79.42	2.27	85.37	2.96	93.50	3.70	98.07	4.51
Node-44	-15.25	75.37	2.16	80.31	2.81	86.83	3.51	91.81	4.26
Node-45	-15.50	74.08	2.11	78.47	2.75	84.72	3.43	89.81	4.17
Node-46	-15.75	71.93	2.10	76.43	2.72	82.39	3.38	87.16	4.10
Node-47	-16.25	71.86	2.11	76.55	2.74	81.59	3.40	86.43	4.11
Node-48	-16.75	80.40	2.53	82.96	3.23	86.17	3.95	89.08	4.70

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 37. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (100-175 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	100 EFPDs		125 EFPDs		150 EFPDs		175 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-3									
Node-49	16.25	63.57	1.99	65.05	2.54	67.18	3.10	69.03	3.69
Node-50	15.75	56.39	1.69	59.16	2.18	63.07	2.70	65.90	3.24
Node-51	15.25	55.74	1.65	58.54	2.14	62.96	2.64	65.99	3.19
Node-52	14.75	54.72	1.63	57.64	2.10	60.78	2.60	63.85	3.13
Node-53	14.50	52.52	1.53	56.40	1.99	60.38	2.48	64.26	3.00
Node-54	14.25	54.98	1.57	59.60	2.05	64.49	2.56	68.50	3.12
Node-55	13.75	59.52	1.74	63.59	2.25	68.53	2.80	72.44	3.40
Node-56	13.25	74.04	2.34	76.33	2.99	79.11	3.65	80.86	4.34
Node-57	10.25	83.04	2.54	86.63	3.26	91.24	4.02	94.26	4.81
Node-58	9.75	75.46	2.11	81.66	2.76	88.27	3.47	93.51	4.24
Node-59	9.25	71.18	1.99	77.42	2.60	84.39	3.28	92.20	4.01
Node-60	8.75	70.85	2.00	76.65	2.62	83.84	3.28	90.96	4.01
Node-61	8.50	71.20	1.99	77.05	2.61	85.43	3.27	92.96	4.02
Node-62	8.25	73.89	2.10	80.72	2.74	88.73	3.44	94.97	4.21
Node-63	7.75	80.06	2.24	85.77	2.93	92.34	3.68	98.43	4.48
Node-64	7.25	95.87	2.88	100.53	3.71	105.22	4.58	108.10	5.49
Node-65	4.25	100.32	3.04	106.31	3.91	112.59	4.84	115.95	5.81
Node-66	3.75	88.80	2.41	96.94	3.19	105.06	4.03	112.96	4.94
Node-67	3.25	84.85	2.27	93.11	3.00	101.75	3.81	109.03	4.70
Node-68	2.75	80.67	2.20	88.81	2.90	97.80	3.67	105.06	4.52
Node-69	2.50	81.09	2.22	89.27	2.93	96.32	3.70	104.47	4.54
Node-70	2.25	82.68	2.28	90.59	3.00	98.31	3.78	106.09	4.64
Node-71	1.75	91.13	2.47	99.39	3.26	107.22	4.12	114.14	5.05
Node-72	1.25	104.46	3.15	110.23	4.05	116.17	5.01	118.59	6.02
Node-73	-1.75	106.10	3.18	112.03	4.10	117.84	5.08	120.54	6.10
Node-74	-2.25	91.48	2.47	99.96	3.26	109.54	4.13	116.42	5.08
Node-75	-2.75	85.84	2.38	94.14	3.12	103.16	3.94	109.83	4.83
Node-76	-3.25	84.57	2.27	93.48	3.01	102.54	3.82	110.60	4.71
Node-77	-3.50	82.34	2.27	90.36	2.98	99.22	3.77	107.91	4.63
Node-78	-3.75	86.33	2.38	94.69	3.13	103.20	3.96	110.99	4.85
Node-79	-4.25	92.55	2.53	101.22	3.34	109.28	4.22	116.88	5.16
Node-80	-4.75	104.64	3.11	109.96	4.02	116.21	4.97	119.17	5.98
Node-81	-7.75	105.36	3.12	110.71	4.03	116.65	4.99	121.17	6.00
Node-82	-8.25	92.14	2.48	99.71	3.28	108.48	4.14	114.19	5.08
Node-83	-8.75	82.57	2.29	90.26	3.00	98.85	3.79	106.65	4.64
Node-84	-9.25	78.74	2.16	86.16	2.84	94.06	3.59	103.05	4.40
Node-85	-9.50	77.50	2.13	84.28	2.81	92.46	3.54	100.66	4.34
Node-86	-9.75	77.35	2.13	84.02	2.80	92.08	3.53	99.36	4.33
Node-87	-10.25	81.37	2.23	88.93	2.94	97.69	3.71	105.00	4.55
Node-88	-10.75	95.95	2.86	101.24	3.70	106.80	4.57	110.36	5.50
Node-89	-13.75	94.08	2.91	98.15	3.72	101.37	4.57	103.42	5.45
Node-90	-14.25	82.65	2.32	88.75	3.04	94.59	3.81	99.37	4.63
Node-91	-14.75	74.13	2.13	78.84	2.78	85.29	3.46	90.62	4.20
Node-92	-15.25	70.70	2.05	75.47	2.67	81.25	3.32	86.60	4.03
Node-93	-15.50	69.46	2.01	74.32	2.61	80.57	3.26	86.66	3.96
Node-94	-15.75	67.25	1.95	72.49	2.53	77.93	3.16	83.35	3.84
Node-95	-16.25	69.94	2.04	74.85	2.64	80.91	3.29	84.36	4.00
Node-96	-16.75	77.55	2.46	80.76	3.14	84.50	3.84	86.19	4.57

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 37. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (100-175 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	100 EFPDs		125 EFPDs		150 EFPDs		175 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-2									
Node-97	16.25	45.35	1.35	48.31	1.75	51.54	2.17	53.78	2.61
Node-98	15.75	36.46	1.00	39.24	1.32	43.14	1.66	47.05	2.03
Node-99	15.25	34.23	0.93	37.12	1.23	41.30	1.55	45.35	1.91
Node-100	14.75	34.02	0.94	37.48	1.23	42.04	1.56	46.75	1.92
Node-101	14.50	33.98	0.91	38.10	1.21	42.50	1.54	46.69	1.91
Node-102	14.25	33.64	0.90	38.53	1.19	42.78	1.53	48.40	1.90
Node-103	13.75	36.02	1.00	40.11	1.31	44.78	1.66	50.28	2.05
Node-104	13.25	48.84	1.44	51.90	1.86	56.23	2.31	60.04	2.80
Node-105	10.25	60.44	1.69	65.45	2.22	71.67	2.79	77.66	3.41
Node-106	9.75	46.87	1.19	52.27	1.60	59.80	2.05	67.76	2.57
Node-107	9.25	44.49	1.14	50.76	1.53	58.25	1.97	66.27	2.47
Node-108	8.75	45.38	1.14	51.88	1.53	59.38	1.98	67.91	2.50
Node-109	8.50	46.11	1.15	53.17	1.55	61.42	2.01	70.06	2.54
Node-110	8.25	47.91	1.16	54.36	1.57	63.64	2.04	72.57	2.60
Node-111	7.75	51.57	1.26	58.54	1.71	67.32	2.21	76.09	2.80
Node-112	7.25	70.41	1.94	76.68	2.55	84.91	3.21	91.09	3.95
Node-113	4.25	76.10	2.06	82.81	2.72	90.07	3.44	96.98	4.22
Node-114	3.75	59.85	1.42	69.05	1.94	79.80	2.54	89.62	3.23
Node-115	3.25	54.00	1.33	63.28	1.80	73.40	2.34	84.95	2.98
Node-116	2.75	53.14	1.32	61.82	1.78	72.51	2.32	82.93	2.95
Node-117	2.50	51.96	1.27	61.66	1.72	72.69	2.25	83.55	2.88
Node-118	2.25	54.33	1.31	63.65	1.78	75.38	2.34	86.18	2.99
Node-119	1.75	62.60	1.48	71.76	2.03	84.76	2.65	95.87	3.39
Node-120	1.25	75.89	2.09	84.38	2.75	94.97	3.48	102.42	4.30
Node-121	-1.75	77.39	2.12	84.34	2.79	93.23	3.53	100.77	4.33
Node-122	-2.25	61.01	1.48	70.42	2.01	81.12	2.62	91.72	3.32
Node-123	-2.75	55.52	1.35	65.18	1.83	76.32	2.40	86.27	3.06
Node-124	-3.25	53.13	1.30	62.64	1.76	73.32	2.31	84.73	2.94
Node-125	-3.50	53.66	1.28	62.11	1.75	74.06	2.29	85.67	2.93
Node-126	-3.75	56.52	1.31	66.46	1.80	79.40	2.38	90.86	3.07
Node-127	-4.25	62.69	1.50	72.91	2.05	85.25	2.68	96.40	3.42
Node-128	-4.75	78.49	2.11	86.37	2.80	94.89	3.54	103.06	4.37
Node-129	-7.75	75.85	2.09	83.08	2.75	92.23	3.47	99.20	4.27
Node-130	-8.25	60.71	1.49	70.07	2.01	81.15	2.62	90.92	3.33
Node-131	-8.75	53.27	1.31	62.34	1.77	73.27	2.31	84.33	2.95
Node-132	-9.25	51.86	1.26	59.81	1.71	70.34	2.23	81.91	2.84
Node-133	-9.50	49.51	1.19	57.45	1.62	68.28	2.12	79.09	2.72
Node-134	-9.75	48.96	1.20	57.74	1.62	68.14	2.13	79.91	2.72
Node-135	-10.25	54.51	1.35	63.28	1.82	72.74	2.37	83.29	3.00
Node-136	-10.75	69.07	1.91	75.29	2.51	83.09	3.16	89.92	3.88
Node-137	-13.75	72.14	2.08	78.66	2.71	84.54	3.39	89.51	4.12
Node-138	-14.25	56.44	1.45	63.81	1.94	72.09	2.49	80.15	3.12
Node-139	-14.75	51.40	1.31	57.98	1.75	66.56	2.26	74.29	2.83
Node-140	-15.25	47.89	1.21	54.31	1.62	62.57	2.10	70.48	2.64
Node-141	-15.50	45.91	1.18	52.73	1.58	59.92	2.04	66.37	2.56
Node-142	-15.75	46.33	1.19	52.32	1.60	58.40	2.05	64.30	2.56
Node-143	-16.25	49.25	1.29	55.06	1.72	60.50	2.20	66.41	2.72
Node-144	-16.75	56.53	1.64	61.01	2.13	65.84	2.66	70.17	3.23

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 38. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (200-275 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	200 EFPDs		225 EFPDs		250 EFPDs		275 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-1									
Node-1	16.25	72.88	4.46	74.38	5.09	75.73	5.74	75.45	6.39
Node-2	15.75	68.64	3.83	70.94	4.42	74.12	5.04	75.45	5.68
Node-3	15.25	70.12	3.81	72.78	4.42	75.82	5.05	77.91	5.71
Node-4	14.75	70.91	3.80	74.11	4.41	76.56	5.05	78.78	5.72
Node-5	14.50	75.05	3.83	79.36	4.48	82.10	5.17	84.57	5.88
Node-6	14.25	75.68	3.81	79.57	4.47	82.89	5.16	85.27	5.88
Node-7	13.75	79.41	4.17	83.00	4.86	86.89	5.58	89.12	6.34
Node-8	13.25	85.60	5.23	87.59	5.98	89.91	6.74	89.69	7.52
Node-9	10.25	103.93	5.97	105.38	6.88	106.03	7.79	103.70	8.71
Node-10	9.75	102.15	5.13	105.38	6.02	107.69	6.93	107.15	7.87
Node-11	9.25	101.95	5.11	106.25	6.00	110.70	6.92	110.89	7.88
Node-12	8.75	104.43	5.18	108.60	6.08	113.58	7.03	113.24	8.01
Node-13	8.50	104.96	5.14	110.18	6.05	114.37	7.00	115.16	8.00
Node-14	8.25	108.12	5.38	112.57	6.31	114.94	7.29	114.55	8.29
Node-15	7.75	113.09	5.78	115.50	6.76	117.31	7.76	114.84	8.78
Node-16	7.25	119.49	7.06	117.49	8.10	115.51	9.12	109.67	10.12
Node-17	4.25	123.60	7.22	122.29	8.30	119.03	9.36	111.81	10.39
Node-18	3.75	124.47	6.26	125.78	7.34	124.85	8.43	119.04	9.52
Node-19	3.25	119.81	5.91	122.40	6.95	123.40	8.01	119.41	9.08
Node-20	2.75	123.37	5.98	127.49	7.05	127.84	8.16	123.70	9.27
Node-21	2.50	122.48	5.90	126.58	6.96	127.65	8.06	123.11	9.17
Node-22	2.25	123.35	6.09	126.37	7.16	127.05	8.26	122.23	9.36
Node-23	1.75	125.13	6.45	125.41	7.53	124.30	8.62	118.30	9.70
Node-24	1.25	126.87	7.37	125.45	8.48	122.66	9.56	114.49	10.63
Node-25	-1.75	130.59	7.49	128.51	8.62	125.61	9.74	118.25	10.83
Node-26	-2.25	129.07	6.60	129.78	7.72	128.43	8.84	121.40	9.96
Node-27	-2.75	124.64	6.16	127.20	7.24	126.49	8.34	120.25	9.44
Node-28	-3.25	124.56	6.00	128.84	7.08	131.10	8.20	126.80	9.34
Node-29	**-3.50**	126.62	6.02	130.82	7.12	**132.39**	8.25	128.11	9.40
Node-30	-3.75	127.69	6.15	131.51	7.26	130.98	8.40	126.73	9.54
Node-31	-4.25	127.45	6.56	128.55	7.67	127.21	8.78	119.82	9.89
Node-32	-4.75	126.84	7.50	124.73	8.60	120.47	9.68	112.97	10.73
Node-33	-7.75	123.13	7.24	121.81	8.31	118.12	9.37	112.14	10.39
Node-34	-8.25	122.57	6.27	124.09	7.33	123.14	8.41	118.24	9.48
Node-35	-8.75	118.77	5.95	122.24	6.98	122.26	8.05	118.61	9.11
Node-36	-9.25	116.24	5.75	121.70	6.76	124.61	7.82	122.23	8.90
Node-37	-9.50	115.48	5.56	118.59	6.57	122.85	7.60	120.33	8.66
Node-38	-9.75	116.56	5.75	120.02	6.76	122.14	7.80	119.40	8.86
Node-39	-10.25	116.10	6.00	119.31	7.01	121.00	8.04	116.87	9.09
Node-40	-10.75	117.56	6.73	117.64	7.75	116.37	8.77	111.33	9.78
Node-41	-13.75	110.27	6.75	108.92	7.71	106.88	8.66	101.00	9.58
Node-42	-14.25	105.75	5.70	106.78	6.62	106.23	7.54	102.30	8.46
Node-43	-14.75	103.14	5.36	105.59	6.26	107.09	7.17	105.17	8.10
Node-44	-15.25	97.56	5.06	99.92	5.90	102.71	6.77	101.80	7.66
Node-45	-15.50	94.21	4.95	96.80	5.77	100.59	6.61	99.83	7.48
Node-46	-15.75	90.77	4.86	94.29	5.64	97.75	6.46	97.09	7.31
Node-47	-16.25	90.10	4.86	93.93	5.64	95.11	6.45	93.96	7.28
Node-48	-16.75	91.25	5.47	93.65	6.26	93.92	7.08	91.40	7.89

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 38. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (200-275 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	200 EFPDs		225 EFPDs		250 EFPDs		275 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-3									
Node-49	16.25	71.37	4.29	72.71	4.90	73.15	5.54	72.91	6.17
Node-50	15.75	69.46	3.81	72.49	4.42	74.56	5.05	75.22	5.69
Node-51	15.25	69.79	3.76	72.39	4.37	75.25	5.00	77.89	5.65
Node-52	14.75	68.77	3.69	71.88	4.28	74.69	4.91	75.40	5.55
Node-53	14.50	69.32	3.56	72.59	4.16	77.09	4.79	79.93	5.46
Node-54	14.25	73.35	3.72	77.77	4.36	81.94	5.03	84.46	5.74
Node-55	13.75	77.99	4.03	81.40	4.70	85.34	5.41	87.82	6.15
Node-56	13.25	84.29	5.04	85.52	5.77	87.10	6.51	87.83	7.27
Node-57	10.25	98.65	5.63	99.50	6.48	99.94	7.35	97.98	8.21
Node-58	9.75	100.21	5.05	103.90	5.92	105.99	6.82	105.32	7.74
Node-59	9.25	99.47	4.81	104.40	5.67	108.80	6.58	109.10	7.52
Node-60	8.75	97.44	4.80	102.02	5.64	106.50	6.53	106.69	7.45
Node-61	8.50	99.49	4.82	104.62	5.69	108.98	6.59	109.47	7.54
Node-62	8.25	101.97	5.03	104.77	5.92	108.03	6.83	107.40	7.76
Node-63	7.75	103.86	5.33	106.36	6.23	108.28	7.16	105.78	8.10
Node-64	7.25	111.73	6.43	111.07	7.40	109.01	8.36	104.17	9.31
Node-65	4.25	118.33	6.82	116.43	7.85	113.25	8.86	106.38	9.84
Node-66	3.75	118.55	5.92	119.28	6.95	119.37	7.98	114.75	9.02
Node-67	3.25	116.78	5.64	119.54	6.66	121.09	7.69	117.00	8.74
Node-68	2.75	114.12	5.43	118.94	6.42	121.95	7.46	117.50	8.51
Node-69	2.50	112.78	5.44	118.71	6.42	119.55	7.45	115.85	8.49
Node-70	2.25	114.38	5.56	119.91	6.55	119.89	7.59	115.24	8.63
Node-71	1.75	120.46	6.04	121.76	7.09	120.53	8.15	114.27	9.19
Node-72	1.25	121.39	7.05	119.20	8.10	115.99	9.13	108.45	10.14
Node-73	-1.75	124.27	7.14	122.66	8.22	119.50	9.29	111.09	10.32
Node-74	-2.25	121.98	6.09	122.89	7.15	121.58	8.21	115.95	9.27
Node-75	-2.75	118.15	5.79	121.50	6.81	122.36	7.87	117.53	8.93
Node-76	-3.25	118.30	5.67	122.20	6.69	124.82	7.75	119.74	8.84
Node-77	-3.50	117.21	5.57	121.79	6.58	122.96	7.64	120.06	8.71
Node-78	-3.75	118.28	5.81	121.09	6.84	121.66	7.89	117.29	8.95
Node-79	-4.25	121.68	6.18	122.30	7.23	121.04	8.30	114.91	9.35
Node-80	-4.75	121.50	7.02	119.64	8.07	115.25	9.11	108.93	10.11
Node-81	-7.75	122.14	7.05	120.73	8.11	118.91	9.16	111.78	10.19
Node-82	-8.25	120.47	6.08	121.77	7.12	120.40	8.18	115.44	9.22
Node-83	-8.75	114.10	5.57	118.04	6.56	118.84	7.58	115.83	8.61
Node-84	-9.25	111.57	5.30	116.69	6.27	119.89	7.28	117.62	8.32
Node-85	-9.50	110.06	5.21	114.51	6.17	117.28	7.16	115.02	8.18
Node-86	-9.75	107.40	5.19	112.22	6.13	114.57	7.10	112.62	8.09
Node-87	-10.25	112.00	5.47	114.86	6.44	115.83	7.43	113.68	8.44
Node-88	-10.75	113.18	6.46	113.02	7.44	112.48	8.42	107.75	9.40
Node-89	-13.75	104.53	6.35	104.34	7.26	102.07	8.16	96.85	9.05
Node-90	-14.25	102.96	5.50	104.54	6.39	104.31	7.30	101.20	8.20
Node-91	-14.75	95.17	4.99	98.56	5.81	99.99	6.67	97.92	7.54
Node-92	-15.25	91.16	4.78	94.52	5.57	97.55	6.39	95.98	7.24
Node-93	-15.50	91.87	4.71	96.14	5.51	98.38	6.34	98.47	7.20
Node-94	-15.75	88.12	4.56	91.93	5.33	94.48	6.12	95.06	6.94
Node-95	-16.25	88.99	4.73	91.36	5.50	94.13	6.29	94.82	7.11
Node-96	-16.75	88.77	5.32	90.31	6.09	89.74	6.87	89.00	7.65

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 38. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (200-275 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	200 EFPDs		225 EFPDs		250 EFPDs		275 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-2									
Node-97	16.25	56.99	3.08	59.77	3.57	62.72	4.09	63.73	4.64
Node-98	15.75	51.63	2.44	55.76	2.89	59.97	3.38	62.57	3.90
Node-99	15.25	50.93	2.30	55.23	2.75	60.23	3.22	63.78	3.75
Node-100	14.75	52.38	2.33	58.06	2.78	63.97	3.29	67.58	3.84
Node-101	14.50	52.63	2.31	58.32	2.77	64.37	3.27	69.42	3.83
Node-102	14.25	54.87	2.32	59.26	2.79	65.07	3.31	70.09	3.87
Node-103	13.75	56.25	2.48	61.26	2.97	67.47	3.50	72.75	4.09
Node-104	13.25	64.92	3.32	69.60	3.89	74.39	4.49	78.71	5.14
Node-105	10.25	85.88	4.08	89.24	4.83	93.69	5.60	94.34	6.41
Node-106	9.75	79.08	3.16	86.76	3.85	92.56	4.60	96.70	5.40
Node-107	9.25	76.20	3.05	84.34	3.71	91.75	4.44	95.68	5.24
Node-108	8.75	77.05	3.09	85.43	3.76	94.41	4.50	99.93	5.32
Node-109	8.50	79.53	3.15	87.37	3.84	96.28	4.60	100.71	5.43
Node-110	8.25	81.19	3.23	90.02	3.93	97.64	4.71	101.78	5.56
Node-111	7.75	84.75	3.46	92.52	4.19	100.07	5.00	101.82	5.87
Node-112	7.25	98.62	4.74	102.51	5.60	105.40	6.49	103.33	7.40
Node-113	4.25	103.80	5.06	109.45	5.96	110.51	6.91	108.52	7.87
Node-114	3.75	98.71	4.01	106.07	4.87	111.75	5.79	111.04	6.76
Node-115	3.25	97.23	3.72	106.23	4.56	112.77	5.48	114.08	6.46
Node-116	2.75	94.11	3.67	104.54	4.48	113.37	5.39	113.67	6.37
Node-117	2.50	96.77	3.61	107.14	4.45	113.77	5.38	115.51	6.37
Node-118	2.25	98.94	3.74	109.14	4.60	114.32	5.54	114.74	6.54
Node-119	1.75	105.82	4.22	113.01	5.14	115.54	6.12	113.69	7.12
Node-120	1.25	109.61	5.19	113.54	6.14	114.37	7.13	111.22	8.12
Node-121	-1.75	107.16	5.21	110.60	6.14	111.56	7.10	108.30	8.07
Node-122	-2.25	102.45	4.12	107.88	5.01	112.72	5.94	112.36	6.92
Node-123	-2.75	98.73	3.81	107.20	4.67	114.49	5.60	115.81	6.59
Node-124	-3.25	98.99	3.68	107.99	4.54	114.53	5.48	115.98	6.47
Node-125	-3.50	99.66	3.67	110.66	4.54	117.00	5.50	119.78	6.51
Node-126	-3.75	104.21	3.86	114.17	4.76	119.50	5.75	122.02	6.79
Node-127	-4.25	108.15	4.26	115.23	5.19	119.02	6.19	116.59	7.23
Node-128	-4.75	111.28	5.26	114.79	6.23	114.79	7.22	110.23	8.22
Node-129	-7.75	105.58	5.13	108.64	6.04	109.87	6.99	107.91	7.94
Node-130	-8.25	101.98	4.12	108.85	5.00	112.39	5.95	112.45	6.92
Node-131	-8.75	96.53	3.68	105.18	4.52	110.83	5.43	113.54	6.39
Node-132	-9.25	94.08	3.55	103.27	4.37	109.82	5.26	113.40	6.22
Node-133	-9.50	91.03	3.40	99.97	4.19	108.25	5.06	111.95	6.00
Node-134	-9.75	92.51	3.41	101.59	4.21	111.88	5.09	113.11	6.07
Node-135	-10.25	93.88	3.72	101.40	4.54	108.19	5.42	109.72	6.36
Node-136	-10.75	97.67	4.66	102.80	5.51	105.01	6.40	104.73	7.31
Node-137	-13.75	94.52	4.90	97.36	5.72	98.94	6.56	96.73	7.42
Node-138	-14.25	87.34	3.81	93.05	4.57	96.62	5.38	96.48	6.21
Node-139	-14.75	81.52	3.48	88.31	4.19	92.28	4.95	93.98	5.75
Node-140	-15.25	79.05	3.25	86.66	3.94	92.40	4.69	94.16	5.49
Node-141	-15.50	74.25	3.14	81.82	3.78	89.90	4.49	91.83	5.27
Node-142	-15.75	72.28	3.12	78.37	3.74	84.36	4.42	86.81	5.15
Node-143	-16.25	72.73	3.30	77.42	3.93	82.64	4.60	83.96	5.32
Node-144	-16.75	76.25	3.84	80.20	4.50	83.71	5.20	85.38	5.92

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 39. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (300-375 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	300 EFPDs		325 EFPDs		350 EFPDs		375 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-1									
Node-1	16.25	75.63	7.05	73.85	7.70	72.22	8.35	69.67	8.97
Node-2	15.75	77.50	6.34	76.53	7.01	76.64	7.67	74.84	8.34
Node-3	15.25	80.00	6.39	80.27	7.08	79.93	7.78	77.83	8.47
Node-4	14.75	80.60	6.40	80.59	7.10	79.75	7.80	77.91	8.49
Node-5	14.50	86.19	6.62	86.04	7.36	85.38	8.11	82.92	8.85
Node-6	14.25	86.94	6.62	87.66	7.37	88.07	8.14	85.59	8.90
Node-7	13.75	90.43	7.11	89.15	7.89	88.12	8.67	85.93	9.43
Node-8	13.25	88.55	8.29	85.21	9.06	83.20	9.80	79.36	10.52
Node-9	10.25	100.90	9.61	95.90	10.49	90.25	11.32	84.09	12.10
Node-10	9.75	105.01	8.80	99.92	9.71	94.32	10.58	87.79	11.40
Node-11	9.25	108.75	8.84	103.51	9.79	97.79	10.68	90.98	11.53
Node-12	8.75	112.30	8.99	107.15	9.97	102.29	10.90	94.71	11.79
Node-13	8.50	112.97	9.00	107.65	9.98	101.38	10.91	93.85	11.79
Node-14	8.25	110.70	9.28	104.06	10.24	98.19	11.15	90.68	12.00
Node-15	7.75	109.54	9.77	103.07	10.72	96.56	11.62	88.55	12.46
Node-16	7.25	104.22	11.07	96.65	11.98	90.08	12.82	82.29	13.60
Node-17	4.25	104.28	11.36	96.04	12.26	88.69	13.10	80.44	13.87
Node-18	3.75	112.74	10.55	104.26	11.53	97.05	12.43	88.44	13.27
Node-19	3.25	113.21	10.12	104.21	11.10	95.76	12.01	86.90	12.84
Node-20	2.75	118.28	10.34	109.00	11.37	100.69	12.32	91.08	13.19
Node-21	2.50	117.10	10.24	107.49	11.26	99.84	12.19	90.67	13.05
Node-22	2.25	116.43	10.42	107.10	11.43	99.98	12.36	90.90	13.23
Node-23	1.75	111.11	10.73	101.77	11.69	94.18	12.58	85.29	13.39
Node-24	1.25	107.31	11.62	97.69	12.55	90.85	13.40	82.23	14.19
Node-25	-1.75	110.82	11.85	101.56	12.81	94.09	13.70	85.99	14.51
Node-26	-2.25	114.31	11.01	104.75	12.00	96.77	12.91	87.56	13.75
Node-27	-2.75	113.45	10.48	104.45	11.47	95.85	12.37	86.64	13.21
Node-28	-3.25	120.26	10.44	110.68	11.48	103.11	12.44	93.73	13.34
Node-29	-3.50	121.00	10.51	110.75	11.56	102.80	12.52	93.28	13.41
Node-30	-3.75	120.90	10.64	111.51	11.69	103.32	12.66	93.46	13.55
Node-31	-4.25	112.04	10.93	102.74	11.90	94.70	12.79	85.74	13.61
Node-32	-4.75	105.46	11.71	96.15	12.62	88.73	13.46	80.04	14.23
Node-33	-7.75	105.62	11.37	96.75	12.28	89.13	13.12	80.81	13.90
Node-34	-8.25	112.30	10.50	104.07	11.48	96.87	12.38	87.80	13.22
Node-35	-8.75	113.00	10.14	103.63	11.12	96.19	12.02	87.59	12.85
Node-36	-9.25	118.49	9.96	109.91	10.99	101.92	11.94	92.59	12.83
Node-37	-9.50	115.93	9.71	107.96	10.71	99.92	11.65	91.49	12.52
Node-38	-9.75	114.72	9.90	106.28	10.89	98.44	11.81	90.38	12.67
Node-39	-10.25	111.92	10.11	103.48	11.08	96.76	11.98	88.06	12.82
Node-40	-10.75	105.86	10.75	97.96	11.67	91.62	12.52	83.26	13.31
Node-41	-13.75	97.05	10.46	90.00	11.30	83.81	12.08	76.99	12.81
Node-42	-14.25	99.71	9.35	93.55	10.22	88.20	11.03	81.80	11.79
Node-43	-14.75	101.98	9.01	96.85	9.90	92.02	10.74	85.50	11.54
Node-44	-15.25	99.66	8.55	95.18	9.41	91.58	10.24	85.90	11.03
Node-45	-15.50	98.88	8.35	94.63	9.20	91.64	10.03	85.94	10.82
Node-46	-15.75	95.53	8.15	91.94	8.98	88.94	9.78	83.91	10.55
Node-47	-16.25	92.35	8.10	89.66	8.90	85.63	9.68	81.19	10.42
Node-48	-16.75	89.73	8.68	85.70	9.46	82.50	10.21	77.71	10.92

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 39. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (300-375 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	300 EFPDs		325 EFPDs		350 EFPDs		375 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-3									
Node-49	16.25	74.04	6.80	72.58	7.45	70.59	8.08	68.52	8.69
Node-50	15.75	76.52	6.35	76.09	7.01	75.50	7.67	74.09	8.33
Node-51	15.25	78.58	6.33	79.10	7.01	78.71	7.69	77.86	8.38
Node-52	14.75	76.63	6.21	76.76	6.87	76.56	7.54	74.55	8.20
Node-53	14.50	81.87	6.15	81.96	6.86	82.22	7.57	80.30	8.29
Node-54	14.25	86.90	6.47	86.62	7.23	85.46	7.98	83.68	8.72
Node-55	13.75	88.84	6.91	88.47	7.68	87.10	8.45	84.04	9.21
Node-56	13.25	87.67	8.03	85.60	8.79	83.36	9.53	79.48	10.26
Node-57	10.25	95.23	9.06	90.30	9.89	85.16	10.67	79.96	11.41
Node-58	9.75	103.14	8.65	97.75	9.55	92.79	10.40	86.50	11.20
Node-59	9.25	106.59	8.47	102.10	9.39	97.49	10.28	90.29	11.13
Node-60	8.75	104.57	8.38	99.33	9.29	95.01	10.15	87.98	10.97
Node-61	8.50	106.78	8.49	102.54	9.42	97.79	10.31	90.56	11.15
Node-62	8.25	104.37	8.70	99.36	9.60	93.63	10.46	86.65	11.28
Node-63	7.75	102.41	9.01	96.78	9.90	91.17	10.74	83.67	11.53
Node-64	7.25	98.99	10.21	92.31	11.07	86.04	11.87	78.70	12.62
Node-65	4.25	100.79	10.76	92.63	11.64	86.18	12.44	78.86	13.19
Node-66	3.75	109.12	10.01	101.44	10.96	94.35	11.84	86.07	12.66
Node-67	3.25	111.05	9.76	102.24	10.72	95.13	11.61	86.44	12.44
Node-68	2.75	113.13	9.53	104.82	10.52	97.65	11.42	89.18	12.27
Node-69	2.50	111.05	9.50	102.24	10.46	95.72	11.35	86.98	12.18
Node-70	2.25	110.80	9.63	102.75	10.59	95.62	11.48	87.10	12.31
Node-71	1.75	108.37	10.18	99.78	11.12	92.22	11.99	83.50	12.79
Node-72	1.25	101.51	11.08	93.27	11.96	86.10	12.77	78.44	13.52
Node-73	-1.75	104.69	11.29	96.46	12.20	89.78	13.03	81.78	13.81
Node-74	-2.25	109.24	10.28	99.83	11.22	92.19	12.09	83.85	12.89
Node-75	-2.75	112.26	9.95	102.87	10.92	95.34	11.81	86.69	12.64
Node-76	-3.25	114.02	9.88	105.20	10.87	97.92	11.78	88.83	12.63
Node-77	-3.50	113.66	9.75	104.66	10.74	96.10	11.64	87.24	12.48
Node-78	-3.75	111.13	9.96	102.02	10.93	94.08	11.81	85.41	12.63
Node-79	-4.25	108.51	10.34	99.16	11.28	90.95	12.15	82.44	12.93
Node-80	-4.75	101.87	11.05	92.77	11.94	85.53	12.74	77.35	13.49
Node-81	-7.75	105.84	11.16	97.34	12.08	90.80	12.93	82.95	13.71
Node-82	-8.25	110.04	10.22	101.64	11.18	95.13	12.06	86.64	12.89
Node-83	-8.75	112.31	9.62	104.48	10.59	96.66	11.50	87.77	12.34
Node-84	-9.25	113.28	9.34	105.21	10.32	98.68	11.24	90.83	12.09
Node-85	-9.50	110.41	9.18	103.68	10.14	96.76	11.04	88.92	11.88
Node-86	-9.75	109.73	9.07	102.42	10.02	96.04	10.91	88.23	11.75
Node-87	-10.25	109.09	9.43	101.97	10.37	94.78	11.26	86.43	12.08
Node-88	-10.75	102.62	10.33	95.91	11.22	89.60	12.06	82.56	12.83
Node-89	-13.75	92.26	9.89	86.13	10.69	80.73	11.44	74.55	12.14
Node-90	-14.25	98.07	9.08	92.27	9.93	87.81	10.73	81.35	11.49
Node-91	-14.75	95.79	8.39	90.96	9.22	86.64	10.01	81.01	10.76
Node-92	-15.25	93.43	8.07	89.48	8.88	85.17	9.66	79.63	10.40
Node-93	-15.50	95.48	8.05	92.11	8.88	89.16	9.68	83.79	10.45
Node-94	-15.75	95.19	7.77	91.59	8.59	88.68	9.39	83.81	10.16
Node-95	-16.25	94.06	7.93	90.72	8.75	87.02	9.54	81.99	10.29
Node-96	-16.75	86.95	8.42	83.06	9.18	80.01	9.90	75.41	10.59

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 39. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (300-375 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	300 EFPDs		325 EFPDs		350 EFPDs		375 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-2									
Node-97	16.25	65.64	5.19	66.24	5.76	66.36	6.33	65.70	6.91
Node-98	15.75	66.26	4.44	68.07	5.01	68.30	5.60	67.99	6.20
Node-99	15.25	68.69	4.30	70.86	4.90	72.01	5.51	71.88	6.14
Node-100	14.75	71.22	4.43	73.96	5.05	75.66	5.69	75.21	6.35
Node-101	14.50	74.13	4.44	76.97	5.08	79.35	5.75	79.29	6.44
Node-102	14.25	74.18	4.48	77.49	5.12	79.96	5.80	79.69	6.49
Node-103	13.75	76.63	4.72	79.02	5.38	81.68	6.07	81.05	6.78
Node-104	13.25	81.10	5.82	82.69	6.52	83.58	7.24	81.49	7.97
Node-105	10.25	94.94	7.23	92.90	8.06	89.74	8.86	85.71	9.64
Node-106	9.75	98.08	6.24	96.87	7.09	93.98	7.93	89.41	8.75
Node-107	9.25	97.95	6.07	97.41	6.92	95.22	7.76	91.72	8.59
Node-108	8.75	102.59	6.18	100.87	7.07	98.91	7.95	94.63	8.81
Node-109	8.50	103.55	6.31	101.82	7.20	98.87	8.09	93.72	8.95
Node-110	8.25	103.42	6.44	101.69	7.34	99.56	8.22	93.73	9.09
Node-111	7.75	102.03	6.75	99.66	7.63	95.97	8.50	90.85	9.33
Node-112	7.25	102.12	8.30	99.04	9.19	94.69	10.04	89.76	10.87
Node-113	4.25	103.72	8.82	97.92	9.72	92.83	10.56	86.68	11.37
Node-114	3.75	108.28	7.72	103.22	8.66	98.29	9.56	92.46	10.41
Node-115	3.25	113.15	7.45	108.60	8.43	103.65	9.38	97.10	10.28
Node-116	2.75	113.34	7.36	108.08	8.34	102.70	9.28	95.29	10.17
Node-117	2.50	114.29	7.37	108.23	8.36	104.02	9.30	97.52	10.20
Node-118	2.25	113.51	7.53	107.88	8.52	102.54	9.45	95.42	10.34
Node-119	1.75	110.23	8.11	103.92	9.06	98.61	9.96	90.89	10.82
Node-120	1.25	106.72	9.09	100.30	10.01	95.27	10.88	88.69	11.71
Node-121	-1.75	102.65	9.01	95.61	9.90	90.29	10.73	83.94	11.51
Node-122	-2.25	109.44	7.89	103.31	8.84	97.61	9.74	90.43	10.59
Node-123	-2.75	113.72	7.59	107.74	8.58	102.65	9.52	95.39	10.41
Node-124	-3.25	115.21	7.48	109.21	8.48	103.18	9.42	96.01	10.32
Node-125	-3.50	117.39	7.55	111.46	8.57	105.63	9.54	97.70	10.46
Node-126	-3.75	119.47	7.85	114.35	8.88	109.05	9.88	101.39	10.82
Node-127	-4.25	113.35	8.24	106.62	9.22	100.03	10.15	92.88	11.02
Node-128	-4.75	106.17	9.18	99.53	10.10	93.72	10.96	87.08	11.78
Node-129	-7.75	102.91	8.88	96.32	9.77	90.80	10.61	83.76	11.39
Node-130	-8.25	109.49	7.90	103.28	8.85	98.20	9.74	90.95	10.60
Node-131	-8.75	112.53	7.38	108.14	8.35	102.89	9.29	95.71	10.18
Node-132	-9.25	113.21	7.20	108.62	8.18	104.67	9.13	97.50	10.03
Node-133	-9.50	111.88	6.97	108.55	7.94	104.41	8.88	96.96	9.79
Node-134	-9.75	112.19	7.05	109.05	8.02	104.26	8.97	97.66	9.87
Node-135	-10.25	109.64	7.31	104.38	8.26	99.03	9.17	92.67	10.02
Node-136	-10.75	101.41	8.22	96.86	9.10	91.99	9.94	85.45	10.74
Node-137	-13.75	94.90	8.26	90.18	9.09	85.58	9.87	79.86	10.61
Node-138	-14.25	96.51	7.05	92.94	7.89	89.24	8.70	84.37	9.47
Node-139	-14.75	94.45	6.57	93.38	7.39	90.02	8.20	85.95	8.98
Node-140	-15.25	95.37	6.31	94.60	7.13	92.06	7.96	87.30	8.75
Node-141	-15.50	93.65	6.07	92.62	6.88	90.44	7.68	85.67	8.47
Node-142	-15.75	90.32	5.91	88.98	6.69	87.52	7.46	84.39	8.22
Node-143	-16.25	86.03	6.05	85.10	6.80	84.43	7.53	81.71	8.27
Node-144	-16.75	86.71	6.66	85.71	7.42	84.41	8.16	81.51	8.89

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 40. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (400-550 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	400 EFPDs		450 EFPDs		500 EFPDs		550 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-1									
Node-1	16.25	67.89	9.58	62.05	10.73	56.20	11.78	50.85	12.73
Node-2	15.75	72.29	8.99	66.31	10.21	60.30	11.33	53.85	12.35
Node-3	15.25	76.11	9.15	70.59	10.44	63.43	11.63	57.18	12.70
Node-4	14.75	74.42	9.17	67.58	10.43	60.70	11.58	53.40	12.59
Node-5	14.50	80.11	9.57	71.95	10.92	64.01	12.13	56.53	13.21
Node-6	14.25	83.55	9.64	75.44	11.05	67.95	12.33	60.07	13.47
Node-7	13.75	82.98	10.18	73.59	11.57	65.48	12.81	57.54	13.91
Node-8	13.25	75.80	11.21	67.03	12.49	58.71	13.61	51.04	14.59
Node-9	10.25	78.81	12.83	67.84	14.15	58.84	15.28	51.52	16.26
Node-10	9.75	82.35	12.16	69.88	13.53	59.87	14.69	51.77	15.69
Node-11	9.25	84.65	12.32	72.01	13.73	61.27	14.93	52.33	15.95
Node-12	8.75	88.81	12.61	76.10	14.09	65.66	15.35	57.23	16.45
Node-13	8.50	87.77	12.61	75.03	14.07	64.55	15.32	55.48	16.39
Node-14	8.25	85.16	12.79	72.51	14.20	62.35	15.41	53.62	16.45
Node-15	7.75	81.68	13.23	68.67	14.58	58.12	15.72	49.84	16.68
Node-16	7.25	75.90	14.31	64.19	15.57	54.64	16.63	47.69	17.54
Node-17	4.25	74.68	14.57	63.76	15.81	55.39	16.87	48.47	17.79
Node-18	3.75	82.02	14.04	69.49	15.40	59.35	16.56	51.33	17.54
Node-19	3.25	80.15	13.59	66.92	14.92	55.96	16.02	47.38	16.95
Node-20	2.75	83.85	13.98	69.98	15.37	58.60	16.52	49.81	17.49
Node-21	2.50	82.74	13.84	68.77	15.21	57.30	16.34	48.65	17.29
Node-22	2.25	83.65	14.02	69.83	15.40	58.69	16.55	50.18	17.52
Node-23	1.75	78.61	14.13	65.57	15.43	55.54	16.52	47.44	17.44
Node-24	1.25	75.67	14.90	64.03	16.16	54.84	17.22	47.88	18.14
Node-25	-1.75	79.81	15.26	68.04	16.58	58.56	17.71	51.59	18.69
Node-26	-2.25	80.79	14.51	67.70	15.85	57.26	16.97	49.36	17.92
Node-27	-2.75	79.49	13.96	65.48	15.27	54.66	16.35	46.39	17.25
Node-28	-3.25	86.66	14.15	73.58	15.59	63.22	16.81	55.02	17.86
Node-29	-3.50	85.89	14.22	72.24	15.65	61.96	16.84	54.08	17.88
Node-30	-3.75	86.31	14.37	72.49	15.79	61.87	17.00	53.78	18.03
Node-31	-4.25	78.39	14.36	66.06	15.65	56.18	16.75	48.83	17.68
Node-32	-4.75	73.75	14.92	61.74	16.14	52.66	17.16	45.90	18.04
Node-33	-7.75	74.78	14.60	62.85	15.84	53.80	16.88	46.85	17.77
Node-34	-8.25	80.67	13.98	67.63	15.32	57.36	16.44	49.21	17.39
Node-35	-8.75	80.38	13.61	66.61	14.94	55.77	16.04	47.41	16.96
Node-36	-9.25	85.56	13.63	72.06	15.05	60.80	16.24	51.61	17.25
Node-37	-9.50	84.61	13.31	70.99	14.71	60.23	15.89	51.37	16.89
Node-38	-9.75	83.42	13.45	70.19	14.83	59.37	16.00	50.55	16.98
Node-39	-10.25	81.49	13.58	68.91	14.93	58.40	16.07	50.27	17.05
Node-40	-10.75	77.31	14.04	65.95	15.32	56.52	16.42	49.32	17.36
Node-41	-13.75	71.72	13.48	61.87	14.67	53.33	15.71	46.37	16.60
Node-42	-14.25	76.41	12.50	65.85	13.78	56.38	14.88	48.84	15.82
Node-43	-14.75	80.25	12.28	68.38	13.62	58.56	14.76	51.05	15.73
Node-44	-15.25	81.15	11.78	70.22	13.13	61.07	14.31	53.48	15.33
Node-45	-15.50	81.40	11.57	70.86	12.93	61.67	14.11	54.23	15.15
Node-46	-15.75	78.94	11.28	68.88	12.60	60.38	13.75	52.96	14.77
Node-47	-16.25	76.76	11.12	67.17	12.41	58.76	13.53	51.29	14.51
Node-48	-16.75	73.37	11.60	64.28	12.83	56.53	13.90	49.79	14.85

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 40. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (400-550 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)(continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	400 EFPDs		450 EFPDs		500 EFPDs		550 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-3									
Node-49	16.25	66.00	9.28	59.84	10.40	54.23	11.41	49.05	12.33
Node-50	15.75	71.72	8.97	65.54	10.19	59.04	11.29	53.23	12.29
Node-51	15.25	75.66	9.05	69.18	10.34	62.96	11.51	56.67	12.57
Node-52	14.75	72.47	8.85	66.31	10.08	58.98	11.20	52.41	12.19
Node-53	14.50	78.37	8.98	71.52	10.31	63.63	11.52	56.56	12.59
Node-54	14.25	80.66	9.45	73.03	10.82	64.99	12.05	57.56	13.14
Node-55	13.75	80.60	9.94	72.55	11.29	63.82	12.52	56.15	13.59
Node-56	13.25	75.86	10.95	67.27	12.22	59.47	13.35	52.69	14.35
Node-57	10.25	74.82	12.11	64.79	13.36	56.36	14.44	49.51	15.38
Node-58	9.75	80.53	11.95	68.78	13.29	59.49	14.44	52.03	15.43
Node-59	9.25	85.24	11.91	73.74	13.33	63.90	14.56	55.83	15.63
Node-60	8.75	82.43	11.74	70.60	13.11	60.69	14.29	52.47	15.30
Node-61	8.50	84.89	11.94	73.17	13.36	63.14	14.58	54.77	15.63
Node-62	8.25	80.60	12.03	68.51	13.37	58.78	14.51	50.68	15.49
Node-63	7.75	77.61	12.26	65.31	13.55	55.74	14.63	47.90	15.56
Node-64	7.25	73.00	13.30	62.18	14.52	53.40	15.55	46.41	16.44
Node-65	4.25	73.01	13.87	62.36	15.09	53.53	16.12	46.55	17.02
Node-66	3.75	79.68	13.41	67.78	14.73	57.91	15.86	50.26	16.82
Node-67	3.25	79.32	13.19	66.55	14.50	56.73	15.60	48.66	16.55
Node-68	2.75	82.66	13.05	70.21	14.42	59.84	15.58	51.51	16.58
Node-69	2.50	80.17	12.93	66.90	14.25	57.20	15.37	49.58	16.32
Node-70	2.25	80.06	13.07	67.33	14.39	57.10	15.51	49.26	16.46
Node-71	1.75	77.06	13.51	64.82	14.79	54.49	15.86	46.80	16.77
Node-72	1.25	72.87	14.20	61.84	15.41	53.04	16.43	46.45	17.32
Node-73	-1.75	75.85	14.52	64.83	15.78	56.45	16.86	50.00	17.81
Node-74	-2.25	76.62	13.62	64.15	14.89	54.70	15.95	47.38	16.86
Node-75	-2.75	79.83	13.39	67.24	14.72	57.67	15.83	50.11	16.79
Node-76	-3.25	81.38	13.40	68.04	14.75	57.78	15.87	50.13	16.84
Node-77	-3.50	79.74	13.24	66.16	14.55	55.78	15.65	47.83	16.57
Node-78	-3.75	78.54	13.37	65.76	14.67	56.04	15.76	48.08	16.69
Node-79	-4.25	75.75	13.65	64.13	14.90	55.07	15.97	47.52	16.88
Node-80	-4.75	71.18	14.16	59.81	15.33	50.88	16.32	43.96	17.17
Node-81	-7.75	76.83	14.43	65.55	15.71	56.66	16.80	49.89	17.75
Node-82	-8.25	80.19	13.64	68.36	14.97	58.80	16.10	51.39	17.08
Node-83	-8.75	80.97	13.10	68.25	14.44	57.63	15.57	49.37	16.53
Node-84	-9.25	84.08	12.88	71.25	14.28	60.42	15.46	52.00	16.46
Node-85	-9.50	82.50	12.65	69.16	14.02	58.79	15.16	50.19	16.14
Node-86	-9.75	82.07	12.51	68.32	13.87	57.55	15.00	49.02	15.95
Node-87	-10.25	80.15	12.83	67.71	14.16	57.60	15.29	49.24	16.24
Node-88	-10.75	76.90	13.55	66.14	14.83	57.34	15.93	50.17	16.89
Node-89	-13.75	69.45	12.78	60.11	13.94	51.71	14.95	45.47	15.81
Node-90	-14.25	76.08	12.20	65.42	13.47	56.79	14.56	49.95	15.51
Node-91	-14.75	76.55	11.46	65.66	12.74	57.12	13.83	49.80	14.79
Node-92	-15.25	75.31	11.09	65.33	12.35	56.48	13.44	48.92	14.38
Node-93	-15.50	79.76	11.18	69.86	12.52	60.95	13.69	53.69	14.71
Node-94	-15.75	79.84	10.89	70.65	12.22	63.20	13.41	56.62	14.47
Node-95	-16.25	77.27	11.00	68.03	12.30	60.44	13.44	53.67	14.45
Node-96	-16.75	71.18	11.25	62.63	12.44	54.75	13.49	48.32	14.41

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 40. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (400-550 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	400 EFPDs		450 EFPDs		500 EFPDs		550 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-2									
Node-97	16.25	65.28	7.48	61.68	8.59	57.56	9.64	53.59	10.62
Node-98	15.75	67.97	6.79	64.86	7.96	60.76	9.06	56.05	10.09
Node-99	15.25	72.04	6.76	69.13	8.00	64.27	9.17	59.10	10.26
Node-100	14.75	74.99	7.00	72.13	8.29	66.64	9.52	61.03	10.64
Node-101	14.50	77.89	7.12	73.67	8.46	67.85	9.71	61.65	10.86
Node-102	14.25	78.69	7.18	74.42	8.53	68.48	9.80	62.73	10.96
Node-103	13.75	80.49	7.48	74.66	8.85	68.94	10.12	62.46	11.28
Node-104	13.25	80.35	8.67	74.32	10.04	67.77	11.30	61.33	12.45
Node-105	10.25	82.38	10.39	74.29	11.77	66.03	13.02	59.20	14.13
Node-106	9.75	84.71	9.52	75.82	10.95	66.24	12.22	58.75	13.33
Node-107	9.25	87.58	9.39	77.68	10.86	68.29	12.16	60.00	13.31
Node-108	8.75	89.98	9.63	79.97	11.14	70.86	12.49	63.14	13.68
Node-109	8.50	89.46	9.76	79.60	11.26	70.16	12.60	61.79	13.77
Node-110	8.25	89.62	9.90	79.73	11.41	70.34	12.74	62.03	13.92
Node-111	7.75	85.77	10.12	75.40	11.56	65.84	12.82	57.58	13.92
Node-112	7.25	84.72	11.65	74.69	13.06	66.09	14.32	59.04	15.43
Node-113	4.25	81.69	12.12	71.49	13.49	63.20	14.69	55.82	15.75
Node-114	3.75	86.93	11.21	76.35	12.67	66.47	13.95	58.30	15.06
Node-115	3.25	91.10	11.12	79.61	12.65	69.02	13.98	60.26	15.13
Node-116	2.75	90.07	11.00	78.45	12.51	67.77	13.82	58.70	14.95
Node-117	2.50	92.07	11.05	80.47	12.59	69.71	13.93	60.92	15.10
Node-118	2.25	90.47	11.17	78.10	12.68	67.16	13.98	58.13	15.10
Node-119	1.75	85.10	11.61	73.22	13.03	63.24	14.25	54.83	15.30
Node-120	1.25	82.65	12.48	71.16	13.86	61.44	15.05	53.73	16.07
Node-121	-1.75	78.45	12.24	67.61	13.55	58.52	14.68	50.89	15.65
Node-122	-2.25	84.79	11.37	72.70	12.79	62.91	14.00	54.57	15.05
Node-123	-2.75	89.85	11.23	77.68	12.73	67.31	14.03	58.29	15.16
Node-124	-3.25	90.52	11.15	77.91	12.66	67.46	13.96	58.84	15.09
Node-125	-3.50	91.88	11.30	79.07	12.83	67.79	14.15	58.73	15.28
Node-126	-3.75	95.41	11.70	82.76	13.30	72.37	14.68	63.62	15.89
Node-127	-4.25	87.19	11.82	75.55	13.28	65.59	14.54	57.18	15.64
Node-128	-4.75	81.46	12.53	70.74	13.89	61.11	15.07	53.71	16.09
Node-129	-7.75	78.02	12.12	66.99	13.42	57.82	14.54	50.09	15.51
Node-130	-8.25	85.37	11.38	72.77	12.81	62.99	14.02	54.33	15.07
Node-131	-8.75	89.93	11.02	77.98	12.52	67.26	13.82	58.26	14.94
Node-132	-9.25	91.68	10.88	79.15	12.41	68.83	13.73	59.80	14.88
Node-133	-9.50	91.61	10.63	79.59	12.16	69.42	13.49	60.34	14.65
Node-134	-9.75	92.92	10.72	81.20	12.27	71.04	13.63	61.76	14.82
Node-135	-10.25	86.98	10.83	75.97	12.29	66.42	13.56	57.84	14.67
Node-136	-10.75	80.34	11.48	70.25	12.83	61.54	14.01	54.44	15.04
Node-137	-13.75	75.49	11.30	67.54	12.58	60.02	13.71	53.43	14.72
Node-138	-14.25	80.18	10.20	71.52	11.55	63.57	12.76	56.43	13.82
Node-139	-14.75	81.56	9.73	72.96	11.10	64.94	12.33	57.38	13.42
Node-140	-15.25	83.68	9.51	75.84	10.93	67.80	12.20	60.54	13.34
Node-141	-15.50	82.89	9.21	74.39	10.61	66.51	11.86	59.06	12.98
Node-142	-15.75	81.38	8.96	73.07	10.33	65.94	11.56	59.28	12.68
Node-143	-16.25	79.41	8.98	71.79	10.32	64.82	11.53	58.02	12.62
Node-144	-16.75	79.15	9.60	72.51	10.94	66.01	12.17	59.84	13.29

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 41. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (600-750 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	600 EFPDs		650 EFPDs		700 EFPDs		750 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-1									
Node-1	16.25	46.01	13.59	41.39	14.36	37.87	15.06	35.99	15.72
Node-2	15.75	48.24	13.26	43.14	14.07	38.92	14.79	36.71	15.47
Node-3	15.25	51.40	13.66	46.42	14.53	41.91	15.31	39.69	16.04
Node-4	14.75	47.32	13.49	41.79	14.28	37.18	14.99	35.02	15.63
Node-5	14.50	50.32	14.16	44.87	15.00	40.37	15.76	38.07	16.46
Node-6	14.25	53.60	14.48	47.89	15.38	43.29	16.19	40.80	16.94
Node-7	13.75	50.89	14.87	45.25	15.73	40.79	16.49	38.32	17.20
Node-8	13.25	44.81	15.44	39.50	16.19	35.42	16.86	33.43	17.47
Node-9	10.25	45.58	17.13	40.96	17.89	37.03	18.58	34.96	19.22
Node-10	9.75	45.00	16.55	39.53	17.31	34.97	17.97	32.69	18.57
Node-11	9.25	45.28	16.82	40.10	17.58	35.79	18.25	33.57	18.87
Node-12	8.75	50.67	17.41	45.93	18.26	41.84	19.03	39.47	19.76
Node-13	8.50	48.21	17.31	42.63	18.12	38.29	18.83	35.78	19.50
Node-14	8.25	46.90	17.34	41.59	18.12	37.63	18.82	35.38	19.48
Node-15	7.75	43.32	17.51	38.16	18.24	34.01	18.87	31.72	19.46
Node-16	7.25	41.93	18.34	37.40	19.04	34.05	19.67	32.08	20.26
Node-17	4.25	43.22	18.60	39.27	19.33	36.19	19.99	34.26	20.62
Node-18	3.75	45.41	18.40	41.38	19.16	38.10	19.86	35.94	20.52
Node-19	3.25	40.78	17.74	35.50	18.42	31.46	19.01	29.30	19.55
Node-20	2.75	43.08	18.32	38.06	19.04	34.35	19.68	32.23	20.27
Node-21	2.50	42.00	18.10	37.14	18.80	33.41	19.42	31.24	20.00
Node-22	2.25	43.74	18.36	38.71	19.09	34.88	19.74	32.66	20.34
Node-23	1.75	41.49	18.23	36.95	18.93	33.52	19.54	31.51	20.13
Node-24	1.25	42.92	18.94	39.18	19.66	36.16	20.32	34.26	20.94
Node-25	-1.75	46.34	19.55	42.35	20.33	39.21	21.04	37.18	21.72
Node-26	-2.25	43.37	18.74	38.93	19.47	35.58	20.12	33.53	20.74
Node-27	-2.75	40.17	18.02	35.38	18.69	31.78	19.29	29.85	19.84
Node-28	-3.25	48.62	18.78	43.64	19.59	39.96	20.33	37.75	21.02
Node-29	-3.50	48.18	18.78	43.44	19.59	39.72	20.32	37.43	21.01
Node-30	-3.75	47.32	18.92	42.55	19.71	38.81	20.43	36.56	21.10
Node-31	-4.25	43.06	18.50	38.86	19.22	35.55	19.87	33.51	20.49
Node-32	-4.75	40.64	18.81	36.60	19.49	33.59	20.10	31.62	20.69
Node-33	-7.75	41.47	18.56	37.56	19.25	34.57	19.88	32.66	20.48
Node-34	-8.25	43.00	18.21	37.98	18.93	34.05	19.57	31.97	20.16
Node-35	-8.75	40.98	17.75	36.04	18.43	32.41	19.03	30.34	19.60
Node-36	-9.25	44.54	18.10	39.50	18.85	35.61	19.51	33.40	20.13
Node-37	-9.50	44.66	17.74	39.67	18.49	35.39	19.15	33.13	19.77
Node-38	-9.75	44.14	17.82	38.87	18.56	34.84	19.21	32.61	19.82
Node-39	-10.25	44.27	17.89	39.40	18.63	35.76	19.29	33.55	19.91
Node-40	-10.75	43.47	18.18	38.98	18.91	35.69	19.57	33.63	20.19
Node-41	-13.75	40.80	17.37	36.36	18.05	32.75	18.67	30.77	19.23
Node-42	-14.25	42.68	16.63	37.65	17.35	33.62	17.98	31.54	18.56
Node-43	-14.75	44.47	16.59	39.45	17.33	35.49	17.99	33.37	18.61
Node-44	-15.25	46.82	16.22	41.48	17.01	37.25	17.70	34.94	18.35
Node-45	-15.50	47.99	16.05	42.96	16.86	38.70	17.58	36.51	18.25
Node-46	-15.75	46.57	15.65	41.19	16.43	36.90	17.12	34.57	17.77
Node-47	-16.25	45.16	15.37	40.11	16.13	35.93	16.81	33.81	17.43
Node-48	-16.75	44.18	15.69	39.10	16.43	35.61	17.09	33.76	17.71

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 41. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (600-750 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	600 EFPDs		650 EFPDs		700 EFPDs		750 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-3									
Node-49	16.25	44.15	13.16	39.79	13.90	36.25	14.57	34.40	15.20
Node-50	15.75	48.20	13.19	43.82	14.00	39.72	14.74	37.68	15.43
Node-51	15.25	51.35	13.53	46.30	14.39	41.69	15.17	39.42	15.90
Node-52	14.75	46.60	13.07	41.34	13.85	36.95	14.55	34.73	15.19
Node-53	14.50	50.30	13.54	45.07	14.39	40.64	15.15	38.40	15.85
Node-54	14.25	50.99	14.11	44.95	14.96	40.00	15.72	37.67	16.41
Node-55	13.75	49.82	14.53	43.92	15.36	39.49	16.10	37.16	16.79
Node-56	13.25	46.83	15.23	42.00	16.02	38.10	16.73	35.87	17.39
Node-57	10.25	43.86	16.21	39.45	16.95	35.85	17.61	33.94	18.24
Node-58	9.75	45.92	16.30	41.18	17.08	37.48	17.77	35.35	18.42
Node-59	9.25	49.33	16.56	44.20	17.39	40.13	18.13	37.83	18.83
Node-60	8.75	45.47	16.17	40.24	16.93	35.96	17.61	33.65	18.23
Node-61	8.50	47.87	16.54	42.70	17.34	38.36	18.06	35.98	18.73
Node-62	8.25	43.85	16.33	38.50	17.06	34.48	17.71	32.35	18.31
Node-63	7.75	41.77	16.36	36.84	17.05	32.84	17.67	30.71	18.24
Node-64	7.25	41.04	17.21	36.91	17.90	33.64	18.52	31.79	19.11
Node-65	4.25	41.31	17.79	37.38	18.49	34.38	19.12	32.50	19.71
Node-66	3.75	44.24	17.66	39.82	18.40	36.54	19.07	34.45	19.71
Node-67	3.25	42.49	17.36	37.57	18.07	34.31	18.70	32.49	19.29
Node-68	2.75	45.74	17.44	40.98	18.20	37.84	18.89	35.80	19.55
Node-69	2.50	43.36	17.15	38.37	17.87	34.77	18.51	32.74	19.12
Node-70	2.25	43.45	17.28	38.80	18.01	35.24	18.66	33.15	19.27
Node-71	1.75	40.73	17.55	36.08	18.23	32.68	18.83	30.81	19.40
Node-72	1.25	41.80	18.10	38.35	18.80	35.53	19.44	33.77	20.06
Node-73	-1.75	44.92	18.64	41.05	19.40	38.14	20.09	36.07	20.75
Node-74	-2.25	41.73	17.65	37.40	18.35	33.77	18.97	31.77	19.56
Node-75	-2.75	43.94	17.63	39.15	18.36	35.52	19.02	33.33	19.63
Node-76	-3.25	43.71	17.67	38.99	18.40	35.39	19.05	33.55	19.67
Node-77	-3.50	41.45	17.37	36.84	18.06	33.43	18.68	31.41	19.26
Node-78	-3.75	41.96	17.49	37.31	18.19	33.92	18.82	32.05	19.41
Node-79	-4.25	41.88	17.68	37.66	18.38	34.46	19.01	32.51	19.61
Node-80	-4.75	39.10	17.91	35.25	18.56	32.43	19.15	30.60	19.72
Node-81	-7.75	45.05	18.58	41.45	19.34	38.53	20.04	36.61	20.71
Node-82	-8.25	45.57	17.94	41.00	18.70	37.52	19.39	35.32	20.04
Node-83	-8.75	42.99	17.35	38.10	18.07	34.24	18.71	32.12	19.30
Node-84	-9.25	45.08	17.33	39.65	18.08	35.57	18.74	33.24	19.36
Node-85	-9.50	43.51	16.97	38.53	17.70	34.65	18.35	32.51	18.95
Node-86	-9.75	42.21	16.77	36.88	17.47	32.66	18.09	30.41	18.66
Node-87	-10.25	42.99	17.06	37.98	17.78	34.00	18.42	31.93	19.01
Node-88	-10.75	44.48	17.72	40.28	18.47	36.81	19.15	34.84	19.79
Node-89	-13.75	39.94	16.57	35.75	17.24	32.40	17.84	30.57	18.40
Node-90	-14.25	44.17	16.35	39.70	17.09	36.12	17.76	34.03	18.38
Node-91	-14.75	43.57	15.62	38.80	16.35	35.11	17.00	33.06	17.61
Node-92	-15.25	42.86	15.19	37.61	15.91	33.83	16.54	31.72	17.13
Node-93	-15.50	47.27	15.61	41.94	16.40	37.84	17.10	35.53	17.76
Node-94	-15.75	50.86	15.43	45.71	16.28	41.70	17.05	39.38	17.78
Node-95	-16.25	48.22	15.36	43.54	16.17	39.77	16.90	37.70	17.59
Node-96	-16.75	42.97	15.22	38.61	15.94	34.81	16.59	32.94	17.19

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 41. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (600-750 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	600 EFPDs		650 EFPDs		700 EFPDs		750 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)	Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-2									
Node-97	16.25	49.72	11.53	45.75	12.38	42.36	13.15	40.52	13.89
Node-98	15.75	52.03	11.04	47.88	11.93	43.73	12.74	41.85	13.50
Node-99	15.25	54.61	11.27	50.25	12.19	46.01	13.04	43.89	13.84
Node-100	14.75	55.34	11.68	50.64	12.61	46.34	13.47	44.11	14.28
Node-101	14.50	56.34	11.90	51.15	12.85	46.54	13.72	44.10	14.53
Node-102	14.25	57.07	12.02	51.65	12.98	46.84	13.86	44.40	14.67
Node-103	13.75	56.66	12.34	51.28	13.30	46.56	14.17	44.06	14.97
Node-104	13.25	55.76	13.48	50.53	14.43	45.93	15.28	43.58	16.08
Node-105	10.25	53.09	15.12	48.01	16.02	43.36	16.83	41.03	17.58
Node-106	9.75	52.01	14.32	46.17	15.19	40.89	15.97	38.37	16.68
Node-107	9.25	53.19	14.32	47.23	15.21	41.92	16.00	39.38	16.73
Node-108	8.75	55.90	14.74	49.90	15.68	44.61	16.52	41.92	17.29
Node-109	8.50	54.50	14.81	48.73	15.73	43.66	16.55	40.97	17.30
Node-110	8.25	54.84	14.96	48.43	15.88	43.27	16.70	40.63	17.45
Node-111	7.75	50.66	14.89	44.55	15.73	39.46	16.48	36.95	17.17
Node-112	7.25	52.52	16.42	47.38	17.30	43.02	18.10	40.73	18.85
Node-113	4.25	50.31	16.69	45.13	17.53	40.95	18.29	38.75	19.00
Node-114	3.75	51.55	16.04	46.13	16.90	41.33	17.68	38.99	18.40
Node-115	3.25	52.98	16.14	46.88	17.03	41.91	17.81	39.37	18.54
Node-116	2.75	51.52	15.93	45.52	16.79	40.40	17.55	37.78	18.25
Node-117	2.50	53.33	16.12	46.90	17.01	41.64	17.80	38.86	18.52
Node-118	2.25	50.93	16.08	44.72	16.93	39.58	17.68	36.84	18.36
Node-119	1.75	48.00	16.22	42.07	17.02	37.25	17.73	34.85	18.37
Node-120	1.25	47.29	16.97	42.12	17.77	37.82	18.47	35.61	19.13
Node-121	-1.75	44.62	16.50	39.68	17.25	35.55	17.92	33.40	18.54
Node-122	-2.25	47.78	15.96	42.40	16.76	37.82	17.48	35.41	18.13
Node-123	-2.75	50.86	16.13	45.01	16.98	40.20	17.74	37.64	18.43
Node-124	-3.25	51.50	16.07	45.32	16.93	40.46	17.70	37.99	18.40
Node-125	-3.50	51.28	16.27	45.00	17.12	39.70	17.88	37.10	18.57
Node-126	-3.75	56.16	16.96	49.82	17.90	44.79	18.74	42.09	19.51
Node-127	-4.25	49.94	16.59	44.20	17.43	39.48	18.17	37.10	18.85
Node-128	-4.75	47.58	16.99	42.47	17.79	38.16	18.50	35.79	19.17
Node-129	-7.75	43.86	16.34	38.73	17.08	34.57	17.73	32.48	18.33
Node-130	-8.25	47.32	15.98	41.66	16.77	36.95	17.47	34.48	18.11
Node-131	-8.75	50.99	15.91	44.94	16.77	39.90	17.52	37.32	18.21
Node-132	-9.25	52.31	15.88	45.88	16.76	40.84	17.53	38.18	18.24
Node-133	-9.50	52.92	15.66	46.50	16.55	41.26	17.33	38.57	18.04
Node-134	-9.75	54.68	15.85	48.24	16.77	42.89	17.58	40.11	18.32
Node-135	-10.25	51.09	15.63	45.11	16.49	40.15	17.25	37.64	17.94
Node-136	-10.75	48.12	15.95	42.74	16.76	38.35	17.48	36.09	18.14
Node-137	-13.75	48.01	15.62	43.11	16.43	39.13	17.16	37.05	17.83
Node-138	-14.25	50.45	14.77	45.17	15.62	40.58	16.38	38.14	17.09
Node-139	-14.75	50.56	14.38	44.90	15.23	40.10	15.98	37.76	16.68
Node-140	-15.25	54.01	14.36	48.33	15.27	43.61	16.08	41.11	16.84
Node-141	-15.50	52.71	13.97	47.34	14.86	42.52	15.66	40.09	16.40
Node-142	-15.75	53.15	13.68	47.89	14.57	43.33	15.38	40.87	16.13
Node-143	-16.25	51.78	13.60	46.31	14.47	41.74	15.25	39.37	15.98
Node-144	-16.75	54.58	14.29	50.19	15.22	46.23	16.07	44.02	16.87

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 42. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (800 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	800 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-1			
Node-1	16.25	33.03	16.33
Node-2	15.75	33.31	16.09
Node-3	15.25	36.05	16.71
Node-4	14.75	31.42	16.23
Node-5	14.50	34.54	17.11
Node-6	14.25	37.11	17.63
Node-7	13.75	34.82	17.85
Node-8	13.25	30.61	18.04
Node-9	10.25	32.16	19.82
Node-10	9.75	29.31	19.13
Node-11	9.25	30.59	19.44
Node-12	8.75	36.52	20.44
Node-13	8.50	32.71	20.11
Node-14	8.25	32.68	20.08
Node-15	7.75	29.03	20.01
Node-16	7.25	29.91	20.81
Node-17	4.25	32.14	21.21
Node-18	3.75	33.72	21.14
Node-19	3.25	26.79	20.06
Node-20	2.75	29.77	20.83
Node-21	2.50	28.81	20.54
Node-22	2.25	30.09	20.90
Node-23	1.75	29.33	20.67
Node-24	1.25	32.48	21.54
Node-25	-1.75	35.27	22.37
Node-26	-2.25	31.23	21.31
Node-27	-2.75	27.48	20.35
Node-28	-3.25	35.38	21.67
Node-29	-3.50	35.07	21.65
Node-30	-3.75	34.20	21.73
Node-31	-4.25	31.33	21.07
Node-32	-4.75	29.56	21.23
Node-33	-7.75	30.78	21.05
Node-34	-8.25	29.55	20.71
Node-35	-8.75	28.24	20.12
Node-36	-9.25	30.80	20.70
Node-37	-9.50	30.44	20.34
Node-38	-9.75	29.89	20.37
Node-39	-10.25	30.99	20.49
Node-40	-10.75	31.17	20.76
Node-41	-13.75	28.19	19.76
Node-42	-14.25	28.64	19.10
Node-43	-14.75	30.50	19.18
Node-44	-15.25	31.88	18.95
Node-45	-15.50	33.39	18.88
Node-46	-15.75	31.20	18.35
Node-47	-16.25	30.62	18.00
Node-48	-16.75	30.94	18.28

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 42. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (800 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	800 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-3			
Node-49	16.25	31.54	15.79
Node-50	15.75	34.36	16.07
Node-51	15.25	36.00	16.57
Node-52	14.75	31.07	15.78
Node-53	14.50	34.53	16.50
Node-54	14.25	34.04	17.05
Node-55	13.75	33.64	17.42
Node-56	13.25	33.03	18.00
Node-57	10.25	31.46	18.82
Node-58	9.75	32.51	19.03
Node-59	9.25	35.07	19.48
Node-60	8.75	30.67	18.81
Node-61	8.50	32.93	19.34
Node-62	8.25	29.72	18.86
Node-63	7.75	28.05	18.77
Node-64	7.25	29.60	19.65
Node-65	4.25	30.45	20.27
Node-66	3.75	32.06	20.30
Node-67	3.25	30.31	19.85
Node-68	2.75	33.44	20.17
Node-69	2.50	30.34	19.68
Node-70	2.25	30.84	19.84
Node-71	1.75	28.85	19.93
Node-72	1.25	31.93	20.64
Node-73	-1.75	33.93	21.38
Node-74	-2.25	29.56	20.11
Node-75	-2.75	31.06	20.21
Node-76	-3.25	31.76	20.25
Node-77	-3.50	29.21	19.80
Node-78	-3.75	29.94	19.96
Node-79	-4.25	30.32	20.17
Node-80	-4.75	28.83	20.25
Node-81	-7.75	34.54	21.34
Node-82	-8.25	33.17	20.65
Node-83	-8.75	29.68	19.85
Node-84	-9.25	30.47	19.93
Node-85	-9.50	29.92	19.51
Node-86	-9.75	27.57	19.18
Node-87	-10.25	29.33	19.56
Node-88	-10.75	32.45	20.39
Node-89	-13.75	28.32	18.93
Node-90	-14.25	31.35	18.97
Node-91	-14.75	30.22	18.18
Node-92	-15.25	28.71	17.67
Node-93	-15.50	32.28	18.37
Node-94	-15.75	36.01	18.45
Node-95	-16.25	34.72	18.24
Node-96	-16.75	30.02	17.76

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 42. AGR-1 Fuel Compact Projected Fission Power Density and Burnup vs. EFPD (800 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) (continued)

Stack ID or Node ID	Node mid-point distance to core center (in)	800 EFPDs	
		Fission Power Density (W/cm^3)	Burnup (% FIMA)
Stack-2			
Node-97	16.25	37.39	14.58
Node-98	15.75	38.29	14.21
Node-99	15.25	40.20	14.59
Node-100	14.75	40.27	15.03
Node-101	14.50	39.98	15.27
Node-102	14.25	40.35	15.42
Node-103	13.75	40.04	15.72
Node-104	13.25	39.96	16.82
Node-105	10.25	37.38	18.28
Node-106	9.75	34.33	17.33
Node-107	9.25	35.33	17.40
Node-108	8.75	37.92	18.01
Node-109	8.50	37.14	18.00
Node-110	8.25	36.69	18.14
Node-111	7.75	33.13	17.79
Node-112	7.25	37.43	19.54
Node-113	4.25	35.69	19.67
Node-114	3.75	35.52	19.06
Node-115	3.25	35.77	19.21
Node-116	2.75	33.87	18.90
Node-117	2.50	34.98	19.18
Node-118	2.25	33.24	18.99
Node-119	1.75	31.31	18.97
Node-120	1.25	32.55	19.74
Node-121	-1.75	30.40	19.11
Node-122	-2.25	31.92	18.73
Node-123	-2.75	34.17	19.08
Node-124	-3.25	34.18	19.04
Node-125	-3.50	33.43	19.20
Node-126	-3.75	38.32	20.23
Node-127	-4.25	33.74	19.49
Node-128	-4.75	32.82	19.78
Node-129	-7.75	29.48	18.88
Node-130	-8.25	31.10	18.70
Node-131	-8.75	33.67	18.85
Node-132	-9.25	34.39	18.88
Node-133	-9.50	34.79	18.70
Node-134	-9.75	36.26	19.01
Node-135	-10.25	33.90	18.58
Node-136	-10.75	32.84	18.76
Node-137	-13.75	33.95	18.47
Node-138	-14.25	34.45	17.74
Node-139	-14.75	34.14	17.32
Node-140	-15.25	37.19	17.54
Node-141	-15.50	36.04	17.08
Node-142	-15.75	36.87	16.83
Node-143	-16.25	35.56	16.64
Node-144	-16.75	40.66	17.62

Note: 1) All table values have a relative uncertainty band of 1σ = 2.5%.
2) MCNP-calculated results were normalized to 22.47 MW East lobe power.

Table 43. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (0-150 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	0 EFPDs		50 EFPDs		100 EFPDs		150 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-1									
Node-1	16.25	0.42	0.00	0.43	1.84	0.43	3.69	0.43	5.57
Node-2	15.75	0.44	0.00	0.45	1.93	0.45	3.88	0.46	5.86
Node-3	15.25	0.46	0.00	0.47	2.01	0.47	4.05	0.48	6.12
Node-4	14.75	0.48	0.00	0.49	2.10	0.49	4.23	0.50	6.40
Node-5	14.50	0.49	0.00	0.50	2.17	0.51	4.38	0.52	6.63
Node-6	14.25	0.49	0.00	0.50	2.18	0.51	4.39	0.53	6.66
Node-7	13.75	0.50	0.00	0.51	2.20	0.52	4.42	0.53	6.71
Node-8	13.25	0.54	0.00	0.54	2.35	0.55	4.73	0.56	7.14
Node-9	10.25	0.59	0.00	0.60	2.58	0.61	5.22	0.62	7.91
Node-10	9.75	0.60	0.00	0.61	2.64	0.62	5.34	0.64	8.11
Node-11	9.25	0.60	0.00	0.61	2.65	0.63	5.36	0.64	8.14
Node-12	8.75	0.61	0.00	0.63	2.71	0.64	5.47	0.66	8.30
Node-13	8.50	0.63	0.00	0.64	2.77	0.66	5.60	0.67	8.51
Node-14	8.25	0.64	0.00	0.65	2.79	0.66	5.66	0.68	8.61
Node-15	7.75	0.66	0.00	0.67	2.88	0.68	5.84	0.70	8.88
Node-16	7.25	0.66	0.00	0.67	2.89	0.68	5.82	0.70	8.82
Node-17	4.25	0.70	0.00	0.71	3.07	0.73	6.20	0.74	9.41
Node-18	3.75	0.70	0.00	0.71	3.06	0.73	6.22	0.75	9.45
Node-19	3.25	0.72	0.00	0.73	3.15	0.74	6.36	0.77	9.66
Node-20	2.75	0.70	0.00	0.71	3.06	0.73	6.20	0.75	9.43
Node-21	2.50	0.70	0.00	0.72	3.09	0.73	6.26	0.75	9.52
Node-22	2.25	0.69	0.00	0.71	3.05	0.73	6.18	0.74	9.40
Node-23	1.75	0.69	0.00	0.71	3.05	0.72	6.18	0.74	9.40
Node-24	1.25	0.71	0.00	0.72	3.13	0.74	6.32	0.75	9.56
Node-25	-1.75	0.70	0.00	0.71	3.07	0.73	6.21	0.74	9.40
Node-26	-2.25	0.70	0.00	0.72	3.09	0.74	6.28	0.76	9.57
Node-27	-2.75	0.71	0.00	0.73	3.14	0.74	6.35	0.76	9.65
Node-28	-3.25	0.70	0.00	0.71	3.08	0.73	6.24	0.76	9.51
Node-29	-3.50	0.71	0.00	0.73	3.13	0.74	6.35	0.77	9.68
Node-30	-3.75	0.68	0.00	0.70	3.01	0.72	6.13	0.75	9.35
Node-31	-4.25	0.70	0.00	0.71	3.07	0.73	6.23	0.74	9.44
Node-32	-4.75	0.70	0.00	0.71	3.08	0.73	6.24	0.74	9.45
Node-33	-7.75	0.70	0.00	0.71	3.07	0.72	6.19	0.74	9.38
Node-34	-8.25	0.69	0.00	0.70	3.01	0.72	6.10	0.74	9.31
Node-35	-8.75	0.69	0.00	0.70	3.04	0.72	6.14	0.74	9.35
Node-36	-9.25	0.65	0.00	0.67	2.89	0.68	5.84	0.70	8.89
Node-37	-9.50	0.66	0.00	0.68	2.92	0.69	5.93	0.71	9.01
Node-38	-9.75	0.67	0.00	0.68	2.93	0.69	5.94	0.72	9.04
Node-39	-10.25	0.65	0.00	0.66	2.87	0.68	5.80	0.70	8.83
Node-40	-10.75	0.62	0.00	0.63	2.73	0.64	5.50	0.66	8.34
Node-41	-13.75	0.59	0.00	0.60	2.59	0.61	5.23	0.62	7.93
Node-42	-14.25	0.59	0.00	0.60	2.58	0.61	5.23	0.62	7.92
Node-43	-14.75	0.57	0.00	0.58	2.52	0.59	5.09	0.61	7.71
Node-44	-15.25	0.56	0.00	0.57	2.45	0.58	4.95	0.59	7.51
Node-45	-15.50	0.53	0.00	0.54	2.35	0.55	4.74	0.57	7.19
Node-46	-15.75	0.52	0.00	0.53	2.30	0.54	4.64	0.56	7.04
Node-47	-16.25	0.50	0.00	0.51	2.18	0.51	4.40	0.53	6.67
Node-48	-16.75	0.49	0.00	0.50	2.15	0.50	4.31	0.51	6.53

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 43. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (0-150 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	0 EFPDs		50 EFPDs		100 EFPDs		150 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-3									
Node-49	16.25	0.43	0.00	0.43	1.87	0.44	3.76	0.44	5.67
Node-50	15.75	0.46	0.00	0.46	2.00	0.47	4.03	0.48	6.08
Node-51	15.25	0.47	0.00	0.47	2.04	0.48	4.12	0.49	6.23
Node-52	14.75	0.48	0.00	0.48	2.09	0.49	4.22	0.50	6.39
Node-53	14.50	0.51	0.00	0.51	2.21	0.52	4.47	0.53	6.75
Node-54	14.25	0.50	0.00	0.51	2.19	0.52	4.42	0.53	6.70
Node-55	13.75	0.52	0.00	0.53	2.28	0.54	4.59	0.55	6.95
Node-56	13.25	0.54	0.00	0.55	2.36	0.55	4.73	0.55	7.12
Node-57	10.25	0.60	0.00	0.61	2.64	0.62	5.32	0.64	8.07
Node-58	9.75	0.62	0.00	0.63	2.73	0.64	5.51	0.66	8.37
Node-59	9.25	0.61	0.00	0.62	2.68	0.63	5.42	0.65	8.22
Node-60	8.75	0.63	0.00	0.64	2.76	0.65	5.57	0.67	8.44
Node-61	8.50	0.62	0.00	0.63	2.72	0.65	5.50	0.66	8.35
Node-62	8.25	0.64	0.00	0.65	2.82	0.67	5.70	0.69	8.66
Node-63	7.75	0.66	0.00	0.67	2.89	0.68	5.84	0.70	8.86
Node-64	7.25	0.66	0.00	0.67	2.88	0.68	5.81	0.69	8.79
Node-65	4.25	0.70	0.00	0.72	3.09	0.73	6.25	0.74	9.46
Node-66	3.75	0.70	0.00	0.72	3.09	0.73	6.25	0.75	9.50
Node-67	3.25	0.71	0.00	0.72	3.10	0.74	6.29	0.76	9.56
Node-68	2.75	0.71	0.00	0.72	3.11	0.74	6.29	0.76	9.59
Node-69	2.50	0.72	0.00	0.74	3.19	0.75	6.44	0.77	9.78
Node-70	2.25	0.71	0.00	0.73	3.14	0.74	6.35	0.77	9.65
Node-71	1.75	0.72	0.00	0.74	3.19	0.75	6.45	0.78	9.80
Node-72	1.25	0.71	0.00	0.72	3.12	0.73	6.28	0.75	9.51
Node-73	-1.75	0.72	0.00	0.73	3.15	0.74	6.34	0.76	9.62
Node-74	-2.25	0.72	0.00	0.73	3.17	0.75	6.40	0.77	9.73
Node-75	-2.75	0.71	0.00	0.73	3.14	0.75	6.36	0.76	9.66
Node-76	-3.25	0.71	0.00	0.73	3.15	0.74	6.37	0.76	9.65
Node-77	-3.50	0.70	0.00	0.72	3.10	0.73	6.25	0.75	9.49
Node-78	-3.75	0.70	0.00	0.71	3.07	0.73	6.21	0.74	9.42
Node-79	-4.25	0.71	0.00	0.72	3.12	0.74	6.31	0.76	9.59
Node-80	-4.75	0.69	0.00	0.71	3.05	0.72	6.16	0.74	9.35
Node-81	-7.75	0.69	0.00	0.70	3.03	0.72	6.12	0.73	9.28
Node-82	-8.25	0.69	0.00	0.71	3.05	0.73	6.19	0.74	9.38
Node-83	-8.75	0.69	0.00	0.70	3.03	0.72	6.14	0.74	9.34
Node-84	-9.25	0.66	0.00	0.67	2.90	0.69	5.88	0.71	8.95
Node-85	-9.50	0.68	0.00	0.69	3.00	0.71	6.05	0.73	9.19
Node-86	-9.75	0.66	0.00	0.68	2.93	0.69	5.92	0.71	8.99
Node-87	-10.25	0.66	0.00	0.67	2.91	0.69	5.91	0.71	8.98
Node-88	-10.75	0.64	0.00	0.65	2.83	0.66	5.70	0.68	8.64
Node-89	-13.75	0.59	0.00	0.60	2.61	0.61	5.26	0.62	7.94
Node-90	-14.25	0.59	0.00	0.60	2.60	0.61	5.24	0.63	7.95
Node-91	-14.75	0.56	0.00	0.57	2.46	0.58	4.98	0.60	7.55
Node-92	-15.25	0.57	0.00	0.58	2.50	0.59	5.04	0.60	7.64
Node-93	-15.50	0.54	0.00	0.55	2.39	0.56	4.82	0.58	7.33
Node-94	-15.75	0.53	0.00	0.54	2.33	0.55	4.69	0.56	7.13
Node-95	-16.25	0.51	0.00	0.51	2.21	0.53	4.48	0.54	6.81
Node-96	-16.75	0.49	0.00	0.50	2.16	0.51	4.36	0.52	6.59

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 43. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (0-150 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	0 EFPDs		50 EFPDs		100 EFPDs		150 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-2									
Node-97	16.25	0.37	0.00	0.38	1.63	0.38	3.28	0.39	4.96
Node-98	15.75	0.38	0.00	0.39	1.68	0.39	3.38	0.40	5.10
Node-99	15.25	0.40	0.00	0.41	1.76	0.41	3.55	0.42	5.37
Node-100	14.75	0.42	0.00	0.42	1.84	0.43	3.70	0.44	5.60
Node-101	14.50	0.43	0.00	0.44	1.90	0.45	3.82	0.46	5.79
Node-102	14.25	0.43	0.00	0.43	1.88	0.44	3.79	0.45	5.75
Node-103	13.75	0.46	0.00	0.47	2.02	0.48	4.08	0.49	6.18
Node-104	13.25	0.46	0.00	0.47	2.02	0.47	4.05	0.48	6.11
Node-105	10.25	0.53	0.00	0.54	2.31	0.55	4.69	0.56	7.12
Node-106	9.75	0.54	0.00	0.55	2.37	0.56	4.81	0.58	7.30
Node-107	9.25	0.54	0.00	0.55	2.38	0.57	4.83	0.58	7.34
Node-108	8.75	0.55	0.00	0.56	2.40	0.57	4.87	0.59	7.41
Node-109	8.50	0.55	0.00	0.56	2.41	0.58	4.89	0.59	7.46
Node-110	8.25	0.57	0.00	0.57	2.48	0.59	5.04	0.61	7.68
Node-111	7.75	0.56	0.00	0.57	2.47	0.59	5.01	0.61	7.63
Node-112	7.25	0.57	0.00	0.58	2.50	0.59	5.04	0.60	7.65
Node-113	4.25	0.62	0.00	0.62	2.70	0.64	5.44	0.65	8.27
Node-114	3.75	0.61	0.00	0.62	2.69	0.64	5.46	0.66	8.32
Node-115	3.25	0.61	0.00	0.62	2.66	0.63	5.39	0.66	8.23
Node-116	2.75	0.61	0.00	0.62	2.66	0.63	5.40	0.66	8.23
Node-117	2.50	0.62	0.00	0.63	2.71	0.64	5.47	0.67	8.35
Node-118	2.25	0.62	0.00	0.63	2.71	0.64	5.50	0.67	8.39
Node-119	1.75	0.62	0.00	0.63	2.74	0.65	5.56	0.68	8.48
Node-120	1.25	0.62	0.00	0.64	2.74	0.65	5.54	0.66	8.40
Node-121	-1.75	0.62	0.00	0.63	2.71	0.64	5.47	0.66	8.34
Node-122	-2.25	0.61	0.00	0.62	2.69	0.64	5.46	0.66	8.33
Node-123	-2.75	0.63	0.00	0.64	2.76	0.65	5.58	0.68	8.51
Node-124	-3.25	0.63	0.00	0.64	2.77	0.66	5.62	0.68	8.57
Node-125	-3.50	0.62	0.00	0.64	2.75	0.66	5.58	0.67	8.49
Node-126	-3.75	0.61	0.00	0.62	2.67	0.64	5.43	0.66	8.28
Node-127	-4.25	0.61	0.00	0.63	2.71	0.64	5.49	0.66	8.35
Node-128	-4.75	0.61	0.00	0.62	2.69	0.64	5.45	0.66	8.29
Node-129	-7.75	0.60	0.00	0.61	2.63	0.62	5.32	0.64	8.09
Node-130	-8.25	0.59	0.00	0.60	2.60	0.62	5.26	0.64	8.03
Node-131	-8.75	0.61	0.00	0.63	2.70	0.64	5.47	0.67	8.35
Node-132	-9.25	0.60	0.00	0.60	2.61	0.62	5.29	0.64	8.05
Node-133	-9.50	0.58	0.00	0.59	2.55	0.60	5.16	0.63	7.86
Node-134	-9.75	0.58	0.00	0.59	2.57	0.61	5.19	0.63	7.90
Node-135	-10.25	0.57	0.00	0.58	2.53	0.60	5.12	0.62	7.80
Node-136	-10.75	0.55	0.00	0.56	2.42	0.57	4.89	0.59	7.44
Node-137	-13.75	0.53	0.00	0.54	2.32	0.55	4.69	0.56	7.10
Node-138	-14.25	0.50	0.00	0.51	2.20	0.52	4.47	0.54	6.80
Node-139	-14.75	0.49	0.00	0.50	2.15	0.51	4.37	0.53	6.66
Node-140	-15.25	0.50	0.00	0.50	2.18	0.52	4.43	0.53	6.74
Node-141	-15.50	0.48	0.00	0.48	2.09	0.50	4.23	0.51	6.43
Node-142	-15.75	0.45	0.00	0.46	2.00	0.48	4.05	0.49	6.15
Node-143	-16.25	0.44	0.00	0.45	1.94	0.46	3.91	0.47	5.94
Node-144	-16.75	0.43	0.00	0.43	1.88	0.44	3.79	0.45	5.75

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 44. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (200-350 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	200 EFPDs		250 EFPDs		300 EFPDs		350 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-1									
Node-1	16.25	0.44	7.46	0.44	9.38	0.44	11.30	0.44	13.22
Node-2	15.75	0.47	7.87	0.48	9.93	0.48	12.00	0.48	14.06
Node-3	15.25	0.49	8.22	0.50	10.36	0.50	12.51	0.50	14.67
Node-4	14.75	0.51	8.60	0.52	10.83	0.52	13.07	0.52	15.32
Node-5	14.50	0.53	8.93	0.54	11.27	0.55	13.63	0.55	15.99
Node-6	14.25	0.53	8.97	0.54	11.31	0.55	13.67	0.54	16.02
Node-7	13.75	0.54	9.03	0.55	11.40	0.55	13.79	0.55	16.15
Node-8	13.25	0.56	9.58	0.57	12.05	0.57	14.54	0.57	16.99
Node-9	10.25	0.63	10.64	0.64	13.39	0.63	16.12	0.63	18.84
Node-10	9.75	0.65	10.94	0.66	13.79	0.66	16.63	0.65	19.46
Node-11	9.25	0.66	10.99	0.67	13.88	0.67	16.77	0.66	19.63
Node-12	8.75	0.68	11.23	0.69	14.20	0.68	17.15	0.67	20.06
Node-13	8.50	0.69	11.50	0.70	14.53	0.70	17.56	0.69	20.56
Node-14	8.25	0.69	11.61	0.70	14.64	0.70	17.67	0.69	20.63
Node-15	7.75	0.72	11.97	0.72	15.09	0.72	18.18	0.70	21.20
Node-16	7.25	0.70	11.86	0.70	14.89	0.70	17.91	0.68	20.87
Node-17	4.25	0.75	12.66	0.75	15.91	0.74	19.09	0.72	22.20
Node-18	3.75	0.76	12.75	0.77	16.06	0.76	19.33	0.74	22.53
Node-19	3.25	0.78	13.04	0.79	16.45	0.78	19.82	0.76	23.10
Node-20	2.75	0.77	12.74	0.77	16.08	0.76	19.39	0.75	22.62
Node-21	2.50	0.77	12.85	0.78	16.24	0.77	19.56	0.76	22.83
Node-22	2.25	0.77	12.71	0.77	16.03	0.76	19.32	0.74	22.54
Node-23	1.75	0.76	12.68	0.77	16.00	0.75	19.24	0.73	22.41
Node-24	1.25	0.76	12.82	0.76	16.09	0.75	19.31	0.73	22.46
Node-25	-1.75	0.75	12.64	0.75	15.88	0.74	19.06	0.73	22.20
Node-26	-2.25	0.78	12.93	0.77	16.27	0.76	19.56	0.74	22.76
Node-27	-2.75	0.79	13.04	0.79	16.44	0.78	19.80	0.76	23.09
Node-28	-3.25	0.78	12.87	0.78	16.26	0.78	19.61	0.75	22.87
Node-29	-3.50	0.79	13.08	0.80	16.52	0.78	19.90	0.76	23.21
Node-30	-3.75	0.76	12.64	0.78	16.01	0.77	19.33	0.75	22.55
Node-31	-4.25	0.76	12.72	0.77	16.06	0.76	19.35	0.74	22.56
Node-32	-4.75	0.75	12.69	0.75	15.95	0.74	19.14	0.72	22.27
Node-33	-7.75	0.75	12.60	0.74	15.82	0.74	19.00	0.72	22.11
Node-34	-8.25	0.76	12.59	0.76	15.86	0.75	19.10	0.73	22.25
Node-35	-8.75	0.76	12.63	0.77	15.94	0.76	19.23	0.74	22.44
Node-36	-9.25	0.73	12.02	0.73	15.19	0.73	18.34	0.71	21.42
Node-37	-9.50	0.73	12.17	0.74	15.36	0.74	18.53	0.72	21.64
Node-38	-9.75	0.74	12.22	0.74	15.42	0.74	18.62	0.72	21.75
Node-39	-10.25	0.71	11.91	0.72	15.01	0.71	18.09	0.69	21.09
Node-40	-10.75	0.67	11.22	0.67	14.12	0.66	16.98	0.65	19.79
Node-41	-13.75	0.62	10.62	0.63	13.32	0.62	15.99	0.61	18.61
Node-42	-14.25	0.64	10.67	0.63	13.39	0.63	16.11	0.62	18.77
Node-43	-14.75	0.62	10.40	0.62	13.09	0.62	15.78	0.61	18.43
Node-44	-15.25	0.61	10.14	0.61	12.76	0.61	15.39	0.60	17.96
Node-45	-15.50	0.57	9.67	0.58	12.16	0.58	14.67	0.57	17.11
Node-46	-15.75	0.57	9.51	0.58	12.00	0.58	14.50	0.57	16.96
Node-47	-16.25	0.54	8.99	0.54	11.33	0.54	13.67	0.53	15.98
Node-48	-16.75	0.52	8.77	0.52	11.04	0.52	13.28	0.51	15.51

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 44. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (200-350 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	200 EFPDs		250 EFPDs		300 EFPDs		350 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-3									
Node-49	16.25	0.45	7.61	0.45	9.57	0.45	11.53	0.46	13.49
Node-50	15.75	0.48	8.16	0.49	10.29	0.50	12.44	0.50	14.60
Node-51	15.25	0.50	8.38	0.51	10.57	0.51	12.78	0.51	15.00
Node-52	14.75	0.51	8.58	0.52	10.81	0.52	13.04	0.52	15.27
Node-53	14.50	0.54	9.07	0.55	11.43	0.55	13.81	0.55	16.20
Node-54	14.25	0.54	9.02	0.55	11.37	0.55	13.76	0.55	16.14
Node-55	13.75	0.55	9.35	0.56	11.77	0.57	14.22	0.57	16.67
Node-56	13.25	0.56	9.55	0.57	12.01	0.57	14.46	0.57	16.91
Node-57	10.25	0.64	10.85	0.65	13.66	0.65	16.47	0.64	19.25
Node-58	9.75	0.67	11.27	0.68	14.19	0.68	17.12	0.67	20.02
Node-59	9.25	0.66	11.07	0.67	13.98	0.67	16.88	0.67	19.76
Node-60	8.75	0.68	11.38	0.69	14.37	0.69	17.37	0.69	20.34
Node-61	8.50	0.68	11.28	0.68	14.23	0.69	17.19	0.67	20.10
Node-62	8.25	0.70	11.70	0.71	14.75	0.70	17.79	0.69	20.77
Node-63	7.75	0.72	11.96	0.72	15.06	0.72	18.16	0.70	21.20
Node-64	7.25	0.70	11.82	0.70	14.85	0.70	17.86	0.68	20.82
Node-65	4.25	0.75	12.70	0.75	15.95	0.74	19.14	0.73	22.28
Node-66	3.75	0.77	12.82	0.78	16.18	0.77	19.50	0.75	22.75
Node-67	3.25	0.78	12.92	0.79	16.33	0.78	19.68	0.76	22.95
Node-68	2.75	0.79	12.99	0.80	16.43	0.79	19.83	0.77	23.16
Node-69	2.50	0.80	13.23	0.81	16.73	0.80	20.19	0.78	23.55
Node-70	2.25	0.78	13.03	0.79	16.44	0.78	19.82	0.76	23.10
Node-71	1.75	0.80	13.26	0.80	16.73	0.79	20.14	0.77	23.48
Node-72	1.25	0.76	12.78	0.76	16.05	0.75	19.28	0.73	22.44
Node-73	-1.75	0.77	12.93	0.77	16.26	0.76	19.54	0.75	22.77
Node-74	-2.25	0.78	13.11	0.79	16.52	0.78	19.88	0.76	23.16
Node-75	-2.75	0.78	13.04	0.79	16.47	0.78	19.83	0.76	23.13
Node-76	-3.25	0.78	13.02	0.79	16.45	0.79	19.86	0.77	23.19
Node-77	-3.50	0.77	12.82	0.79	16.22	0.78	19.59	0.76	22.87
Node-78	-3.75	0.76	12.72	0.77	16.06	0.77	19.37	0.75	22.60
Node-79	-4.25	0.78	12.95	0.79	16.34	0.77	19.68	0.76	22.95
Node-80	-4.75	0.74	12.56	0.74	15.77	0.73	18.93	0.72	22.02
Node-81	-7.75	0.74	12.48	0.74	15.67	0.73	18.82	0.72	21.92
Node-82	-8.25	0.75	12.64	0.75	15.90	0.75	19.12	0.73	22.29
Node-83	-8.75	0.76	12.61	0.76	15.89	0.75	19.14	0.74	22.32
Node-84	-9.25	0.72	12.08	0.73	15.24	0.73	18.38	0.72	21.47
Node-85	-9.50	0.75	12.41	0.75	15.67	0.75	18.91	0.74	22.10
Node-86	-9.75	0.73	12.14	0.74	15.33	0.73	18.50	0.72	21.60
Node-87	-10.25	0.72	12.08	0.73	15.22	0.72	18.32	0.70	21.37
Node-88	-10.75	0.69	11.61	0.69	14.61	0.69	17.58	0.68	20.50
Node-89	-13.75	0.63	10.66	0.63	13.37	0.62	16.05	0.61	18.68
Node-90	-14.25	0.64	10.72	0.64	13.50	0.63	16.22	0.62	18.90
Node-91	-14.75	0.61	10.21	0.62	12.87	0.61	15.51	0.60	18.11
Node-92	-15.25	0.62	10.32	0.62	13.00	0.62	15.69	0.61	18.31
Node-93	-15.50	0.59	9.89	0.60	12.47	0.60	15.05	0.59	17.59
Node-94	-15.75	0.58	9.61	0.58	12.13	0.59	14.66	0.58	17.15
Node-95	-16.25	0.55	9.17	0.55	11.56	0.55	13.95	0.54	16.30
Node-96	-16.75	0.52	8.83	0.52	11.06	0.52	13.31	0.52	15.54

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 44. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (200-350 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	200 EFPDs		250 EFPDs		300 EFPDs		350 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-2									
Node-97	16.25	0.39	6.65	0.40	8.38	0.40	10.12	0.40	11.86
Node-98	15.75	0.41	6.85	0.42	8.65	0.42	10.49	0.42	12.32
Node-99	15.25	0.43	7.24	0.44	9.16	0.45	11.11	0.45	13.07
Node-100	14.75	0.45	7.55	0.46	9.53	0.46	11.53	0.47	13.56
Node-101	14.50	0.47	7.80	0.48	9.87	0.49	11.97	0.49	14.10
Node-102	14.25	0.46	7.76	0.47	9.81	0.48	11.90	0.49	14.00
Node-103	13.75	0.50	8.33	0.51	10.51	0.51	12.72	0.51	14.94
Node-104	13.25	0.48	8.20	0.49	10.32	0.50	12.47	0.49	14.60
Node-105	10.25	0.57	9.60	0.58	12.09	0.58	14.60	0.58	17.09
Node-106	9.75	0.59	9.86	0.60	12.46	0.60	15.07	0.59	17.64
Node-107	9.25	0.60	9.92	0.61	12.56	0.62	15.22	0.61	17.85
Node-108	8.75	0.60	10.01	0.62	12.70	0.62	15.40	0.62	18.08
Node-109	8.50	0.61	10.08	0.62	12.76	0.62	15.46	0.61	18.12
Node-110	8.25	0.63	10.39	0.64	13.17	0.64	15.95	0.63	18.69
Node-111	7.75	0.62	10.33	0.63	13.06	0.64	15.80	0.63	18.50
Node-112	7.25	0.61	10.30	0.62	13.00	0.62	15.68	0.61	18.33
Node-113	4.25	0.67	11.17	0.68	14.10	0.67	16.99	0.66	19.82
Node-114	3.75	0.68	11.27	0.69	14.27	0.69	17.23	0.67	20.14
Node-115	3.25	0.67	11.14	0.69	14.11	0.69	17.09	0.68	20.00
Node-116	2.75	0.68	11.17	0.69	14.16	0.69	17.13	0.67	20.04
Node-117	2.50	0.69	11.35	0.71	14.41	0.70	17.45	0.69	20.41
Node-118	2.25	0.69	11.35	0.70	14.39	0.70	17.41	0.69	20.37
Node-119	1.75	0.69	11.47	0.71	14.51	0.70	17.54	0.68	20.49
Node-120	1.25	0.68	11.35	0.69	14.33	0.68	17.26	0.66	20.12
Node-121	-1.75	0.68	11.26	0.68	14.20	0.67	17.11	0.66	19.98
Node-122	-2.25	0.69	11.29	0.69	14.28	0.69	17.26	0.67	20.18
Node-123	-2.75	0.70	11.55	0.72	14.65	0.71	17.73	0.70	20.73
Node-124	-3.25	0.71	11.63	0.72	14.74	0.71	17.83	0.70	20.86
Node-125	-3.50	0.70	11.51	0.72	14.60	0.71	17.67	0.70	20.68
Node-126	-3.75	0.69	11.25	0.70	14.27	0.69	17.25	0.67	20.16
Node-127	-4.25	0.68	11.30	0.70	14.32	0.69	17.29	0.67	20.19
Node-128	-4.75	0.67	11.18	0.67	14.09	0.67	16.97	0.65	19.80
Node-129	-7.75	0.65	10.92	0.66	13.75	0.65	16.55	0.63	19.29
Node-130	-8.25	0.67	10.91	0.67	13.80	0.66	16.66	0.65	19.45
Node-131	-8.75	0.69	11.34	0.69	14.34	0.69	17.32	0.67	20.24
Node-132	-9.25	0.66	10.90	0.67	13.79	0.67	16.68	0.66	19.54
Node-133	-9.50	0.65	10.65	0.66	13.51	0.66	16.38	0.65	19.19
Node-134	-9.75	0.65	10.72	0.67	13.60	0.67	16.49	0.66	19.33
Node-135	-10.25	0.64	10.56	0.65	13.37	0.65	16.17	0.63	18.91
Node-136	-10.75	0.61	10.06	0.62	12.73	0.61	15.37	0.60	17.94
Node-137	-13.75	0.57	9.55	0.57	12.00	0.57	14.45	0.56	16.85
Node-138	-14.25	0.55	9.19	0.56	11.61	0.55	14.00	0.54	16.35
Node-139	-14.75	0.54	9.00	0.55	11.36	0.55	13.73	0.54	16.06
Node-140	-15.25	0.55	9.12	0.56	11.52	0.56	13.94	0.55	16.33
Node-141	-15.50	0.53	8.70	0.53	11.00	0.54	13.34	0.53	15.65
Node-142	-15.75	0.50	8.31	0.51	10.52	0.52	12.75	0.51	14.96
Node-143	-16.25	0.48	8.03	0.49	10.13	0.49	12.26	0.49	14.36
Node-144	-16.75	0.46	7.75	0.47	9.77	0.47	11.81	0.47	13.82

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 45. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (400-550 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	400 EFPDs		450 EFPDs		500 EFPDs		550 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-1									
Node-1	16.25	0.45	15.16	0.44	17.08	0.44	18.98	0.43	20.85
Node-2	15.75	0.48	16.12	0.47	18.14	0.46	20.14	0.46	22.12
Node-3	15.25	0.49	16.80	0.49	18.91	0.48	20.97	0.47	23.01
Node-4	14.75	0.52	17.55	0.51	19.75	0.50	21.91	0.49	24.03
Node-5	14.50	0.54	18.32	0.53	20.60	0.52	22.86	0.51	25.08
Node-6	14.25	0.54	18.37	0.53	20.67	0.52	22.94	0.52	25.17
Node-7	13.75	0.55	18.51	0.54	20.83	0.53	23.11	0.52	25.35
Node-8	13.25	0.56	19.42	0.55	21.82	0.55	24.19	0.54	26.52
Node-9	10.25	0.62	21.50	0.61	24.12	0.60	26.71	0.59	29.26
Node-10	9.75	0.64	22.22	0.63	24.94	0.62	27.61	0.61	30.25
Node-11	9.25	0.65	22.43	0.63	25.16	0.62	27.85	0.61	30.49
Node-12	8.75	0.66	22.92	0.65	25.71	0.64	28.46	0.62	31.16
Node-13	8.50	0.68	23.50	0.67	26.37	0.65	29.20	0.64	31.97
Node-14	8.25	0.67	23.55	0.66	26.40	0.65	29.20	0.64	31.96
Node-15	7.75	0.69	24.17	0.67	27.07	0.66	29.92	0.65	32.72
Node-16	7.25	0.67	23.76	0.66	26.59	0.65	29.39	0.64	32.15
Node-17	4.25	0.71	25.25	0.70	28.26	0.69	31.23	0.68	34.17
Node-18	3.75	0.72	25.65	0.71	28.70	0.70	31.71	0.69	34.67
Node-19	3.25	0.74	26.31	0.73	29.45	0.71	32.54	0.70	35.58
Node-20	2.75	0.73	25.76	0.71	28.84	0.70	31.87	0.69	34.84
Node-21	2.50	0.74	26.01	0.72	29.12	0.71	32.18	0.70	35.19
Node-22	2.25	0.73	25.67	0.71	28.73	0.70	31.74	0.68	34.70
Node-23	1.75	0.72	25.53	0.71	28.58	0.70	31.59	0.69	34.55
Node-24	1.25	0.72	25.59	0.71	28.66	0.70	31.68	0.69	34.68
Node-25	-1.75	0.71	25.28	0.70	28.29	0.69	31.28	0.68	34.24
Node-26	-2.25	0.72	25.87	0.71	28.93	0.70	31.93	0.69	34.91
Node-27	-2.75	0.74	26.30	0.73	29.46	0.72	32.57	0.71	35.63
Node-28	-3.25	0.74	26.06	0.72	29.18	0.71	32.25	0.70	35.27
Node-29	-3.50	0.75	26.44	0.73	29.59	0.72	32.70	0.71	35.77
Node-30	-3.75	0.72	25.68	0.71	28.74	0.70	31.75	0.69	34.73
Node-31	-4.25	0.72	25.67	0.71	28.73	0.70	31.73	0.69	34.71
Node-32	-4.75	0.71	25.32	0.70	28.33	0.69	31.30	0.68	34.25
Node-33	-7.75	0.70	25.14	0.69	28.12	0.68	31.07	0.68	33.99
Node-34	-8.25	0.72	25.35	0.70	28.37	0.69	31.36	0.68	34.31
Node-35	-8.75	0.72	25.56	0.71	28.63	0.70	31.65	0.69	34.63
Node-36	-9.25	0.69	24.41	0.68	27.35	0.67	30.25	0.66	33.11
Node-37	-9.50	0.70	24.67	0.69	27.65	0.68	30.57	0.67	33.44
Node-38	-9.75	0.71	24.81	0.69	27.80	0.68	30.73	0.67	33.61
Node-39	-10.25	0.68	24.02	0.67	26.91	0.66	29.76	0.65	32.57
Node-40	-10.75	0.64	22.54	0.63	25.24	0.62	27.91	0.61	30.54
Node-41	-13.75	0.60	21.18	0.59	23.73	0.58	26.24	0.57	28.72
Node-42	-14.25	0.61	21.39	0.60	23.97	0.59	26.51	0.58	29.00
Node-43	-14.75	0.60	21.04	0.59	23.59	0.58	26.11	0.57	28.58
Node-44	-15.25	0.59	20.50	0.58	23.00	0.57	25.45	0.56	27.87
Node-45	-15.50	0.56	19.52	0.55	21.89	0.54	24.21	0.53	26.51
Node-46	-15.75	0.56	19.37	0.55	21.73	0.54	24.05	0.53	26.34
Node-47	-16.25	0.52	18.24	0.51	20.46	0.50	22.63	0.50	24.78
Node-48	-16.75	0.51	17.70	0.50	19.85	0.49	21.96	0.48	24.05

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 45. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (400-550 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	400 EFPDs		450 EFPDs		500 EFPDs		550 EFPDs	
		Fast Flux x10^{14} (n/cm^{2}sec)	Fast Fluence x10^{20} (n/cm^2)	Fast Flux x10^{14} (n/cm^{2}sec)	Fast Fluence x10^{20} (n/cm^2)	Fast Flux x10^{14} (n/cm^{2}sec)	Fast Fluence x10^{20} (n/cm^2)	Fast Flux x10^{14} (n/cm^{2}sec)	Fast Fluence x10^{20} (n/cm^2)
Stack-3									
Node-49	16.25	0.45	15.44	0.45	17.37	0.44	19.29	0.44	21.19
Node-50	15.75	0.49	16.72	0.49	18.84	0.48	20.93	0.48	23.00
Node-51	15.25	0.51	17.18	0.50	19.35	0.49	21.48	0.49	23.60
Node-52	14.75	0.51	17.49	0.51	19.69	0.50	21.86	0.49	23.99
Node-53	14.50	0.55	18.57	0.54	20.91	0.53	23.22	0.53	25.49
Node-54	14.25	0.55	18.52	0.54	20.86	0.53	23.17	0.53	25.44
Node-55	13.75	0.56	19.11	0.56	21.52	0.55	23.90	0.54	26.25
Node-56	13.25	0.56	19.33	0.55	21.72	0.55	24.08	0.54	26.42
Node-57	10.25	0.63	21.97	0.62	24.66	0.61	27.31	0.61	29.92
Node-58	9.75	0.65	22.85	0.64	25.62	0.63	28.35	0.62	31.05
Node-59	9.25	0.65	22.59	0.64	25.37	0.63	28.11	0.62	30.80
Node-60	8.75	0.68	23.27	0.67	26.15	0.65	28.98	0.64	31.75
Node-61	8.50	0.66	22.95	0.65	25.75	0.64	28.51	0.63	31.22
Node-62	8.25	0.68	23.69	0.66	26.55	0.65	29.36	0.65	32.15
Node-63	7.75	0.69	24.17	0.67	27.07	0.66	29.92	0.65	32.75
Node-64	7.25	0.67	23.73	0.66	26.58	0.65	29.41	0.65	32.22
Node-65	4.25	0.72	25.37	0.70	28.40	0.69	31.40	0.69	34.36
Node-66	3.75	0.74	25.93	0.72	29.04	0.71	32.10	0.70	35.14
Node-67	3.25	0.74	26.15	0.72	29.27	0.71	32.35	0.70	35.39
Node-68	2.75	0.75	26.42	0.74	29.60	0.72	32.73	0.71	35.79
Node-69	2.50	0.76	26.82	0.74	30.04	0.73	33.19	0.72	36.29
Node-70	2.25	0.74	26.32	0.73	29.47	0.72	32.58	0.71	35.65
Node-71	1.75	0.75	26.74	0.74	29.92	0.73	33.07	0.72	36.19
Node-72	1.25	0.72	25.53	0.71	28.58	0.70	31.59	0.69	34.58
Node-73	-1.75	0.73	25.93	0.72	29.05	0.71	32.12	0.71	35.17
Node-74	-2.25	0.74	26.37	0.73	29.52	0.72	32.62	0.71	35.69
Node-75	-2.75	0.75	26.36	0.73	29.52	0.72	32.63	0.71	35.68
Node-76	-3.25	0.75	26.45	0.74	29.63	0.72	32.76	0.71	35.83
Node-77	-3.50	0.74	26.08	0.72	29.21	0.71	32.28	0.70	35.31
Node-78	-3.75	0.73	25.76	0.72	28.85	0.70	31.90	0.69	34.89
Node-79	-4.25	0.74	26.14	0.72	29.27	0.71	32.34	0.71	35.39
Node-80	-4.75	0.70	25.06	0.69	28.05	0.68	30.99	0.68	33.91
Node-81	-7.75	0.70	24.96	0.69	27.95	0.69	30.91	0.68	33.85
Node-82	-8.25	0.72	25.38	0.70	28.42	0.70	31.43	0.69	34.40
Node-83	-8.75	0.72	25.44	0.71	28.50	0.70	31.52	0.69	34.48
Node-84	-9.25	0.70	24.49	0.69	27.45	0.67	30.36	0.66	33.22
Node-85	-9.50	0.72	25.22	0.71	28.27	0.70	31.28	0.68	34.22
Node-86	-9.75	0.70	24.64	0.69	27.61	0.67	30.51	0.66	33.37
Node-87	-10.25	0.69	24.34	0.67	27.26	0.66	30.11	0.65	32.93
Node-88	-10.75	0.66	23.35	0.65	26.15	0.64	28.91	0.63	31.64
Node-89	-13.75	0.60	21.28	0.59	23.84	0.59	26.38	0.58	28.89
Node-90	-14.25	0.61	21.53	0.60	24.11	0.59	26.64	0.58	29.15
Node-91	-14.75	0.60	20.68	0.58	23.20	0.57	25.68	0.56	28.11
Node-92	-15.25	0.60	20.90	0.59	23.44	0.58	25.95	0.57	28.42
Node-93	-15.50	0.58	20.08	0.57	22.53	0.56	24.94	0.55	27.32
Node-94	-15.75	0.57	19.59	0.55	21.98	0.54	24.33	0.54	26.65
Node-95	-16.25	0.53	18.60	0.52	20.85	0.51	23.06	0.51	25.24
Node-96	-16.75	0.51	17.72	0.50	19.87	0.49	21.98	0.48	24.08

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 45. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (400-550 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	400 EFPDs		450 EFPDs		500 EFPDs		550 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-2									
Node-97	**16.25**	0.40	13.60	0.40	**15.33**	0.40	17.05	0.39	18.74
Node-98	15.75	0.43	14.16	0.42	15.97	0.41	17.75	0.41	19.51
Node-99	15.25	0.45	15.00	0.45	16.93	0.44	18.81	0.43	20.68
Node-100	14.75	0.47	15.57	0.46	17.57	0.45	19.53	0.45	21.47
Node-101	14.50	0.49	16.22	0.48	18.31	0.47	20.36	0.47	22.38
Node-102	14.25	0.49	16.10	0.48	18.16	0.47	20.19	0.46	22.18
Node-103	13.75	0.51	17.13	0.50	19.30	0.49	21.44	0.48	23.53
Node-104	13.25	0.49	16.72	0.49	18.82	0.48	20.89	0.48	22.95
Node-105	10.25	0.57	19.54	0.56	21.94	0.55	24.31	0.54	26.64
Node-106	9.75	0.58	20.16	0.58	22.65	0.57	25.09	0.56	27.49
Node-107	9.25	0.60	20.43	0.59	22.96	0.58	25.46	0.57	27.92
Node-108	8.75	0.61	20.73	0.60	23.33	0.59	25.87	0.58	28.38
Node-109	8.50	0.60	20.73	0.59	23.28	0.58	25.79	0.57	28.28
Node-110	8.25	0.62	21.37	0.61	24.00	0.60	26.59	0.59	29.14
Node-111	7.75	0.61	21.15	0.60	23.74	0.59	26.29	0.58	28.79
Node-112	7.25	0.60	20.92	0.59	23.47	0.58	26.00	0.58	28.49
Node-113	4.25	0.64	22.60	0.64	25.36	0.63	28.08	0.62	30.77
Node-114	3.75	0.66	23.00	0.65	25.79	0.63	28.53	0.63	31.24
Node-115	3.25	0.66	22.84	0.64	25.62	0.63	28.36	0.63	31.07
Node-116	2.75	0.65	22.85	0.64	25.62	0.63	28.32	0.62	31.00
Node-117	2.50	0.67	23.29	0.65	26.12	0.64	28.89	0.63	31.61
Node-118	2.25	0.67	23.26	0.65	26.07	0.64	28.83	0.63	31.56
Node-119	1.75	0.67	23.38	0.65	26.21	0.64	28.98	0.63	31.72
Node-120	1.25	0.65	22.94	0.64	25.70	0.63	28.42	0.62	31.11
Node-121	-1.75	0.65	22.77	0.64	25.53	0.62	28.23	0.62	30.89
Node-122	-2.25	0.66	23.01	0.64	25.79	0.63	28.50	0.62	31.18
Node-123	-2.75	0.68	23.66	0.66	26.52	0.65	29.32	0.64	32.07
Node-124	-3.25	0.68	23.80	0.66	26.67	0.66	29.50	0.65	32.30
Node-125	-3.50	0.68	23.61	0.66	26.48	0.65	29.29	0.64	32.04
Node-126	-3.75	0.66	23.01	0.64	25.78	0.63	28.50	0.62	31.17
Node-127	-4.25	0.65	23.02	0.64	25.78	0.63	28.50	0.62	31.18
Node-128	-4.75	0.64	22.56	0.63	25.29	0.62	27.96	0.61	30.60
Node-129	-7.75	0.62	21.98	0.61	24.62	0.60	27.23	0.60	29.81
Node-130	-8.25	0.64	22.20	0.63	24.91	0.61	27.57	0.61	30.18
Node-131	-8.75	0.67	23.11	0.65	25.92	0.64	28.68	0.63	31.42
Node-132	-9.25	0.65	22.34	0.63	25.08	0.62	27.76	0.61	30.41
Node-133	-9.50	0.64	21.95	0.62	24.65	0.61	27.29	0.60	29.89
Node-134	-9.75	0.64	22.11	0.63	24.82	0.62	27.48	0.61	30.10
Node-135	-10.25	0.62	21.60	0.61	24.24	0.60	26.83	0.59	29.38
Node-136	-10.75	0.59	20.47	0.57	22.96	0.57	25.41	0.56	27.81
Node-137	-13.75	0.55	19.22	0.54	21.56	0.53	23.86	0.53	26.13
Node-138	-14.25	0.54	18.66	0.53	20.94	0.52	23.17	0.51	25.38
Node-139	-14.75	0.53	18.34	0.52	20.58	0.51	22.78	0.50	24.93
Node-140	-15.25	0.54	18.66	0.53	20.97	0.53	23.24	0.52	25.48
Node-141	-15.50	0.53	17.92	0.52	20.14	0.50	22.32	0.50	24.47
Node-142	-15.75	0.50	17.14	0.50	19.28	0.49	21.39	0.48	23.47
Node-143	-16.25	0.48	16.43	0.47	18.48	0.47	20.49	0.46	22.47
Node-144	-16.75	0.46	15.81	0.45	17.77	0.45	19.70	0.44	21.60

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 46. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (600-700 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	600 EFPDs		650 EFPDs		700 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-1							
Node-1	16.25	0.43	22.71	0.43	24.56	0.42	26.38
Node-2	15.75	0.45	24.08	0.45	26.01	0.44	27.92
Node-3	15.25	0.47	25.03	0.46	27.03	0.46	29.01
Node-4	14.75	0.49	26.13	0.48	28.21	0.47	30.26
Node-5	14.50	0.51	27.26	0.50	29.42	0.50	31.57
Node-6	14.25	0.51	27.38	0.51	29.56	0.50	31.71
Node-7	13.75	0.52	27.58	0.51	29.78	0.50	31.95
Node-8	13.25	0.54	28.84	0.53	31.14	0.53	33.42
Node-9	10.25	0.58	31.79	0.58	34.29	0.58	36.78
Node-10	9.75	0.60	32.85	0.60	35.43	0.59	37.98
Node-11	9.25	0.60	33.10	0.60	35.68	0.59	38.24
Node-12	8.75	0.61	33.81	0.61	36.44	0.60	39.03
Node-13	8.50	0.64	34.73	0.63	37.45	0.63	40.15
Node-14	8.25	0.63	34.68	0.63	37.39	0.62	40.08
Node-15	7.75	0.64	35.50	0.64	38.25	0.63	41.00
Node-16	7.25	0.63	34.89	0.63	37.61	0.63	40.32
Node-17	4.25	0.68	37.09	0.67	39.98	0.67	42.86
Node-18	3.75	0.68	37.60	0.67	40.51	0.67	43.39
Node-19	3.25	0.70	38.59	0.69	41.58	0.69	44.55
Node-20	2.75	0.68	37.78	0.68	40.71	0.68	43.63
Node-21	2.50	0.69	38.17	0.69	41.13	0.68	44.07
Node-22	2.25	0.68	37.62	0.67	40.52	0.67	43.40
Node-23	1.75	0.68	37.48	0.67	40.38	0.67	43.26
Node-24	1.25	0.69	37.64	0.68	40.60	0.68	43.53
Node-25	-1.75	0.68	37.18	0.68	40.10	0.67	43.01
Node-26	-2.25	0.68	37.85	0.68	40.78	0.67	43.69
Node-27	-2.75	0.70	38.66	0.70	41.66	0.69	44.65
Node-28	-3.25	0.69	38.26	0.69	41.23	0.68	44.17
Node-29	-3.50	0.70	38.81	0.70	41.82	0.69	44.81
Node-30	-3.75	0.68	37.67	0.67	40.59	0.67	43.49
Node-31	-4.25	0.68	37.65	0.67	40.56	0.67	43.45
Node-32	-4.75	0.68	37.17	0.67	40.08	0.67	42.96
Node-33	-7.75	0.67	36.88	0.67	39.76	0.66	42.63
Node-34	-8.25	0.67	37.21	0.67	40.10	0.66	42.97
Node-35	-8.75	0.68	37.56	0.67	40.48	0.67	43.38
Node-36	-9.25	0.65	35.92	0.65	38.71	0.64	41.47
Node-37	-9.50	0.66	36.28	0.65	39.09	0.65	41.88
Node-38	-9.75	0.66	36.47	0.66	39.30	0.65	42.12
Node-39	-10.25	0.64	35.35	0.64	38.11	0.63	40.85
Node-40	-10.75	0.60	33.15	0.60	35.73	0.59	38.30
Node-41	-13.75	0.57	31.16	0.56	33.59	0.56	36.00
Node-42	-14.25	0.57	31.47	0.57	33.91	0.56	36.34
Node-43	-14.75	0.57	31.03	0.56	33.45	0.55	35.85
Node-44	-15.25	0.55	30.26	0.55	32.62	0.54	34.97
Node-45	-15.50	0.53	28.78	0.52	31.02	0.51	33.23
Node-46	-15.75	0.52	28.60	0.51	30.82	0.51	33.03
Node-47	-16.25	0.49	26.90	0.48	28.99	0.48	31.06
Node-48	-16.75	0.48	26.11	0.47	28.16	0.47	30.19

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 46. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (600-700 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	600 EFPDs		650 EFPDs		700 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-3							
Node-49	16.25	0.43	23.06	0.43	24.91	0.43	26.75
Node-50	15.75	0.47	25.05	0.47	27.08	0.46	29.07
Node-51	15.25	0.48	25.69	0.48	27.76	0.47	29.80
Node-52	14.75	0.49	26.11	0.48	28.19	0.48	30.26
Node-53	14.50	0.52	27.74	0.51	29.96	0.51	32.15
Node-54	14.25	0.52	27.68	0.51	29.88	0.51	32.07
Node-55	13.75	0.54	28.57	0.53	30.87	0.53	33.15
Node-56	13.25	0.54	28.74	0.53	31.04	0.53	33.33
Node-57	10.25	0.60	32.51	0.59	35.07	0.59	37.61
Node-58	9.75	0.62	33.71	0.61	36.35	0.61	38.98
Node-59	9.25	0.61	33.45	0.61	36.08	0.60	38.69
Node-60	8.75	0.63	34.49	0.62	37.19	0.62	39.87
Node-61	8.50	0.62	33.92	0.62	36.58	0.61	39.23
Node-62	8.25	0.64	34.91	0.63	37.65	0.63	40.37
Node-63	7.75	0.65	35.54	0.64	38.31	0.64	41.06
Node-64	7.25	0.64	35.00	0.64	37.76	0.64	40.52
Node-65	4.25	0.68	37.30	0.68	40.22	0.67	43.12
Node-66	3.75	0.69	38.13	0.69	41.11	0.68	44.07
Node-67	3.25	0.69	38.39	0.69	41.37	0.68	44.33
Node-68	2.75	0.70	38.83	0.70	41.83	0.69	44.82
Node-69	2.50	0.71	39.37	0.71	42.42	0.70	45.46
Node-70	2.25	0.71	38.70	0.70	41.72	0.70	44.73
Node-71	1.75	0.71	39.28	0.71	42.34	0.70	45.38
Node-72	1.25	0.69	37.55	0.68	40.50	0.68	43.44
Node-73	-1.75	0.70	38.21	0.70	41.23	0.70	44.23
Node-74	-2.25	0.70	38.74	0.70	41.76	0.69	44.76
Node-75	-2.75	0.70	38.71	0.70	41.72	0.69	44.70
Node-76	-3.25	0.70	38.86	0.69	41.86	0.69	44.85
Node-77	-3.50	0.69	38.29	0.68	41.24	0.68	44.18
Node-78	-3.75	0.68	37.85	0.68	40.78	0.67	43.69
Node-79	-4.25	0.70	38.41	0.69	41.40	0.69	44.37
Node-80	-4.75	0.67	36.82	0.67	39.70	0.67	42.58
Node-81	-7.75	0.68	36.76	0.67	39.66	0.67	42.56
Node-82	-8.25	0.68	37.34	0.68	40.26	0.67	43.17
Node-83	-8.75	0.68	37.42	0.68	40.34	0.67	43.24
Node-84	-9.25	0.65	36.03	0.65	38.82	0.64	41.59
Node-85	-9.50	0.67	37.13	0.67	40.02	0.66	42.88
Node-86	-9.75	0.66	36.21	0.65	39.01	0.64	41.79
Node-87	-10.25	0.65	35.72	0.64	38.48	0.64	41.23
Node-88	-10.75	0.63	34.34	0.62	37.03	0.62	39.70
Node-89	-13.75	0.58	31.38	0.57	33.86	0.57	36.32
Node-90	-14.25	0.57	31.62	0.57	34.08	0.56	36.52
Node-91	-14.75	0.56	30.52	0.55	32.90	0.55	35.27
Node-92	-15.25	0.56	30.86	0.56	33.27	0.55	35.66
Node-93	-15.50	0.54	29.67	0.54	31.98	0.53	34.29
Node-94	-15.75	0.53	28.94	0.52	31.20	0.52	33.44
Node-95	-16.25	0.50	27.40	0.50	29.54	0.49	31.67
Node-96	-16.75	0.48	26.14	0.47	28.19	0.47	30.23

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 46. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (600-700 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	600 EFPDs		650 EFPDs		700 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-2							
Node-97	16.25	0.39	20.42	0.38	22.07	0.38	23.71
Node-98	15.75	0.40	21.25	0.40	22.97	0.39	24.66
Node-99	15.25	0.43	22.52	0.42	24.35	0.42	26.16
Node-100	14.75	0.44	23.37	0.44	25.25	0.43	27.12
Node-101	14.50	0.46	24.38	0.46	26.36	0.45	28.31
Node-102	14.25	0.46	24.15	0.45	26.09	0.44	28.00
Node-103	13.75	0.48	25.60	0.47	27.66	0.47	29.69
Node-104	13.25	0.47	24.99	0.47	27.01	0.46	29.02
Node-105	10.25	0.54	28.95	0.53	31.24	0.53	33.51
Node-106	9.75	0.55	29.87	0.54	32.22	0.54	34.55
Node-107	9.25	0.56	30.34	0.55	32.73	0.55	35.10
Node-108	8.75	0.57	30.86	0.56	33.29	0.56	35.69
Node-109	8.50	0.57	30.73	0.56	33.15	0.56	35.55
Node-110	8.25	0.58	31.66	0.58	34.15	0.57	36.62
Node-111	7.75	0.57	31.26	0.56	33.69	0.56	36.11
Node-112	7.25	0.57	30.95	0.56	33.38	0.56	35.80
Node-113	4.25	0.61	33.42	0.61	36.06	0.61	38.68
Node-114	3.75	0.62	33.91	0.61	36.55	0.61	39.19
Node-115	3.25	0.62	33.74	0.61	36.39	0.61	39.01
Node-116	2.75	0.61	33.63	0.61	36.26	0.60	38.87
Node-117	2.50	0.62	34.29	0.61	36.95	0.61	39.58
Node-118	2.25	0.62	34.24	0.61	36.90	0.61	39.54
Node-119	1.75	0.63	34.43	0.62	37.12	0.62	39.78
Node-120	1.25	0.62	33.78	0.61	36.42	0.61	39.05
Node-121	-1.75	0.61	33.53	0.61	36.14	0.60	38.74
Node-122	-2.25	0.61	33.83	0.61	36.45	0.60	39.07
Node-123	-2.75	0.63	34.78	0.62	37.47	0.62	40.13
Node-124	-3.25	0.64	35.05	0.63	37.77	0.63	40.47
Node-125	-3.50	0.63	34.75	0.62	37.44	0.62	40.11
Node-126	-3.75	0.61	33.82	0.60	36.42	0.60	39.00
Node-127	-4.25	0.61	33.84	0.61	36.46	0.60	39.06
Node-128	-4.75	0.60	33.21	0.60	35.81	0.60	38.39
Node-129	-7.75	0.59	32.36	0.58	34.89	0.58	37.40
Node-130	-8.25	0.60	32.75	0.59	35.30	0.58	37.83
Node-131	-8.75	0.62	34.12	0.62	36.78	0.61	39.40
Node-132	-9.25	0.61	33.03	0.60	35.63	0.59	38.20
Node-133	-9.50	0.59	32.46	0.59	35.00	0.58	37.52
Node-134	-9.75	0.60	32.69	0.59	35.25	0.59	37.79
Node-135	-10.25	0.58	31.91	0.58	34.40	0.57	36.88
Node-136	-10.75	0.55	30.20	0.55	32.57	0.54	34.92
Node-137	-13.75	0.52	28.39	0.52	30.64	0.51	32.86
Node-138	-14.25	0.51	27.56	0.50	29.71	0.49	31.85
Node-139	-14.75	0.49	27.06	0.49	29.17	0.48	31.26
Node-140	-15.25	0.51	27.68	0.50	29.85	0.50	32.00
Node-141	-15.50	0.49	26.59	0.48	28.68	0.48	30.74
Node-142	-15.75	0.47	25.52	0.47	27.54	0.46	29.54
Node-143	-16.25	0.45	24.42	0.45	26.35	0.44	28.26
Node-144	-16.75	0.44	23.49	0.43	25.35	0.43	27.19

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 47. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (750-800 days, 19.7% U-235 enriched, irradiated in ATR B-10 position)

Stack ID or Node ID	Node mid-point distance to core center (in)	750 EFPDs		800 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-1					
Node-1	16.25	0.42	28.18	0.42	29.98
Node-2	15.75	0.44	29.81	0.44	31.69
Node-3	15.25	0.46	30.97	0.45	32.93
Node-4	14.75	0.47	32.28	0.47	34.30
Node-5	14.50	0.49	33.69	0.49	35.80
Node-6	14.25	0.49	33.84	0.49	35.97
Node-7	13.75	0.50	34.11	0.49	36.24
Node-8	13.25	0.52	35.69	0.52	37.95
Node-9	10.25	0.57	39.26	0.57	41.72
Node-10	9.75	0.59	40.53	0.58	43.05
Node-11	9.25	0.59	40.78	0.59	43.32
Node-12	8.75	0.60	41.61	0.60	44.19
Node-13	8.50	0.62	42.83	0.62	45.49
Node-14	8.25	0.62	42.76	0.62	45.42
Node-15	7.75	0.63	43.72	0.63	46.43
Node-16	7.25	0.62	43.02	0.62	45.71
Node-17	4.25	0.66	45.73	0.66	48.60
Node-18	3.75	0.67	46.27	0.67	49.15
Node-19	3.25	0.68	47.51	0.68	50.45
Node-20	2.75	0.67	46.53	0.67	49.42
Node-21	2.50	0.68	47.00	0.68	49.92
Node-22	2.25	0.66	46.27	0.66	49.14
Node-23	1.75	0.66	46.13	0.66	49.00
Node-24	1.25	0.68	46.46	0.68	49.38
Node-25	-1.75	0.67	45.91	0.67	48.79
Node-26	-2.25	0.67	46.59	0.67	49.47
Node-27	-2.75	0.69	47.63	0.69	50.59
Node-28	-3.25	0.68	47.10	0.68	50.02
Node-29	-3.50	0.69	47.78	0.69	50.74
Node-30	-3.75	0.67	46.37	0.66	49.24
Node-31	-4.25	0.66	46.32	0.66	49.19
Node-32	-4.75	0.67	45.84	0.66	48.70
Node-33	-7.75	0.66	45.49	0.66	48.34
Node-34	-8.25	0.66	45.81	0.66	48.65
Node-35	-8.75	0.67	46.26	0.67	49.14
Node-36	-9.25	0.64	44.22	0.63	46.96
Node-37	-9.50	0.64	44.66	0.64	47.43
Node-38	-9.75	0.65	44.92	0.65	47.72
Node-39	-10.25	0.63	43.58	0.63	46.30
Node-40	-10.75	0.59	40.86	0.59	43.42
Node-41	-13.75	0.55	38.39	0.55	40.78
Node-42	-14.25	0.56	38.75	0.56	41.16
Node-43	-14.75	0.55	38.23	0.55	40.60
Node-44	-15.25	0.54	37.30	0.54	39.62
Node-45	-15.50	0.51	35.43	0.51	37.62
Node-46	-15.75	0.51	35.21	0.50	37.39
Node-47	-16.25	0.48	33.12	0.47	35.17
Node-48	-16.75	0.47	32.21	0.47	34.22

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 47. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (750-800 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	750 EFPDs		800 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-3					
Node-49	16.25	0.42	28.58	0.42	30.40
Node-50	15.75	0.46	31.05	0.46	33.02
Node-51	15.25	0.47	31.82	0.47	33.83
Node-52	14.75	0.47	32.31	0.47	34.34
Node-53	14.50	0.50	34.33	0.50	36.49
Node-54	14.25	0.50	34.24	0.50	36.40
Node-55	13.75	0.52	35.41	0.52	37.65
Node-56	13.25	0.53	35.59	0.52	37.86
Node-57	10.25	0.58	40.14	0.58	42.66
Node-58	9.75	0.60	41.59	0.60	44.19
Node-59	9.25	0.60	41.28	0.60	43.86
Node-60	8.75	0.62	42.53	0.61	45.18
Node-61	8.50	0.61	41.85	0.60	44.46
Node-62	8.25	0.63	43.07	0.62	45.76
Node-63	7.75	0.63	43.81	0.63	46.54
Node-64	7.25	0.63	43.26	0.63	45.99
Node-65	4.25	0.67	46.01	0.67	48.90
Node-66	3.75	0.68	47.02	0.68	49.97
Node-67	3.25	0.68	47.27	0.68	50.20
Node-68	2.75	0.69	47.79	0.68	50.75
Node-69	2.50	0.70	48.48	0.70	51.49
Node-70	2.25	0.69	47.73	0.69	50.71
Node-71	1.75	0.70	48.41	0.70	51.44
Node-72	1.25	0.68	46.37	0.68	49.30
Node-73	-1.75	0.69	47.23	0.69	50.22
Node-74	-2.25	0.69	47.75	0.69	50.73
Node-75	-2.75	0.69	47.67	0.68	50.62
Node-76	-3.25	0.69	47.82	0.69	50.78
Node-77	-3.50	0.68	47.10	0.68	50.02
Node-78	-3.75	0.67	46.58	0.67	49.46
Node-79	-4.25	0.68	47.32	0.68	50.26
Node-80	-4.75	0.66	45.45	0.66	48.31
Node-81	-7.75	0.67	45.44	0.67	48.32
Node-82	-8.25	0.67	46.06	0.67	48.95
Node-83	-8.75	0.67	46.12	0.67	49.00
Node-84	-9.25	0.64	44.35	0.64	47.10
Node-85	-9.50	0.66	45.73	0.66	48.57
Node-86	-9.75	0.64	44.56	0.64	47.33
Node-87	-10.25	0.63	43.98	0.63	46.71
Node-88	-10.75	0.61	42.35	0.61	45.00
Node-89	-13.75	0.57	38.77	0.56	41.21
Node-90	-14.25	0.56	38.94	0.56	41.35
Node-91	-14.75	0.54	37.62	0.54	39.96
Node-92	-15.25	0.55	38.04	0.55	40.42
Node-93	-15.50	0.53	36.58	0.53	38.86
Node-94	-15.75	0.52	35.67	0.51	37.89
Node-95	-16.25	0.49	33.78	0.49	35.88
Node-96	-16.75	0.47	32.26	0.47	34.28

Note: 1) Fast neutron flux for E > 0.18 MeV

Table 47. AGR-1 Fuel Compact Projected Fast Flux and Fast Fluence vs. EFPD (750-800 days, 19.7% U-235 enriched, irradiated in ATR B-10 position) continued

Stack ID or Node ID	Node mid-point distance to core center (in)	750 EFPDs		800 EFPDs	
		Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)	Fast Flux $x10^{14}$ (n/cm^2sec)	Fast Fluence $x10^{20}$ (n/cm^2)
Stack-2					
Node-97	16.25	0.37	25.33	0.37	26.94
Node-98	15.75	0.39	26.34	0.39	28.00
Node-99	15.25	0.41	27.95	0.41	29.74
Node-100	14.75	0.43	28.96	0.43	30.80
Node-101	14.50	0.45	30.23	0.44	32.15
Node-102	14.25	0.44	29.90	0.44	31.79
Node-103	13.75	0.46	31.70	0.46	33.69
Node-104	13.25	0.46	31.00	0.46	32.98
Node-105	10.25	0.52	35.78	0.52	38.04
Node-106	9.75	0.54	36.87	0.54	39.19
Node-107	9.25	0.54	37.45	0.54	39.79
Node-108	8.75	0.55	38.08	0.55	40.46
Node-109	8.50	0.55	37.93	0.55	40.31
Node-110	8.25	0.57	39.06	0.56	41.49
Node-111	7.75	0.56	38.52	0.55	40.91
Node-112	7.25	0.56	38.21	0.55	40.60
Node-113	4.25	0.61	41.30	0.60	43.91
Node-114	3.75	0.61	41.80	0.60	44.40
Node-115	3.25	0.60	41.62	0.60	44.21
Node-116	2.75	0.60	41.45	0.60	44.03
Node-117	2.50	0.61	42.21	0.60	44.82
Node-118	2.25	0.61	42.17	0.60	44.78
Node-119	1.75	0.62	42.44	0.61	45.09
Node-120	1.25	0.61	41.67	0.60	44.28
Node-121	-1.75	0.60	41.32	0.60	43.89
Node-122	-2.25	0.60	41.66	0.60	44.25
Node-123	-2.75	0.61	42.77	0.61	45.40
Node-124	-3.25	0.62	43.15	0.62	45.82
Node-125	-3.50	0.61	42.75	0.61	45.39
Node-126	-3.75	0.59	41.57	0.59	44.13
Node-127	-4.25	0.60	41.65	0.60	44.22
Node-128	-4.75	0.59	40.95	0.59	43.51
Node-129	-7.75	0.58	39.89	0.58	42.39
Node-130	-8.25	0.58	40.34	0.58	42.84
Node-131	-8.75	0.61	42.02	0.60	44.63
Node-132	-9.25	0.59	40.74	0.59	43.28
Node-133	-9.50	0.58	40.03	0.58	42.52
Node-134	-9.75	0.58	40.30	0.58	42.81
Node-135	-10.25	0.57	39.34	0.57	41.80
Node-136	-10.75	0.54	37.26	0.54	39.59
Node-137	-13.75	0.51	35.07	0.51	37.27
Node-138	-14.25	0.49	33.97	0.49	36.08
Node-139	-14.75	0.48	33.32	0.47	35.37
Node-140	-15.25	0.49	34.13	0.49	36.24
Node-141	-15.50	0.47	32.79	0.47	34.83
Node-142	-15.75	0.46	31.52	0.45	33.48
Node-143	-16.25	0.44	30.15	0.43	32.02
Node-144	-16.75	0.42	29.02	0.42	30.84

Note: 1) Fast neutron flux for E > 0.18 MeV

9.0 References

1. S. B. Grover email communication to G. S. Chang, et. al., "AGR-1 Neutronics Analysis," September 8, 2006 (see Attachment A for details).

2. P. A. Roth, "Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 136A," EDF-6325, Rev. 1, November 14, 2005.

3. P. A. Roth, "Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 131B," EDF-3968, Rev. 1, November 6, 2003.

4. ATR Test Plan dated 7/21/06 – LES.

5. W. C. Cook, A. C. Smith, "ATR CSAP Code Package on the Workstation Version 1," PG-T-96-002, May 1996.

6. X-5 Monte Carlo Team, "MCNP—A General Monte Carlo N-Particle Transport Code, Version 5," Volume I (LA-UR-03-1987) and Volume II (LA-CP-0245), Los Alamos National Laboratory April 24, 2003 (Revised 6/30/2004).

7. A. G. Croff, "ORIGEN2: A Versatile Computer Code for Calculating the Nuclide Compositions and Characteristics of Nuclear Materials, Nuclear Technology", Vol. 62, pp. 335-352, 1983.

8. J. T. Maki email communication to G. S. Chang, "Subject: AGR-1 compact data," May 24, 2006 (see attachment C for details).

9. J. T. Maki, "AGR-1 Irradiation Test Specification," EDF-4731, Rev. 1, July 30, 2004.

10. A. J. Palmer email communication to R. G. Ambrosek, et. al., "Subject: AGR-1 Graphite Boron Content – Use Nominal Values," June 8, 2006 (see Attachment D for details).

11. A. J. Palmer email communication to G. S. Chang, et. al., "Subject: Hafnium Density and Thickness," May 11, 2006 (see Attachment E for details).

12. A. J. Palmer email communication to J. R. Parry, "Subject: Re: AGR Graphites," June 1, 2006 (see Attachment F for details).

13. A. J. Palmer email communication to M. A. Lillo, "Subject: Composition of Type N Thermocouples," May 25, 2006 (see Attachment G for details).

14. A. J. Palmer, "Thermocouple Recommendations for the AGR-1 Test," EDF-6809, May 4, 2006.

15. J. L. Rempe email communication to R. G. Ambrosek, "Subject: Re: Thermocouples," March 22, 2006 (see attachment H for details).

16. J. L. Rempe email communication to R. G. Ambrosek, "Subject: Ta Tube Dimensions," April 28, 2006 (see attachment I for details).

17. G. S. Chang and J. M. Ryskamp, "Depletion Analysis of Mixed Oxide Fuel Pins in Light Water Reactors and the Advanced Test Reactor," Nucl. Technol., Vol. 129, No. 3, p. 326-337 (2000).

18. G. S. Chang, S. L. Hayes, R. G. Ambrosek, and F. W. Ingram, "Physics Analysis of RERTR Fuel Testing in ATR," Trans. Am. Nucl. Soc., Vol. 83, 208-209 (2001).

19. G. S. Chang, "ATR WG-MOX FUEL PELLET BURNUP MEASUREMENT BY MONTE CARLO – MASS SPECTROMETRIC METHOD," Proceedings of the International Conference on the New Frontiers of Nuclear Technology: Reactor Physics, Safety and High-Performance Computing, The ANS 2002 RPD Topical Meeting, Seoul, Korea, October 7-10, 2002.

20. R. G. Ambrosek and G. S. Chang, "Improved Methodology for Temperature Predictions in Advanced Reactors," HTD-Vol. 316, 1995 National Heat Transfer Conference, Volume 14, ASME 1995.

Attachment A

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Blaine Grover/SBG/CC01/INEEL/US
09/08/2006 03:19 PM

To: Gray S Chang/GSC/CC01/INEEL/US@INEL
cc: Misti A Lillo/LILLMA/CC01/INEEL/US@INEL, James R Parry/PARRJR/CC01/INEEL/US@INEL, Frances M Marshall/FMMA/CC01/INEEL/US@INEL
bcc:
Subject: AGR-1 Neutronics Analysis

Gray,

Please perform the following portion of the confirmatory neutronics analysis for the Advanced Gas Reactor (AGR) experiment AGR-1. The analysis should be performed using the computer codes MCNP and ORIGEN2 coupled via the UNIX script MCWO. The confirmatory neutronics analysis needs to evaluate the neutron/gamma heating rates for the AGR-1 capsule assembly structural components, the AGR-1 capsule assembly reactivity worth relative to an aluminum dummy, the peak fuel fission power density of the AGR-1 fuel compacts, the fuel burnup of the AGR-1 fuel compacts, and the fast neutron fluence (E > 0.18MeV) that will be experienced by the AGR-1 fuel compacts. The neutronics model, analysis details, and results need to be presented in an Engineering Design File (EDF).

Thanks
Blaine

Attachment B

Listing of the AGR-1 confirmatory analysis cross-section data used with the MCWO methodology. Both the MCNP built-in cross-sections and JENDL-3.2 cross-sections were used.

Cross-Section ID	Cross-Section ID
36083.50c	93237.37c
36085.37c	93239.37c
43099.60c	94238.98c
53127.60c	94239.82c
53129.60c	94240.82c
54131.50c	94241.82c
54135.50c	94242.82c
55135.60c	95241.98c
55136.60c	95243.98c
59143.37c	96242.98c
60145.50c	96244.98c
60147.50c	8016.37c
61148.50c	6012.37c
61149.50c	14000.37c
61151.19c	40000.37c
62147.50c	42000.37c
62149.50c	13027.37c
62151.50c	2004.37c
63151.60c	3007.37c
63152.50c	5010.37c
64152.60c	5011.37c
64155.60c	72174.37c
64157.60c	72176.37c
66164.96c	72177.37c
90232.37c	72178.37c
92233.37c	72179.37c
92234.37c	72180.37c
92235.37c	73181.37c
92236.37c	74182.37c
92237.37c	74183.37c
92238.37c	74184.37c

Justifications for using JENDL-3.2 cross-section data for neutronics analysis of the AGR-1 fuel compacts irradiated in the ATR B-10 position.

For the AGR-1 neutronics analysis, the JENDL-3.2, continuous energy cross section library based on JENDL-3.2, cross section data evaluated at 300°K, was used. The justification for using ^{235}U and ^{238}U cross section evaluated at 300° is discussed below.

The fission power density is not a sensitive function of the temperature dependent fission cross section because the fission power density is obtained by the following formula,

$$Fission\ power\ density = \int_0^{20MeV} Q\sigma_f \phi(E)\, dE.$$

In the ATR, a thermal reactor, the fuel fission power density generated in the specimens with B_4C (7 wt%) graphite holder from the thermal neutron flux (E < 0.625 eV) is about 80%. However, if the graphite holder contains no B_4C, the fission power density generated from the thermal neutron flux is about 93.5%. The effect of the resonance KeV range cross section broadening in the remaining 20% fissions is not significant in the fission power integration over neutron energy. To demonstrate it, the AGR-1 fuel compact in the capsule assembly model, ^{235}U with 92235.37c (300°K) and ^{238}U with cross section 92238.37c (300°K) was setup as Case-1. Then, the same capsule assembly model with 92235.17c (1200°K) and ^{238}U with cross section 92238.17c (1200°K) was set up as Case-2. The detailed node by node fission power density comparison between Case-1 and Case-2, at the beginning of the fuel irradiation, are tabulated in Table A-1. From Table A-1, the average fission power density ratio of Case-2 and Case-1 is 1.0034, which shows no significant difference within one uncertainty band ($1\sigma=\pm2.5\%$) for the MCNP calculation. However, please note that the temperature dependent cross section is a very important parameter when performing the power reactor criticality calculations.

Table B-1: Comparison of the node fission power density between Case-1 and Case-2 at the beginning of irradiation.

Node/Stack ID	Node Mid-Point Distance from Core Center (in)	Cross Section @ 300°K (W/cm^3)	Cross Section @ 1200°K (W/cm^3)	Ratio of Case-2 to Case-1
Stack-1				
Node-1	16.75	40.98	41.13	1.00364
Node-2	16.25	44.29	44.51	1.00491
Node-3	15.75	46.57	46.69	1.00256
Node-4	15.25	45.75	45.85	1.00228
Node-5	14.75	49.01	49.05	1.00070
Node-6	14.25	49.65	49.81	1.00329
Node-7	13.75	50.39	50.62	1.00461
Node-8	13.25	48.84	49.08	1.00486
Node-9	10.75	41.93	42.00	1.00164
Node-10	10.25	47.27	47.36	1.00194
Node-11	9.75	47.75	47.92	1.00359
Node-12	9.25	48.23	48.43	1.00413
Node-13	8.75	48.29	48.58	1.00587
Node-14	8.25	46.98	47.08	1.00215
Node-15	7.75	49.23	49.42	1.00375
Node-16	7.25	46.58	46.81	1.00493
Node-17	4.75	47.35	47.59	1.00503
Node-18	4.25	50.25	50.57	1.00647
Node-19	3.75	51.04	51.25	1.00419
Node-20	3.25	51.31	51.50	1.00372
Node-21	2.75	52.31	52.37	1.00117
Node-22	2.25	52.23	52.52	1.00558
Node-23	1.75	51.12	51.24	1.00228
Node-24	1.25	49.93	50.03	1.00205
Node-25	-1.25	48.51	48.57	1.00110
Node-26	-1.75	52.02	52.08	1.00105
Node-27	-2.25	53.66	53.68	1.00028
Node-28	-2.75	52.47	52.47	0.99998
Node-29	-3.25	52.94	53.08	1.00263
Node-30	-3.75	51.29	51.51	1.00428
Node-31	-4.25	51.08	51.16	1.00161
Node-32	-4.75	47.94	48.09	1.00305
Node-33	-7.25	45.87	46.16	1.00630
Node-34	-7.75	50.34	50.55	1.00427
Node-35	-8.25	48.00	48.17	1.00358
Node-36	-8.75	49.46	49.62	1.00333
Node-37	-9.25	48.68	48.90	1.00446
Node-38	-9.75	49.10	49.26	1.00331
Node-39	-10.25	47.39	47.55	1.00325
Node-40	-10.75	44.06	44.22	1.00381
Node-41	-13.25	48.76	49.04	1.00577
Node-42	-13.75	50.27	50.40	1.00257
Node-43	-14.25	50.56	50.79	1.00443
Node-44	-14.75	50.82	51.04	1.00452
Node-45	-15.25	50.45	50.46	1.00018
Node-46	-15.75	47.97	48.21	1.00512
Node-47	-16.25	46.79	46.96	1.00360
Node-48	-16.75	42.94	43.15	1.00479
Average		48.72	48.89	1.00337

Node/Stack ID	Node Mid-Point Distance from Core Center (in)	Cross Section @ 300°K (W/cm^3)	Cross Section @ 1200°K (W/cm^3)	Ratio of Case-2 to Case-1
Stack-3				
Node-49	16.75	43.78	43.77	0.99986
Node-50	16.25	47.08	47.36	1.00586
Node-51	15.75	48.80	49.06	1.00523
Node-52	15.25	50.17	50.46	1.00564
Node-53	14.75	51.63	51.68	1.00104
Node-54	14.25	54.47	54.43	0.99923
Node-55	13.75	54.50	54.65	1.00270
Node-56	13.25	54.21	54.28	1.00116
Node-57	10.75	45.77	46.00	1.00501
Node-58	10.25	48.54	48.82	1.00561
Node-59	9.75	51.14	51.38	1.00471
Node-60	9.25	51.96	52.21	1.00478
Node-61	8.75	52.02	52.25	1.00441
Node-62	8.25	51.16	51.26	1.00190
Node-63	7.75	52.49	52.61	1.00225
Node-64	7.25	50.87	51.05	1.00353
Node-65	4.75	50.52	50.62	1.00185
Node-66	4.25	54.33	54.44	1.00211
Node-67	3.75	55.74	55.82	1.00141
Node-68	3.25	54.89	55.01	1.00222
Node-69	2.75	55.15	55.39	1.00444
Node-70	2.25	56.04	56.33	1.00516
Node-71	1.75	56.42	56.75	1.00581
Node-72	1.25	52.55	52.81	1.00497
Node-73	-1.25	53.66	53.84	1.00330
Node-74	-1.75	55.80	56.19	1.00700
Node-75	-2.25	57.65	57.83	1.00314
Node-76	-2.75	57.35	57.52	1.00291
Node-77	-3.25	57.01	57.10	1.00157
Node-78	-3.75	55.16	55.39	1.00419
Node-79	-4.25	55.81	56.04	1.00402
Node-80	-4.75	51.29	51.35	1.00107
Node-81	-7.25	50.82	51.08	1.00513
Node-82	-7.75	53.23	53.42	1.00361
Node-83	-8.25	52.79	52.85	1.00128
Node-84	-8.75	50.96	51.11	1.00301
Node-85	-9.25	51.38	51.52	1.00270
Node-86	-9.75	50.99	51.16	1.00343
Node-87	-10.25	51.14	51.29	1.00293
Node-88	-10.75	47.15	47.51	1.00772
Node-89	-13.25	50.20	50.35	1.00311
Node-90	-13.75	54.02	54.19	1.00316
Node-91	-14.25	54.13	54.26	1.00234
Node-92	-14.75	52.10	52.40	1.00580
Node-93	-15.25	53.16	53.24	1.00149
Node-94	-15.75	51.68	51.87	1.00372
Node-95	-16.25	49.60	49.77	1.00353
Node-96	-16.75	43.56	43.72	1.00375
Average		52.18	52.36	1.00342

Node/Stack ID	Node Mid-Point Distance from Core Center (in)	Cross Section @ 300°K (W/cm^3)	Cross Section @ 1200°K (W/cm^3)	Ratio of Case-2 to Case-1
Stack-2				
Node-97	16.75	25.01	25.16	1.00595
Node-98	16.25	27.01	27.16	1.00566
Node-99	15.75	27.57	27.79	1.00807
Node-100	15.25	29.68	29.77	1.00309
Node-101	14.75	30.12	30.27	1.00485
Node-102	14.25	30.72	30.82	1.00329
Node-103	13.75	32.01	32.16	1.00475
Node-104	13.25	30.70	30.84	1.00455
Node-105	10.75	25.72	25.88	1.00612
Node-106	10.25	28.01	28.09	1.00270
Node-107	9.75	28.88	28.88	1.00007
Node-108	9.25	29.42	29.52	1.00337
Node-109	8.75	28.96	29.09	1.00432
Node-110	8.25	28.91	29.01	1.00366
Node-111	7.75	29.60	29.61	1.00009
Node-112	7.25	26.99	27.16	1.00656
Node-113	4.75	29.43	29.54	1.00393
Node-114	4.25	31.29	31.28	0.99975
Node-115	3.75	32.13	32.18	1.00155
Node-116	3.25	32.79	32.78	0.99959
Node-117	2.75	31.58	31.68	1.00320
Node-118	2.25	32.33	32.46	1.00402
Node-119	1.75	31.29	31.41	1.00392
Node-120	1.25	29.00	29.13	1.00465
Node-121	-1.25	29.50	29.54	1.00119
Node-122	-1.75	32.50	32.63	1.00414
Node-123	-2.25	32.31	32.32	1.00031
Node-124	-2.75	31.14	31.18	1.00142
Node-125	-3.25	31.53	31.59	1.00182
Node-126	-3.75	31.70	31.68	0.99954
Node-127	-4.25	31.28	31.40	1.00383
Node-128	-4.75	29.23	29.30	1.00207
Node-129	-7.25	27.83	28.01	1.00658
Node-130	-7.75	29.72	29.91	1.00633
Node-131	-8.25	30.41	30.58	1.00556
Node-132	-8.75	30.27	30.25	0.99922
Node-133	-9.25	29.49	29.69	1.00699
Node-134	-9.75	29.55	29.72	1.00581
Node-135	-10.25	28.44	28.54	1.00341
Node-136	-10.75	25.92	26.10	1.00662
Node-137	-13.25	30.63	30.72	1.00302
Node-138	-13.75	33.01	33.13	1.00379
Node-139	-14.25	33.54	33.60	1.00162
Node-140	-14.75	33.04	33.09	1.00164
Node-141	-15.25	32.33	32.36	1.00066
Node-142	-15.75	32.45	32.58	1.00396
Node-143	-16.25	31.81	31.86	1.00184
Node-144	-16.75	28.43	28.51	1.00283
Average		30.11	30.21	1.00329

Attachment C

Gray S Chang/GSC/CC01/INEEL/US
05/25/2006 09:05 AM

To: Misti.Lillo@inl.gov, James R Parry/PARRJR/CC01/INEEL/US@INEL
cc:
bcc:
Subject: Fw: AGR-1 compact data

Idaho National Laboratory
Gray Chang • Consulting Engineer/Scientist
Reactor & Nuclear Physics
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----- Forwarded by Gray S Chang/GSC/CC01/INEEL/US on 05/25/2006 09:04 AM -----

John T Maki/MKI/CC01/INEEL/US
05/24/2006 04:10 PM

To: Gray S Chang/GSC/CC01/INEEL/US@INEL
cc: Blaine Grover/SBG/CC01/INEEL/US@INEL, John R Cox/COXJR/CC01/INEEL/US@INEL, David A Petti/PTI/CC01/INEEL/US@INEL, Charles M Barnes/BMC/CC01/INEEL/US@INEL, Matthias A Ebner/MEBNER/CC01/INEEL/US@INEL
Subject: AGR-1 compact data

Gray,

The attached spread sheet contains the AGR-1 compact data that you requested. Use the Baseline data for Capsules 6 (top) and 3 (middle). Use the Variant 1 data for all other capsules. The attached spread sheet will be updated as data becomes available from ORNL but will be too late for the confirmatory analysis.

AGR-1 compact data 052406.xls

Microsoft Excel - AGR-1 compact data 052406.xls

	A	B	C	D	E	F	G	H	I	J
1	AGR-1 Compact Data (as of date: 5/24/06)									
2										
3				Baseline		Variant 1				
4										
5	U-235 enrichment (wt %)			19.736		19.736				
6	C/U atomic ratio			0.3253		0.3253				
7	O/U atomic ratio			1.3613		1.3613				
8	Kernel diameter (um)			349.7		349.7				
9	Buffer thickness (um)			103.5		102.5				
10	IPyC thickness (um)			39.4		40.5				
11	SiC thickness (um)			35.3		35.7				
12	Kernel density (Mg/m^3)			10.924		10.924				
13	SiC density (Mg/m^3)			3.2075		3.206				
14										
15	Compact mass (g)			5.47888		5.3371				
16	U loading (g U/compact)			0.917		0.915				
17	Compact length (mm)			25.066		25.123				
18	Compact diameter (mm)			12.36		12.36				
19										
20	Mol mass U			237.488052		237.4881				
21	Kernel mass (g)			0.000244606		0.000245				
22	Mass U/particle (g/particle)			0.000220731		0.000221				
23	Mass O/particle (g/particle)			2.02439E-05		2.02E-05				
24	Volume SiC/particle (m^3)			4.99472E-11		5.06E-11				
25	Mass Si/particle (g/particle)			0.000112224		0.000114				
26	Number particles/compact			4154.37959		4145.319				
27										
28	Effective compact density (Mg/m^3)			1.821714425		1.770547				
29										
30	Compact weight % U			16.73699734		17.14414				
31	Compact weight % O			1.535004345		1.572345				
32	Compact weight % Si			8.509416675		8.827004				
33	Compact weight % C			73.21858164		72.45651				
34										
35										
36	Sources:									
37										
38	U-235 enrichment, C/U and O/U ratios:			BWXT Data Qualification Package						
39										
40	Particle dimensions and densities:			Data Compilations reports: ORNL/TM-2006/019						
41				ORNL/TM-2006/020						
42										
43	Compact U loading:			Confirmatory Data Package letters: AGR-1051						
44				AGR-1053						
45										
46	Compact dimensions and mass:			Based on averages of compacts sent to the INL, listed in						
47				INL letters:						
48				and measurement data in Confirmatory Data Package letters						
49										

Sheet1 / Sheet2 / Sheet3

Ready NUM

Attachment D

Joe Palmer/PJA/CC01/INEEL/US
06/08/2006 12:27 PM

To: Richard G Ambrosek/RGA/NON/INEEL/US@INEL, Gray S Chang/GSC/CC01/INEEL/US@INEL, Misti A Lillo/LILLMA/CC01/INEEL/US@INEL, James R Parry/PARRJR/CC01/INEEL/US@INEL

cc: Blaine Grover/SBG/CC01/INEEL/US@INEL, John R Cox/COXJR/CC01/INEEL/US@INEL, David A Petti/PTI/CC01/INEEL/US@INEL, Doug.Miller@graftech.com, Matthias A Ebner/MEBNER/CC01/INEEL/US@INEL,

bcc:

Subject: AGR-1 GRAPHITE BORON CONTENT - USE NOMINAL VALUES

All,

Yesterday afternoon I received a voicemail from Graftech providing verbal results of the boron content in the graphite billets. Their results were within the tolerance range provided in our specification. I've reprinted the values from the specification below.

(1) Boron to be added in the form of B4C at 7 weight percent +/- .35% (5.48 wt% boron +/- .27%)

(2) Boron to be added in the form of B4C at 5.5 weight percent +/- .27% (4.30 wt% boron +/- .22%)

Dick Ambrosek, Blaine Grover and I discussed whether we should use the nominal or measured values for B4C in the physics calculations and we believe nominal is the better option for the following reasons:

(1) If we use nominal values we leave open the possibility that we may be able to use graphite that has been further processed to remove Fe. We have told Graftech to send half the graphite to us as soon as possible and take the other half and attempt further purification. If the purified graphite comes back a with slightly less B4C but still within our specification tolerances we will be able to incorporate it into the test - if the analysis is based on nominal values.

(2) The best I can tell Graftech's analytical accuracy is roughly the same as our tolerance range on B4C weight percent, i.e., about +/- 5 %. We see evidence for this in that Graftech obtained values of 7.0% and 7.3% for two billets of graphite that had the same feed stock mix and same furnace run. So we shouldn't kid ourselves that we know the actual boron content any closer than about +/-5%. This being the case it makes sense to base our calculations on the nominal values.

Having argued that the calculations should be based on the nominal values, these are the results Graftech provided in the voicemail:

Measured	Nominal (spec value)
5.36%	5.5%
7.0%, 7.3%	7.0%
6.18%	NA (this was an extra billet they decided to run half way between our two requested values)

These agree quite well with the little bit that has come back so far from MIT and their prompt gamma analysis (this is an excerpt from Kent Riley's latest email):

"I was able to calibrate with the graphite standards you sent and do one set of measurements on the unknowns, which range between 5.3 and 7.4%."

The apparent agreement is encouraging.

I have instructed Graftech to send us the 5.36% and 7.0% billets (actually bars from these billets) to us as soon as possible along with the corresponding analytic results. Furthermore, I have instructed Graftech to attempt to purify the 7.3% and 6.18% billets to the degree possible. (I've asked them to try and purify the 6.18% billet down to a value that would fall within our 5.5% +/- .25% specification.)

If anyone has any concerns with this logic please bring them up as soon as possible. However, I will be on vacation until June 19th and Blaine Grover (6-4589) will be your contact point until then.

Attachment E

Joe Palmer/PJA/CC01/INEEL/US
05/11/2006 05:27 PM

To	Gray S Chang/GSC/CC01/INEEL/US@INEL, Misti A Lillo/LILLMA/CC01/INEEL/US@INEL, James R Parry/PARRJR/CC01/INEEL/US@INEL
cc	Blaine Grover/SBG/CC01/INEEL/US@INEL
bcc	
Subject	HAFNIUM DENSITY AND THICKNESS

History: **This message has been forwarded.**

I'm attaching measurement information we have on the hafnium strip we'll be using for the neutron shield. We have the complete chemistry information for both lots out at the site, but I only happen to have chemistry for one lot electronically and so I'm attaching that as well (I think the only thing that matters is the % Zr - all other impurities are in the ppm range). You'll see I've written the percent Zr for both lots on the measurement sheets.

I calculated a density of 12.815 g/cc for Lot # J27P30 and a density of 12.25 g/cc for Lot # F18P28. As I mentioned in my previous note, I don't know why these densities are so different and why they are considerably less than theoretical. Feel free to check my math by recalculating these densities.

Hf-LOT-F18P28.pdf Hf-LOT-J27P30.pdf Hf-P050982CertofAnal.jpg

Joe Palmer • Mechanical Engineer, PE
Advanced Energy Technologies, Idaho National Laboratory
Phone: (208) 526-8700 • Email: joe.palmer@inl.gov

(Hf-LOT-F18P28.pdf)

QA # ~~116103~~ 116199 MP 5/4/06

Page 1 of 1

FARO CONTROL STATION

Operator : Robert Mohney
Part Name : Hafnium Foil
Part Serial Number : Lot # F18P28
Device Serial Number : P08-02-04-02471
Controller Version : 1.28
Certification Date : 03/15/05
Time & Date : Thursday May 04 09:24:10 2006
Units : Millimeters

FARO CAM2

C_LENGTH001 *(Constructed Length)*

	Measured	Nominal	+Tol	-Tol	Dev	Out of Tol
X	0000.0000					
Delta Y	0000.2638					
Z	0000.0002					
Length	0000.2638	mm				

C_LENGTH002 *(Constructed Length)*

	Measured	Nominal	+Tol	-Tol	Dev	Out of Tol
X	-0004.5998					
Delta Y	0000.0498					
Z	-0060.1561					
Length	0060.2860	mm				

C_LENGTH003 *(Constructed Length)*

	Measured	Nominal	+Tol	-Tol	Dev	Out of Tol
X	0260.5142					
Delta Y	-0000.0220					
Z	-0014.7747					
Length	0260.9495	mm				

Mass: 65.170g Scale ID 714123 Exp. 8-30-06
AJ Palmer S# 61014 5/4/06

1.76% Zr

5/4/2006

(Hf-LOT-J27P30.pdf)

QA #116103

Page 1 of 1

FARO CONTROL STATION

Operator : Robert Mohney
Part Name : Hafnium Foil
Part Serial Number : Lot # J27P30
Device Serial Number : P08-02-04-02471
Controller Version : 1.28
Certification Date : 03/15/05
Time & Date : Thursday May 04 08:56:40 2006
Units : Millimeters

FARO CAM2

C_LENGTH001 *(Constructed Length)*

	Measured	Nominal	+Tol	-Tol	Dev	Out of Tol
X	0250.9335					
Delta Y	-0000.0228					
Z	-0013.4871					
Length	0251.2957	mm				

C_LENGTH002 *(Constructed Length)*

	Measured	Nominal	+Tol	-Tol	Dev	Out of Tol
X	-0004.7035					
Delta Y	0000.0505					
Z	-0061.3481					
Length	0061.3841	mm				

C_LENGTH003 *(Constructed Length)*

	Measured	Nominal	+Tol	-Tol	Dev	Out of Tol
X	0000.0000					
Delta Y	0000.2590					
Z	0000.0002					
Length	0000.2590	mm				

Mass: 67.878g Scale Cal ID 714123 EXP. 8-30-06.

A J Palmer S# 61014 5/9/06

2.35% Zr

5/4/2006

(Hf-PO50982CertofAnal.jpg)

Certificate of Analysis

THE RIGHT CHEMICALS
THE RIGHT CHEMISTRY®

Attn. Jim Cripps

Hafnium foil, 0.25mm (0.01in) thick, 99.5% (metals basis excluding Zr), Zr nominal 3%

Stock Number: 10793
Lot Number: J27P30

Analysis

Al	41	B	< 0.5	C	69
Cd	2	Co	< 5	Cr	< 20
Cu	< 25	Fe	225	H	< 3
Mg	< 10	Mn	< 20	Mo	< 10
N	< 20	Nb	< 50	Ni	< 25
O	280	Pb	< 5	Si	< 25
Sn	< 10	Ta	< 100	Ti	39
U	< 1	U-235	< 0.007	V	< 10
W	< 10	Zr	2.35 %		

Values given in ppm unless otherwise noted

Certified by:

Paul V Connolly

Quality Control

QA 116103

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Attachment F

Joe Palmer/PJA/CC01/INEEL/US
06/01/2006 05:27 PM

To: James R Parry/PARRJR/CC01/INEEL/US@INEL
cc: Misti A Lillo/LILLMA/CC01/INEEL/US@INEL, Blaine Grover/SBG/CC01/INEEL/US@INEL, Richard G Ambrosek/RGA/NON/INEEL/US@INEL
bcc:
Subject: Re: AGR Graphites

Jim,

I'm attaching the chemical analysis from the practice batch of graphite Graftech made up for us last year. I don't know if this is good enough or not as far as impurities. They are trying to hold the Fe down to less than half of what they got before. You may want to wait a couple more days to get Graftech's analysis of the actual lots we'll be using (this information is expected any day). I'm sure you'll want to wait for that on B4C content.

The chemical analysis is under the "Ash" tab in this spreadsheet. Density is under the Room Temp tab, but he said something about this latest batch being more dense than the practice batch.

TS5173 High Temp Properties.xls

Joe Palmer • Mechanical Engineer, PE
Advanced Energy Technologies, Idaho National Laboratory
Phone: (208) 526-8700 • Email: joe.palmer@inl.gov

James R Parry/PARRJR/CC01/INEEL/US

James R Parry/PARRJR/CC01/INEEL/US
06/01/2006 10:05 AM

To: Joe Palmer/PJA/CC01/INEEL/US@INEL
cc: Misti A Lillo/LILLMA/CC01/INEEL/US@INEL
Subject: AGR Graphites

Joe,

Do you have material properties (major chemical constituents and density) for the graphites used in the AGR experiment? All I was able to get from the Graftech website was information for the grafoil.

Thanks,

Jim

Microsoft Excel - TS5173 High Temp Properties.xls

Mar 02 05 03:10p Shiva Tech 315 431 9800 p.2

SHIVA TECHNOLOGIES

GDMS

ANALYTICAL REPORT

Customer **GrafTech** *P O #* **MC**
Date: 25-Feb-05 *Job #* UO0798

Customer ID **Graphite** *Shiva ID* U050223031
TS5173,2005012704

Element	Concentration [ppm wt]	Element	Concentration [ppm wt]
Li	0.05	Pd	< 0.1
Be	0.03	Ag	< 0.1
B	~ 3 wt%	Cd	< 0.1
C	Matrix	In	< 0.1
N	-	Sn	< 0.5
O	-	Sb	< 0.5
F	< 5	Te	< 0.1
Na	1.4	I	< 0.5
Mg	< 0.5	Cs	< 0.5
Al	41	Ba	0.83
Si	6.4	La	< 0.5
P	5.5	Ce	1.7
S	0.62	Pr	3.1
Cl	< 0.05	Nd	< 0.05
K	< 0.1	Sm	0.18
Ca	83	Eu	0.1
Sc	< 0.1	Gd	< 0.05
Ti	4.5	Tb	< 0.05
V	7	Dy	< 0.05
Cr	3.7	Ho	< 0.05
Mn	0.72	Er	0.1
Fe	160	Tm	< 0.05
Co	0.38	Yb	< 0.05
Ni	7.3	Lu	< 0.05
Cu	< 0.5	Hf	< 0.05
Zn	< 0.5	Ta	< 100
Ga	< 0.1	W	1.3
Ge	< 0.1	Re	< 0.05
As	< 0.1	Os	< 0.05
Se	< 0.1	Ir	< 0.05
Br	< 0.1	Pt	< 0.05
Rb	< 0.05	Au	< 0.1
Sr	0.26	Hg	< 0.1
Y	< 0.05	Tl	< 0.1
Zr	0.24	Pb	< 0.5
Nb	< 0.1	Bi	< 0.1
Mo	0.2	Th	1
Ru	< 0.1	U	< 0.1
Rh	< 0.1		

Page 1 of *

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Room Temp / HT MODULUS-TS-5173-9 / Ash / HT Thermal Co

Ready NUM

Attachment G

Joe Palmer/PJA/CC01/INEEL/US
05/25/2006 04:53 PM

To: Misti A Lillo/LILLMA/CC01/INEEL/US@INEL
cc:
bcc:
Subject: COMPOSITION OF TYPE N THERMOCOUPLES

History: This message has been forwarded.

Misti,

These are the Type N TCs used in the lower 5 capsules. The Type N's used in the top are different.

Sheath: .062" OD x .042" ID, Inconel 600 = 75% Ni, 16% Cr, 8% Fe, 1% Mn
Insulation: MgO 99.4% pure
Thermoelements: .010" dia (both) See last two rows of table below.

TABLE.1- NOMINAL COMPOSITIONS OF ANSI STANDARD BASE-METAL THERMOELEMENT ALLOYS, AND NICROSIL AND NISIL ALLOYS

ALLOY	CHEMICAL COMPOSITION (WEIGHT-%)								
ANSI (1) DESIGNATION	Cr	Si	Mn	Al	Co	Mg	Cu	Ni	Fe
(+)KP, EP	9.5	0.4						bal	
(-)KN		1.0	3.0	2.0	0.4	0.015		bal	
(+)JP			0.3						bal
(-)JN, EN, TN			1.0		0.5		54	44	0.5
(+)TP							100		
(+)NP (nicrosil)	14.2	1.4						bal	
(-)NN (nisil)		4.4				0.10		bal	

The Type N's in the top capsule are Molybdenum sheathed.

Sheath: .092" OD x .056" ID, 99.9% pure Mo
Insulataion: Al2O3 99.4% pure
Thermoelements: Approx .015" dia (both) same composition as above.

Joe Palmer • Mechanical Engineer, PE
Advanced Energy Technologies, Idaho National Laboratory
Phone: (208) 526-8700 • Email: joe.palmer@inl.gov

Attachment H

Richard G Ambrosek/RGA/NON/INEEL/US
05/03/2006 10:56 AM

To: Misti A Lillo/LILLMA/CC01/INEEL/US@INEL
cc:
bcc:
Subject: Fw: Thermocouples

—— Forwarded by Richard G Ambrosek/RGA/NON/INEEL/US on 05/03/2006 10:51 AM ——

Joy L Rempe/YOJ/CC01/INEEL/US
03/22/2006 03:02 PM

To: Richard G Ambrosek/RGA/NON/INEEL/US@INEL
cc: Joe Palmer/PJA/CC01/INEEL/US@INEL
Subject: Re: Thermocouples

Dick,
As I mentioned earlier, there are two types of TCs. Prior to swaging, all wire is 0.010", the insulation has two holes, the MgO has an OD of 0.057" with a hole diameter of 0.015", the HfO2 has an OD of 0.057" with a hole diameter of 0.013", the tubes (both Inconel and Nb1Zr) have an OD of 0.085" with a wall thickness of 0.011". Certifications for all of these materials are attached.

The junction is a very small tantalum tube that we swage onto the two wires. However, I don't think that this is relevant to your calculation. If it is, let me know.

I'll look forward to seeing the calculation results!
Joy

crushable hafnia.jpg crushable magnesia.jpg KW Mo H Cross.jpg Nb1Zr Wah Chang.pdf Nb1Zr Tubes.jpg Inc 600 Tubes.jpg

Joy Rempe · Idaho National Laboratory
Phone: (208) 526-2897 • Cell: (208) 520-3708 • Fax: (208) 526-2930 •
Email: Joy.Rempe@inl.gov

▸ Richard G Ambrosek/RGA/NON/INEEL/US

(crushable hafnia.jpg)

OTC Ozark Technical Ceramics, Inc.

CRUSHABLE MGO INSULATORS
99.8% OZARK GRADE CUM

X CERTIFICATE OF COMPLIANCE
O SUPPLIER DEVIATION REQUEST

CUSTOMER NAME: **INEEL**
CONTRACT NO.: **PC5012759**
CUSTOMER P/N: **U2057x015-3$** (quantity shipped): **616 pc**
OUR JOB NO: **8259** (please refer to this number for all correspondence)

Ozark Technical Ceramics, Inc. certifies that this shipment complies with the specifications of the above referenced contract with the exceptions listed below. Also listed is any additional information for reference as required.

Lotno.Batch no. **6762.100** MOR = 8500
(quantity packaged): 616 pc
1) ITEM #3
2)

Ozark Technical Ceramics, Inc. certifies that this product complies with the requirements of Section 6.1 and Table 1 of ASTM specification E1652-03. Reference Chemical analysis results follow:

MgO:	99.87	CaO	0.04	SiO2:	0.01
Al2O3:	0.03	Fe2O3:	0.03		
S:	0	C:	0	B+CD	<30 ppm

Values in wt % unless specified. MgO value is by difference of emission spec impurities.

By: Amy Kahn Date 2/6/2006
(save as: CUM13Z..xls)

Please note condition of packaging materials and Shipper abuse when you observe any breakage.
For Quality/Quantity issues, please have your inspection information available for review and comparison.
For best results, please refer to the OZARK Job number above and the Lot/Batch number in all correspondence.
All returns must be pre-approved by OZARK. Please contact this office for a Return Authorization.

CUM13

CUM13Z.xls on 2/6/2006

(crushable magnesia.jpg)

OTC Ozark Technical Ceramics, Inc.

X CERTIFICATE OF COMPLIANCE
O SUPPLIER DEVIATION REQUEST

CUSTOMER NAME: **Ineel**
CONTRACT NO.: **PC5012759**
CUSTOMER P/N: **CUH2057x013-2**
OUR JOB NO: **8259** (please refer to this number for all correspondence)

Ozark Technical Ceramics, Inc. certifies that this shipment complies with the specifications of the above referenced contract with the exceptions listed below. Also listed is any additional information for reference as required.

Lotno. Batch no. : **8259.100** MOR: 3150
(quantity shipped): 720 in Item #1

All OZARK crushable and Hard Fired Hafnium Oxide products are made from the highest purity raw materials available (Spectro grade). All cationic impurities are below normal detection limits except ZrO2 which is very similar in chemical properties and is considered a benign adulterant for the majority of high temperature and refractory applications for Hafnium Oxide.

CHEMICAL ANALYTICAL SPECIFICATION :

	spec	Typical
Al:	<500 ppm	36 ppm
Fe:	< 500 ppm	36 ppm
Si:	<500 ppm	45 ppm
Ti:	<500 ppm	24 ppm
C:	<500 ppm	3 ppm
Zr:	< 1.0%	0.39%
(ZrO2)*	< 2.0%	0.54%
total HfO2	>98%	99.44%

** implied by Zr analysis*

Values in ppm unless specified by vol %. HfO2 value is by difference of emission spec impurities.

By: Terry Kahl

Date: 2/6/2006
(save as: Ineel.8259.HUH-Z.xls)

(KW Mo H Cross.jpg)

H. CROSS Company

METAL RIBBONS ··· STRIPS

363 PARK AVE., WEEHAWKEN, NJ 07086 U.S.A.
TEL (201) 863-1134 FAX NO. (201) 863-9297 EMAIL: INFO@HCROSSCOMPANY.COM

BILL TO	SHIP TO
IDAHO NATIONAL LABORATORY ATT: JANICE A. CRANK REF: M/S 3850 2525 NORTH FREEMONT AVE. IDAHO FALLS, ID 83415	IDAHO NATIONAL LABORATORY ATT: JOY L. REMPE REF: EROB, M/S 3840 2525 NORTH FREEMONT AVE. IDAHO FALLS, ID 83415

CERTIFICATION

DATE: 02/06/06	Invoice/Packing Slip # 2019	
TERMS OF PAYMENT:	FOB: ORIGIN WEEHAWKEN, NJ USA COLLECT OR PRE-PAY & BILL	
		JANICE CRANK

QUANTITY	DESCRIPTION	PRICE	AMOUNT
400.00 FT	KW-MOLY WIRE - AS DRAWN TEMPER .010"+-.0002" DIAMETER		

KW MOLY LOT# 724

Analysis in PPM

Na 11	K 117	Al 35
La 12	Si 290	Fe 13
Cr <10	Ni <10	Co 19
W 165	Mn 5	Mg 5
Co <1	Ti 5	Zr <10
O 190	C <10	

PAYABLE IN U.S. DOLLARS ONLY - "GOODS MADE IN THE USA"

This is to certify that the item listed has been fabricated in accordance with applicable specifications on your order.

ALL PRICES QUOTED AND ORDERS ACCEPTED ARE SUBJECT TO ADJUSTMENT WITHOUT NOTICE ON THE BASIS OF THE METAL PRICES PREVAILING ON THE DATE OF SHIPMENT

SPOOLS ARE RETURNABLE FOR CREDIT CONTINGENT UPON THEIR RECEIPT IN GOOD REUSABLE CONDITION WITH TRANSPORTATION PREPAID BY YOU NO DISCOUNT ON SPOOLS POSTAGE

IMPORTANT CLAIMS FOR CREDIT OR DAMAGES ON ACCOUNT OF SHORTAGE OR DEFECTIVE MATERIAL MUST BE MADE WITHIN 10 DAYS

THE GOODS COVERED BY THIS INVOICE WERE PRODUCED IN COMPLIANCE WITH THE REQUIREMENTS OF THE FAIR LABOR STANDARDSACT OF 1966 AS AMENDED INCLUDING SECTION 12-A

SIGNATURE J. McCleary

H. CROSS COMPANY
363 PARK AVE., WEEHAWKEN, NJ 07086
AREA CODE (201) 863-1134

(Nb1Zr Wah Chang.pdf)

Certificate Of Analysis

Wah Chang
An Allegheny Technologies Company

7400 Highway 20 West
Huntsville, Alabama 35806
Telephone: (256) 722-2300
Fax: (256) 722-2381

To	INL
Purchase Order #	35430
Item #	1
Description	Niobium 1 Zr
Condition	Annealed & Pickled
Diameter	0.010" +/- 0.0005"
Length	Spool
Specification	Purchase Order
Date	8/26/04
Date Shipped	See Packing List
Quantity Shipped	1 Spool
Weight Shipped	1 lb.
Sales Order #	123201
Heat #	531128
SFC #	1277480

Ingot Composition Results
IN PPM (Unless Specified)

Element	Spec	1	2	3	4	5	6	7
C	Information	42	37	24	<20	23	<20	25
Fe	Information	<35	<35	<35	<35	<35	<35	<35
H	Information	<3			<3			<3
Hf	Information	<50	<50	<50	<50	<50	<50	<50
Mo	Information	<30	<30	<30	<30	<30	<30	<30
N	Information	21			40			30
Ni	Information	<20	24	37	24	29	29	30
O	Information	60			90			110
Si	Information	<50	<50	<50	<50	<50	<50	<50
Ta	Information	660	1200	1200	1200	1300	1300	1200
Ti	Information	<40	<40	<40	<40	<40	<40	<40
W	Information	<30	<30	<30	<30	<30	<30	<30
Zr	Information	0.91%	1.05%	0.94%	0.97%	0.98%	0.97%	1.14%

This is to certify all items comprising this shipment and in the quantities specified are in conformance to the requirements, drawings, and specifications applicable to the referenced order number shown above.

Analysis Certified by _____ 8/20/04
Quality Assurance

(Nb1Zr Tubes.jpg)

Phone: (610) 489-0300
Fax:(610) 489-6285

Uniform Tubes Inc.

200 W. 7th Ave., Collegeville, PA 19426

Certification of Analyses and Tests

Cert Number : 41182 **P.O.#** : PC2217604 **Prep Date** : 11/8/2004
Customer : IDAHO NATIONAL ENGINEERING **UT SO #** : CT018046 **Qty** : 29.00 FT

Specifications: ASTM B 394 REV 03, CHEM ONLY

Description: OD .083/.085
WA .009/.011
LT 10/20 FT

Chemical Composition

Alloy : COLUMBIUM 1% ZIRCONIUM

Lot No : 3881N **Heat:** 531135
Material : SEAMLESS TUBE

C	<0.002-0.006	WP
Cb	98.50	>WP
Fe	0.004	<WP
H	0.0003	<WP
Hf	0.005	<WP
Mo	0.003	<WP
N	0.006-0.008	WP
Ni	0.002	<WP
O	0.008-0.013	WP
Si	0.005	<WP
Ta	0.02	WP
W	0.003	<WP
Zr	0.93-1.20	WP

0 past 3rd decimal is insignificant
WP = Weight %, PPM = Parts/million
Bal = Balance, ND = Not Detected

Mechanical Properties

Test Number(s): 87116 **Test Date:** 11/8/2004

Temper	- 1 - Annealed
U.T.S. (PSI)	- 49790 55540
Elongation (%) in 2"	- 21.00 - 24.00
Y.S (PSI)	31410 - 35590
Hardness	-
Avg Grain Size	-
Micro	- SATISFACTORY
Flare Test	- SATISFACTORY
Flatten Test	-
Hydrostatic Test	-
Pressure Test	-
Aged U.T.S. (PSI)	-
Aged Elongation (%)	-
Aged Y.S. (PSI)	-
Surface RA	-
Concentricity	-
Corrosion Test	-
Embrittlement Test	-
Surface Check / par.	-

Special Tests: NOTE: COHN TEST RESULTS TO FOLLOW

This is to certify that the material supplied from Material Traceable Number TM89306, UT Index # 102222 is in accordance with the specifications as stated above, or as ammended by UT order acknowledgement.

Uniform Tubes, Inc

Quality Assurance - 11/8/2004

(Inc 600 Tubes.jpg)

03/14/2006 18:18 FAX 610 277 2005 TMI JPP 002/002

TUBE METHODS

P.O. BOX 460
BRIDGEPORT, PA 19405
PH: (610) 279-7700
FAX: (610) 277-2005

TEST REPORT

Accredited Nadcap

TMI Mill # 27860	TMI Lot # 29202	Customer P.O # 5012625	Quantity 15 pcs
Sold to: IDAHO NATIONAL LABS P.O. BOX 1625 IDAHO FALLS, ID 83415		Type & Grade 600 SEAMLESS	Size .083"/.085" OD .009"/.011" WALL
		Specifications ANNEALED ***ACCOUNTING TO BILL DIRECT TO C.C.# ON FILE***	

Chemical Analysis

HEAT#:86493 Melt Source/Analysis: VDM

C	Mn	S	Si	Cr	Ni	Ti	Co	Cu
0.031	0.84	0.002	0.25	16.26	75.03	0.22	0.025	0.02

Al	Fe
0.12	7.15

Mechanical Properties

Tensile Strength	0.2% Offset Yield Strength	% Elongation	Hardness
73,800 PSI	32,800 PSI	40	

Visual PASSED Dimensional PASSED
Eddy current PASSED 10% NOTCH LEVEL

I certify that this report is correct and conforms to above specifications. Nicholas Ricci | Plant Metallurgist 03/14/2006 PAGE 1 OF 1
The test report shall not be reproduced except in full, without the written approval of the laboratory. The recording of false, fictitious, or fraudulent statements or entries on the certificate may be punished as a felony under federal law.

Attachment I

Richard G Ambrosek/RGA/NON/INEEL/US
05/03/2006 10:46 AM

To: Misti A Lillo/LILLMA/CC01/INEEL/US@INEL
cc:
bcc:
Subject: Fw: Ta Tube Dimensions

—— Forwarded by Richard G Ambrosek/RGA/NON/INEEL/US on 05/03/2006 10:46 AM ——

Joy L Rempe/YOJ/CC01/INEEL/US
04/28/2006 12:12 PM

To: Richard G Ambrosek/RGA/NON/INEEL/US@INEL
cc: A Joseph Palmer/PJA/CC01/INEEL/US
Subject: Ta Tube Dimensions

Dick,

Please consider these dimensions as representative. It would be a miracle if you multiply the volume by the density of tantalum and get the masses that I sent to you this week.

Joy

Tantalum Tube	Initial, prior to swaging on wires: ID=0.015" OD=0.025" Length=0.058"

Joy Rempe · **Idaho National Laboratory**
Phone: (208) 526-2897 • Cell: (208) 520-3708 • Fax: (208) 526-2930 •
Email: Joy.Rempe@inl.gov

Attachment J

Reactivity Perturbation Validation Discussion

The purpose of this section is to discus the difference in K_{eff} calculated by MCNP reference model (Case-1) and PDQWS (Case-2)[1] full core models with respect to the Cycle 134A (Case-3) ATR SUrveillance DAta System (ASUDAS)[2] data.

The MCNP and PDQWS input parameters for the ATR models were adjusted to reflect the Cycle 134A initial critical conditions. The as-run or actual Cycle 134A initial critical conditions are given below.

ASUDAS data	Case-3
Balanced OSCC Position	39.2°
K_{eff}	1.00 (Critical)
Neck Shim Positions	
NW-1 thru NW-6	All inserted
NE-1 thru NE-6	All inserted
SW-1 thru SW-3 and	All inserted
SW-5 thru SW-6	All inserted
SE-1 thru SE-3 and	All inserted
SE-5 thru SE-6	All inserted

The PDQWS calculations were performed using the PDQWS computer code on the workstation. PDQWS[3] results were processed using a suite of codes, including most importantly, ROSUB and PQMAP. The cross-sections included in the input deck were generated using the codes COMBINE, SCAMP, SCRABL, and RZPGM. Because the PDQWS core model uses a discrete X-Y mesh to divide the cells, the balanced OSCC position was modeled at 40.1°, which was the closest available position to the ASUDAS value of 39.2°.

The MCNP and PDQWS calculated results and ASUDAS data are given below:

Cycle 134A Parameter	Case-1 (MCNP)	Case-2 (PDQWS)	Case-3 (ASUDAS)
Balanced OSCC Position	39.2°	40.1°	39.2°
K_{eff}	1.00194±0.00018	0.9886	1.0000

Case-1 compared to Case-3

$$\Delta K_{eff} \text{ (MCNP-ASUDAS)} = 1.00194 - 1.0000 = 0.00194$$

Case-2 compared to Case-3

$$\Delta K_{eff} \text{ (PDQWS-ASUDAS)} = 0.9886 - 1.0000 = -0.0114$$

The PDQWS ATR full core model K_{eff} calculation bias with respect to ASUDAS measured data is -0.0114, and the MCNP ATR full core model K_{eff} calculation bias with respect to the ASUDAS measured data is 0.00194.

Using the MCNP-calculated error for K_{eff} (σ = 0.00018), K_{eff} is estimated within a 95% confidence level (2σ) to be 1.00194 ±0.00036 (1.00158 to 1.00230). These results demonstrate that the MCNP-calculated eigenvalue agrees well with both the ASUDAS and the PDQWS eigenvalues.

References

1. Roth, P. A., 2004a, letter to J. D. Abrashoff, PAR-17-04, revision 1, "Startup Outer Shim Prediction for ATR Cycle 134A-1, Revision 1," December 20, 2004.
2. ASUDAS report from DAC Hourly Control History for Cycle 134A-1/A-2 End of Cycle; provided by email from D. V. Thomas to M. A. Lillo, July 11, 2005.
3. Cook W. C., Smith A. C., "ATR CSAP Package on the Workstation Version 1," PG-T-96-002, May 1996.