

# **Advanced Fuel Cycle Initiative AFC-1D, AFC-1G, and AFC-1H End of FY-07 Irradiation Report**

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September 2007



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## ABSTRACT

The purpose of the U.S. Advanced Fuel Cycle Initiative (AFCI), now within the broader context of the Global Nuclear Energy Partnership (GNEP), is to develop and demonstrate the technologies needed to transmute the long-lived transuranic isotopes contained in spent nuclear fuel into shorter-lived fission products. Success in this undertaking could potentially dramatically decrease the volume of material requiring disposal with attendant reductions in long-term radio-toxicity and heat load of high-level waste sent to a geologic repository. One important component of the technology development is investigation of irradiation/transmutation effects on actinide-bearing metallic fuel forms containing plutonium, neptunium, americium (and possibly curium) isotopes. Goals of this initiative include addressing the limited irradiation performance data available on metallic fuels with high concentrations of Pu, Np and Am, as are envisioned for use as actinide transmutation fuels.

The AFC-1 irradiation experiments of transmutation fuels are expected to provide irradiation performance data on non-fertile and low-fertile fuel forms specifically, irradiation growth and swelling, helium production, fission gas release, fission product and fuel constituent migration, fuel phase equilibria, and fuel-cladding chemical interaction.

Contained in this report are the to-date physics evaluations performed on three of the AFC-1 experiments; AFC-1D, AFC-1G and AFC-1H. The AFC-1D irradiation experiment consists of metallic non-fertile fuel compositions with minor actinides for potential use in accelerator driven systems and AFC-1G and AFC-1H irradiation experiments are part of the fast neutron reactor fuel development effort. The metallic fuel experiments and nitride experiment are high burnup analogs to previously irradiated experiments and are to be irradiated to  $\leq 40$  at.% burnup.

Based on the results of the physics evaluations the AFC-1D experiment has completed its irradiation and has been placed in temporary storage in the ATR canal, the AFC-1G and AFC-1H experiments will continue irradiation in the ATR into FY-08 in order to reach the desired programmatic burnup. The specific irradiation schedule for these tests will be determined based on future physics evaluations and all results will be documented in subsequent reports.

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# Advanced Fuel Cycle Initiative AFC-1D, AFC-1G and AFC-1H Irradiation Report

## 1. INTRODUCTION

The irradiation of the Advanced Fuel Cycle Initiative's AFC-1 series fuel capsules and GFR-F1 material capsules is being performed in the Advanced Test Reactor (ATR) East Flux Trap (EFT) positions E1, E2, E3, and E4. There are a total of six AFC-1 fuel capsules and three GFR-F1 capsules that have been fabricated for irradiation. These tests are identified as AFC-1B, AFC-1D, AFC-1AE, AFC-1F, AFC-1G, and AFC-1H, and GFR-F1-1, GFR-F1-2, and GFR-F1-3.

The first series of tests, AFC-1B and AFC-1D, consist of metallic non-fertile fuel compositions with minor actinides for potential use in accelerator driven systems. The second series, AFC-1AE and AFC-1F, consist of non-fertile and low-fertile metallic and nitride fuel compositions with minor actinides for use in fast neutron spectrum reactors or accelerator driven systems. The GFR-F1 (-1, -2, -3) experiment contain fuel related refractory ceramics, nickel based 800H and MA754 (ODS) alloys, and iron based T122 and MA957 (ODS) ferritic alloys. These tests, excluding AFC-1D and GFR-F1-2 (which will be reinserted into the ATR for additional irradiation), have reached their desired burnup and/or fluence and have been shipped to the Materials and Fuels Complex (MFC)<sup>1</sup> for Post Irradiation Examination. The irradiation history for AFC-1B, -1AE, and -1F is detailed in INEEL/EXT-04-02380.<sup>1</sup>

The AFC-1G and AFC-1H capsules are also part of the fast neutron spectrum fuel development effort. The AFC-1H capsule is the high burnup analog of the AFC-1F capsule and the AFC-1G capsule is the high burnup analog of the AFC-1AE nitride fuel form capsule. For AFC-1D, AFC-1G, and AFC-1H the maximum burnup is 40 at.%. In all cases, burnup is defined for these experiments to be percent depletion of initial fissile material.

This report will provide to-date irradiation history on the AFC-1D, AFC-1G, and AFC-1H tests irradiated in FY-07.

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1. Beginning February 1, 2005, the name of the Idaho National Engineering and Environmental Laboratory (INEEL) was changed to Idaho National Laboratory (INL). Argonne National Laboratory-West was re-named the Materials and Fuels Complex (MFC).

## 2. ADVANCED TEST REACTOR DESCRIPTION

As the cross sectional view in Figure 1 shows, the ATR has a unique core configuration and offers 77 possible irradiation positions. The burnup level requirements led to the selection of the EFT for the irradiations. This location is magnified on the right side of Figure 1.

The irradiation environment for the AFCI test assemblies (capsules and baskets) is the ATR Primary Coolant System (PCS). ATR PCS is clean water sampled three times per day and maintained at the slightly acidic pH of 5.0 – 5.3. Chlorides are controlled to < 0.1 ppm (normal < 0.05 ppm). Normal Gross Beta-Gamma activity is < 0.16  $\mu\text{Ci/ml}$ . Control of pH, solids, and chlorides are maintained using ion exchange columns, filters, and chemistry control additives within the system boundaries.

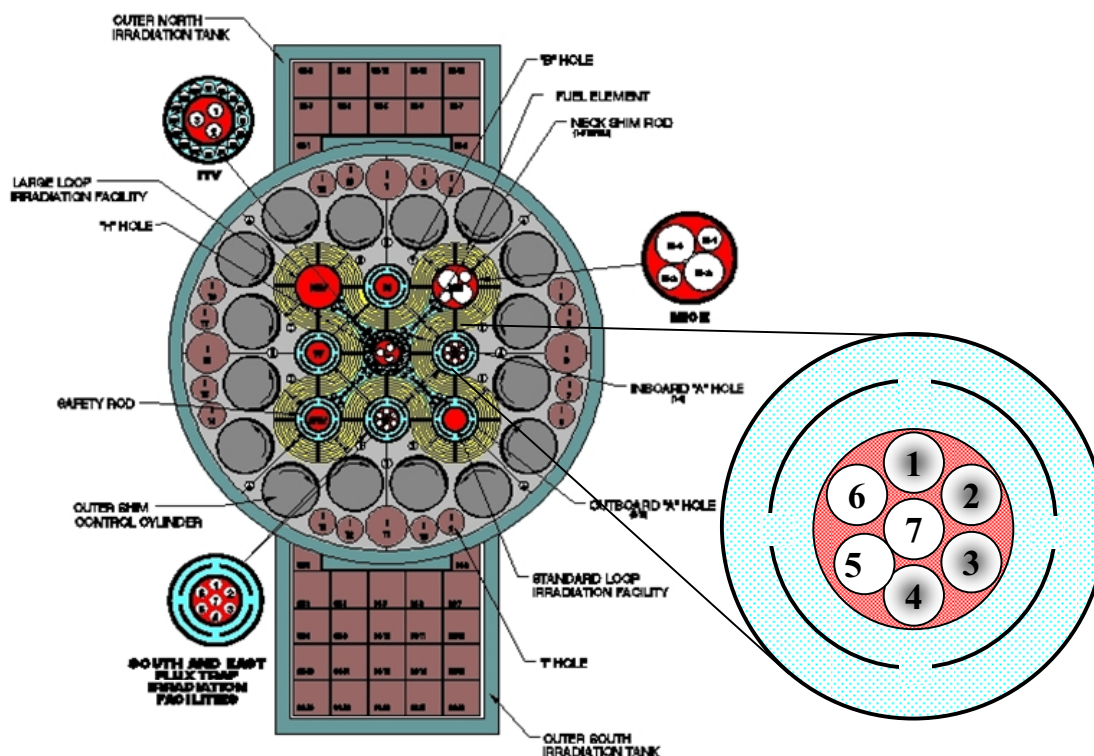


Figure 1. ATR Cross Section with Magnified East Flux Trap.

### 3. IRRADIATION CONDITIONS

All test assemblies were irradiated in accordance with the following documents:

- INL AFCI Experiment Safety Assurance Package
- W7520-0678-ES-01, “Final Experiment Description and Design and Data Package for AFC-1G and AFC-1H,”<sup>2</sup>
- W7520-0481-ES-02 “Final Experiment Description and Design and Data Package for AFC-1A, AFC-1B, AFC-1C and AFC-1D,”<sup>3</sup>
- W7520-0594-ES-00 “Final Experiment Description and Design and Data Package for GFR-F1.”<sup>4</sup>
- B. A. Hilton, “Revised Programmatic Burnup Limit of AFC-1D,” EDF-6575, January 18, 2006.<sup>7</sup>
- H. J. MacLean, “Revised Programmatic Burnup Limit for AFC-1G and AFC-1H,” EDF-7617, February 2007.

The tests were distributed in the ATR EFT drop-in positions: E1, E2, E3 and E4. The anticipated experimental fuel powers in these positions were calculated by using the INL detailed physics code evaluation; Monte Carlo N-Particle (MCNP) full core physics model. The fuel capsules are inserted into cadmium shrouded aluminum baskets that have a maximum basket lifetime of 120 full-power days of irradiation with a source power of 26 MW. This maximum lifetime was determined through analysis and it ensures that the linear heat generation rate (LHGR) limits (see **Table 1**) are not exceeded in any of the experimental fuels.

**Table 1. AFCI test assembly experiment specifications.**

<b>Experiment Specifications for Irradiation in the ATR</b>			
<b>Performance Parameter</b>	<b>AFC-1D (Metallic Fuel)</b>	<b>AFC-1G (Nitride Fuel)</b>	<b>AFC-1H (Metallic Fuel)</b>
<b>Maximum Burnup</b>	40%	40%	40%
<b>Peak Rodlet Linear Power</b>	400 W/cm	400 W/cm	400 W/cm
<b>Peak Cladding Temperature</b>			
Normal Operation	525°C	550°C	550°C
Off-Normal Limit	650°C	650°C	650°C
<b>Fuel Temperature</b>			
Normal Operation	900°C	1400°C	900°C
Off-Normal Limit	1100°C	2100°C	1100°C

The AFC-1D capsule was received at the Reactor Technology Complex (RTC), formerly known as TRA,<sup>b</sup> in June 2003, GFR-F1 was received in February 2004, and AFC-1G and AFC-1H capsules were received in July 2005. Upon receipt, each capsule was inspected and installed in an AFC cadmium shrouded aluminum basket containing an aluminum spacer (used to properly position the capsule axially within the ATR core). The basket assembly was then loaded into the EFT Small Irradiation Housing Assembly (SIHA) for irradiation.

Each test assembly is scheduled to be irradiated in the EFT of the ATR for varying lengths of time depending upon the desired fuel burnup or fluence. The test assemblies are removed from the ATR core and transferred to the canal for temporary storage during all Powered Axial Locating Mechanism (PALM) cycles. As necessary, the test assemblies are also removed during normal scheduled maintenance outages to replace the cadmium baskets. The cadmium baskets are routinely replaced to compensate for filter material burnup.

## 4. IRRADIATION HISTORY

During fiscal year 2007, the AFC-1D, AFC-1G, and AFC-1H test assemblies were inserted into the ATR EFT for irradiation during the following ATR operating cycles: Cycle 138A (startup October 14, 2006), Cycle 138B, Cycle 139A, and Cycle 139B (shutdown September 29, 2007).

**Table 2** shows the to-date irradiation details and history for all the AFC-1 and GFR-F test assemblies.

**Table 2. AFCI Test Assembly East Flux Trap Irradiations**

ATR Operating Cycle	EFPDs	EFT Housing Position	Test Capsule	Cd Basket Condition
131A	48.5	E1	AFC-1B	New
		E2	AFC-1D	New
		E3	Dummy	New
		E4	Dummy	New
131B	13.8	AFC tests removed for high power PALM Cycle		
132A	44.1	E1	AFC-1B	New
		E2	AFC-1F	New
		E3	AFC-1D	New
		E4	AFC-1Æ	New
132B	1.6	AFC tests removed for high power PALM Cycle		
132C	50.3	E1	AFC-1D	New
		E2	AFC-1F	New
		E3	AFC-1Æ	New
		E4	GFR-F1	Depleted*
133A	13.0	AFC tests removed for high power PALM Cycle		
133B	61.4	E1	Dummy	Depleted*
		E2	AFC-1D	Depleted*
		E3	Dummy	Depleted*
		E4	GFR-F1	Depleted*
135B	48.0	E1	AFC-1D	New
		E2	AFC-1H	New
		E3	AFC-1G	New
		E4	GFR-F2	New
135C	40.6	E1	AFC-1D	Depleted*
		E2	AFC-1H	Depleted*
		E3	AFC-1G	Depleted*
		E4	GFR-F2	Depleted*
136A	50.9	E1	AFC-1D	New
		E2	AFC-1H	New
		E3	AFC-1G	New
		E4	GFR-F2	New
136B	39.0	E1	AFC-1D	Depleted*
		E2	AFC-1H	New
		E3	AFC-1G	Depleted*
		E4	GFR-F2	Depleted*
137A	54.1	E1	GFR-F2	Depleted*
		E2	AFC-1H	New

ATR Operating Cycle	EFPDs	EFT Housing Position	Test Capsule	Cd Basket Condition
		E3	AFC-1G	New
		E4	AFC-1D	New
137B	12.1	AFC tests removed for high power PALM Cycle		
138A	58.1	E1	GFR-F2	Depleted*
		E2	AFC-1H	New
		E3	AFC-1G	Depleted*
		E4	AFC-1D	Depleted*
138B	46.6	E1	GFR-F2	Depleted*
		E2	AFC-1H	New
		E3	AFC-1G	New
		E4	AFC-1D	New
139A	51.6	E1	GFR-F2	Depleted*
		E2	AFC-1H	New
		E3	AFC-1G	Depleted*
		E4	AFC-1D	Depleted*
139B	52	E1	Dummy	New
		E2	AFC-1H	New
		E3	AFC-1G	New
		E4	GFR-F2	Depleted*

Depleted = ~50 EFPD of Irradiation

## 5. ANALYSIS AND CALCULATIONS

MCNP was used to calculate the AFC-1 rodlet LHGR. The depletion methodology MCWO (using ORIGEN2) was used to calculate the AFC-1 fuel rodlet burnup behavior versus EFPD's for irradiation within the ATR EFT. The irradiation intervals (beginning of cycle, BOC, middle of cycle, MOC, and end of cycle, EOC intervals) used in these analyses are given in **Table 3**.

**Table 3. Irradiation Intervals Used in Analyses**

Cycle	BOC Analysis Interval (Days)	MOC Analysis Interval (Days)	EOC Analysis Interval (Days)	Analyzed Cycle Duration (Days)
131A	14.0	14.0	20.5	48.5
132A	14.0	14.0	16.0	44.0
132C	15.0	15.0	20.3	50.3
133B	20.0	20.0	21.4	61.4
135B	18.0	18.0	12.0	48.0
135C	15.0	15.0	10.6	40.6
136A	20.0	20.0	10.9	50.9
136B	15.0	15.0	9.0	39.0
137A	16.0	16.0	22.0	54.0
138A	18.0	18.0	21.6	57.6
138B	16.0	16.0	14.7	46.7
139A	15.0	20.0	16.4	51.4

MCNP reports tally results normalized per source particle. The flux tallies have units of neutrons/cm<sup>2</sup> per fission neutron and the heating tallies have units of MeV/gm per fission neutron. 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.

### Neutron Flux Normalization Factor

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

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

$$\left( \frac{2.43 \text{ fission neutrons}}{\text{fission}} \right) \left( \frac{\text{fission}}{200 \text{ MeV}} \right) \left( \frac{6.24146 \times 10^{18} \text{ MeV}}{MW_{\text{core power}} - s} \right) = 7.583 \times 10^{16} \frac{\text{fission neutrons}}{MW_{\text{core power}} - s}$$

### Neutron/Gamma Heating Normalization Factor

Note, the MCNP f6 or f7 tally has units of MeV/g per source neutron.

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

$$\left( \frac{7.583 \times 10^{16} \text{ fission neutrons}}{MW_{\text{core power}} - s} \right) \left( \frac{1.60219 \times 10^{-13} W - s}{MeV} \right) = 1.215 \times 10^4 \frac{\text{fission neutrons} - W}{MW_{\text{core power}} - MeV}$$

## 6. 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 4. 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. Additionally, MCWO and the ATR core model have been benchmarked for heat rate evaluations by comparing the measured temperatures to projected temperatures in various ATR experiments.

Prior to each cycle, projected physics analysis is performed using the computer code MCNP. MCNP is a general purpose Monte Carlo N-Particle transport code used to model and evaluate the linear heat generation rate (LHGR) and fuel burnup of the as-built AFC-1D, -1H, -1G capsule assembly. The depletion methodology used to evaluate the AFCI experiments is known as Monte-Carlo coupled with ORIGEN2<sup>5</sup> (MCWO). MCWO has been verified at the INL by benchmarking calculated flux magnitudes with measured flux levels for several experiments in several test positions of the ATR core. Additionally, MCWO and the ATR core model have been benchmarked for heat rate evaluations by comparing the measured temperatures to projected temperatures in various ATR experiments.



## 7. PROJECTED PHYSICS ANALYSES EXPERIMENT DATA

The planned EFPDs published in the ATR Test Plan are used in the analysis to perform the projected calculations. However, the EFPDs of any cycle may change due to a variety of reasons including unexpected difficulties and the need for an unplanned outage of the ATR. Therefore, the actual EFPDs may vary from the projected EFPDs.

Table 5 shows the total projected and actual EFPDs of irradiation and East Lobe power for each cycle.

**Table 5. Projected EFPDs and East Lobe Power vs. Actual EFPDs and East Lobe Power**

Test	Projected EFPDs	Projected East Lobe Power (MW)	Total Actual EFPDs	Actual East Lobe Power (MW)
<b>Cycle 138A</b>	57	22.47	58.1	22.2
<b>Cycle 138B</b>	51	22.47	46.6	22.47
<b>Cycle 139A</b>	56	22.47	51.6	22.3
<b>Cycle 139B</b>	49	22.47	Not yet available	Not yet available

Before an AFCI experiment is inserted into the ATR, physics calculations and analyses are performed. These physics calculations and analyses project the LHGR for the analyzed irradiation cycle. This analysis ensures that the AFCI tests being inserted into the ATR below the Experiment Safety Assurance Package (ESAP) safety limit for LHGR of 400 W/cm for rodlets contained in an AFCI test assembly. This analysis was performed on the AFCI fuel tests identified as AFC-1D, AFC-1G, and AFC-1H for all ATR Cycles.

Tables 6 thru 9 show the results from the projected heat rates and burnup distribution calculations for each rodlet in the AFC-1D, AFC-1G, and AFC-1H experiments at the end of Cycle 138A, 138B, 139A, and 139B.

**Table 6. Cycle 138A Projected Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (57 EFPD).**

<b>Test Position and ID</b>		<b>Linear Heat Rate (W/cm)</b>	<b>Fission Heat Rate (W/g)</b>	<b><sup>239</sup>Pu Depletion (atom%)</b>	<b>Heavy Metals Depletion (atom%)</b>	<b>Am Depletion (atom%)</b>	<b><sup>235</sup>U Depletion (atom%)</b>
<b>E-2 AFC-1H</b>	Rodlet 1	177.82	133.55	12.01%	7.97%	27.73%	11.46%
	Rodlet 2	232.16	153.25	13.73%	6.94%	33.72%	15.49%
	Rodlet 3	254.80	212.81	19.03%	13.21%	41.04%	16.92%
	Rodlet 4	277.44	208.14	16.96%	11.30%	37.38%	16.44%
	Rodlet 5	269.82	205.87	16.80%	11.59%	34.22%	14.91%
	Rodlet 6	196.93	163.05	15.42%	10.46%	33.30%	13.40%
<b>E-3 AFC-1G</b>	Rodlet 1	124.52	110.15	11.34%	5.99%	--	--
	Dummy	--	--	--	--	--	--
	Rodlet 3	262.14	183.59	13.15%	7.40%	32.36%	16.18%
	Rodlet 4	200.61	180.89	16.64%	9.15%	--	--
	Dummy	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--
<b>E-4 AFC-1D</b>	Rodlet 1	143.14	125.43	19.86%	10.88%	38.17%	--
	Rodlet 2	177.05	156.85	25.27%	12.33%	47.72%	--
	Rodlet 3	270.04	248.12	27.71%	17.78%	--	--
	Rodlet 4	222.99	204.08	27.94%	16.04%	52.91%	--
	Rodlet 5	174.51	187.66	31.93%	20.58%	--	--
	Dummy	--	--	--	--	--	--

**Table 7. Cycle 138B Projected Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the EFT (51 EFPD).**

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	<sup>239</sup> Pu Depletion (atom%)	Heavy Metals Depletion (atom%)	Am Depletion (atom%)	<sup>235</sup> U Depletion (atom%)
<b>E-2 AFC-1H</b>	Rodlet 1	170.86	129.62	13.87%	9.98%	31.40%	13.26%
	Rodlet 2	217.25	144.82	15.69%	8.77%	38.18%	17.79%
	Rodlet 3	239.01	202.47	21.60%	16.10%	45.71%	19.40%
	Rodlet 4	261.65	199.01	19.23%	14.13%	41.92%	18.80%
	Rodlet 5	265.52	205.63	19.29%	14.87%	38.83%	17.21%
	Rodlet 6	173.84	145.51	17.40%	12.72%	37.39%	15.34%
<b>E-3 AFC-1G</b>	Rodlet 1	110.70	98.52	12.91%	7.04%	--	--
	Dummy	--	--	--	--	--	--
	Rodlet 3	240.03	170.18	14.79%	10.29%	36.48%	18.63%
	Rodlet 4	181.03	164.82	18.87%	10.76%	--	--
	Dummy	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--
<b>E-4 AFC-1D</b>	Rodlet 1	125.80	111.07	21.44%	14.52%	41.15%	--
	Rodlet 2	156.17	139.59	27.07%	16.36%	50.89%	--
	Rodlet 3	239.23	222.67	29.87%	19.99%	--	--
	Rodlet 4	197.92	183.19	30.07%	21.03%	56.17%	--
	Rodlet 5	147.78	160.41	34.18%	22.94%	--	--
	Dummy	--	--	--	--	--	--

**Table 8. Projected Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position at the End of Cycle 139A Irradiation (56 EFPD).**

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	<sup>239</sup> Pu Depletion (atom%)	Heavy Metals Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>235</sup> U Depletion (atom%)
<b>E-2 AFC-1H</b>	Rodlet 1	170.31	130.51	15.96%	11.38%	35.76%	15.30%
	Rodlet 2	228.52	153.97	18.11%	10.09%	43.08%	20.63%
	Rodlet 3	250.72	215.76	25.05%	18.59%	51.12%	22.56%
	Rodlet 4	281.86	217.77	22.44%	16.32%	47.77%	21.89%
	Rodlet 5	271.92	214.02	22.46%	17.03%	44.09%	19.95%
	Rodlet 6	194.39	164.76	20.63%	14.77%	42.33%	17.86%
<b>E-3 AFC-1G</b>	Rodlet 1	121.39	108.80	15.04%	8.30%	--	--
	Dummy	--	--	--	--	--	--
	Rodlet 3	249.33	179.17	17.31%	11.61%	41.92%	24.18%
	Rodlet 4	198.09	182.32	22.02%	12.75%	--	--
	Dummy	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--
<b>E-4 AFC-1D</b>	Rodlet 1	132.54	117.96	23.55%	15.65%	44.71%	--
	Rodlet 2	164.79	148.74	29.79%	17.70%	55.00%	--
	Rodlet 3	253.15	239.02	32.81%	22.21%	--	--
	Rodlet 4	221.12	207.42	33.29%	22.87%	60.49%	--
	Rodlet 5	157.61	172.92	37.44%	25.56%	--	--
	Dummy	--	--	--	--	--	--

**Table 9. Projected Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position at the End of Cycle 139B Irradiation (49 EFPD).**

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	<sup>239</sup> Pu Depletion (atom%)	Heavy Metals Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>235</sup> U Depletion (atom%)
<b>E-2 AFC-1H</b>	Rodlet 1	172.27	134.90	17.24%	12.34%	37.96%	16.96%
	Rodlet 2	216.70	148.46	19.66%	11.13%	46.55%	22.88%
	Rodlet 3	207.34	178.11	26.89%	19.75%	52.45%	24.21%
	Rodlet 4	230.09	177.39	23.29%	17.10%	49.64%	23.43%
	Rodlet 5	226.17	178.05	23.39%	17.97%	46.20%	21.73%
	Rodlet 6	172.26	146.76	21.22%	15.61%	43.14%	19.22%
<b>E-3 AFC-1G</b>	Rodlet 1	130.08	110.80	17.64%	9.81%	--	--
	Dummy	--	--	--	--	--	--
	Rodlet 3	222.01	156.59	19.92%	12.39%	45.28%	23.44%
	Rodlet 4	179.83	155.62	24.98%	14.54%	--	--
	Dummy	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--

As identified in the above tables, the maximum LHGR throughout each cycle of irradiation remained under the ESAP LHGR safety limit of 400 W/cm.

## 8. AS-RUN PHYSICS ANALYSIS EXPERIMENT DATA

Neutronics analysis was performed to determine the as-run linear heat generation rate (LHGR) and as-run fuel burnup of the as-built AFC-1D, -1G, and -1H tests. New as-built constituent data were received from the fuel fabricators for the AFC-1AE, AFC-1B, AFC-1D, AFC-1F, AFC-1G and AFC-1H rodlets in January 2007. Analysis was re-performed using the new data provided and preliminary results are listed below.

The as-run re-analysis for ATR Cycles 131A through 139A are based upon the as-run conditions summarized in Table 10.

**Table 10. ATR Power History and Calculated East Lobe Power  
(Powers used to scale MCNP results)**

Cycle	NW Power (MW)	NE Power (MW)	C Power (MW)	SW Power (MW)	SE Power (MW)	Core Power (MW)	E Power (MW)	Cycle EFPD	Post Cycle Cooling (Days)
131A	18.0	17.0	24.3	23.0	24.6	106.9	22.0	48.5	145.7
132A	18.0	18.0	25.7	23.0	27.0	111.7	23.6	44.1	26.4
132C	18.0	18.0	25.6	23.0	27.0	111.6	23.5	50.3	49.9
133B	18.1	18.0	26.6	23.7	27.0	113.4	23.9	61.4	357.6
135B	18.0	18.0	25.0	23.0	25.0	109.0	22.7	48.0	8.8
135C	18.0	18.0	25.0	23.0	25.0	109.0	22.7	40.6	19.0
136A	18.0	18.0	24.0	23.0	23.0	106.0	21.7	50.9	15.0
136B	18.0	18.0	23.9	23.0	23.0	105.9	21.6	39.0	39.0
137A	18.0	18.0	24.7	20.0	25.0	105.7	22.6	54.1	124.1
138A	18.0	18.0	23.6	23.0	25.0	107.6	22.2	58.1	17.0
138B	18.0	18.0	23.3	23.0	25.0	107.3	22.1	46.6	14.0
139A	18.0	18.0	23.9	23.0	25.0	107.9	22.3	51.6	64.0

<sup>(b)</sup> Average C Lobe Power for cycles 135B-1 and 135B-2 was calculated as follows:  
 $C = (24.8 \text{ MW} \cdot (25.5 \text{ EFPD} / 48.0 \text{ EFPD}) + 25.2 \text{ MW} \cdot (22.5 \text{ EFPD} / 48.0 \text{ EFPD})) = 25.0 \text{ MW}$

The ATR Cycle 131A thru 139A as-run calculations were performed for AFC-1D, AFC-1G, and AFC-1H. These results are tabulated in Table 11 through Table 19, respectively.

**Table 11. Cycle 131A As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 106.9 MW, E-lobe 22.07 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1B E-1 14.0 EFPDs</b>	1	116.44	101.18	4.04E+19	0.56%	--	0.47%	1.30%	0.70%
	2	138.84	113.07	4.84E+19	0.86%	--	0.64%	1.74%	1.14%
	3	212.11	178.47	7.59E+19	0.86%	--	0.51%	2.41%	--
	4	173.08	145.68	6.06E+19	0.83%	--	0.69%	1.91%	1.29%
	5	141.03	139.95	4.99E+19	1.00%	--	0.57%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-2 14.0 EFPDs</b>	1	107.99	91.93	3.82E+19	0.59%	--	0.47%	1.11%	0.66%
	2	124.83	104.63	4.35E+19	0.79%	--	0.57%	1.55%	1.04%
	3	200.74	172.53	7.11E+19	0.80%	--	0.48%	2.41%	--
	4	161.89	138.02	5.79E+19	0.84%	--	0.69%	1.87%	1.19%
	5	136.30	127.81	4.49E+19	0.92%	--	0.52%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1B E-1 28.0 EFPDs</b>	1	127.05	110.56	8.44E+19	1.26%	--	1.02%	2.70%	1.47%
	2	138.11	112.68	9.65E+19	1.63%	--	1.16%	3.34%	2.23%
	3	208.14	175.57	1.50E+20	1.65%	--	0.98%	4.68%	--
	4	173.81	146.61	1.21E+20	1.72%	--	1.41%	3.79%	2.47%
	5	141.44	140.63	1.00E+20	1.99%	--	1.14%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-2 28.0 EFPDs</b>	1	114.58	97.67	7.88E+19	1.10%	--	0.88%	2.31%	1.43%
	2	125.80	107.27	8.80E+19	1.51%	--	1.07%	3.13%	2.04%
	3	195.61	165.96	1.39E+20	1.61%	--	0.97%	--	--
	4	159.05	134.49	1.14E+20	1.63%	--	1.32%	3.63%	2.38%
	5	124.70	127.10	8.95E+19	1.77%	--	1.00%	--	--
	6	--	--	--	--	--	--	--	--

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1B E-1 48.5 EFPDs</b>	1	119.80	104.43	1.45E+20	2.14%	--	1.73%	4.65%	2.61%
	2	144.28	117.90	1.70E+20	2.83%	--	1.94%	5.71%	3.82%
	3	211.30	178.65	2.61E+20	2.91%	--	1.74%	7.68%	--
	4	178.80	151.17	2.13E+20	2.99%	--	2.42%	6.55%	4.19%
	5	138.66	138.13	1.72E+20	3.50%	--	2.04%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-2 48.5 EFPDs</b>	1	116.43	99.38	1.39E+20	1.93%	--	1.54%	4.09%	2.47%
	2	130.43	111.39	1.56E+20	2.59%	--	1.78%	5.39%	3.55%
	3	194.04	165.02	2.38E+20	2.73%	--	1.66%	--	--
	4	159.36	135.00	1.97E+20	2.78%	--	2.23%	6.18%	4.06%
	5	130.41	133.13	1.58E+20	3.19%	--	1.83%	--	--
	6	--	--	--	--	--	--	--	--



**Table 12. Cycle 132A As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 111.7 MW, E-lobe 23.6 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1B E-1 14.0 EFPDs</b>	1	131.89	114.80	1.91E+20	3.45%	--	2.49%	7.36%	1.47%
	2	159.12	133.75	2.26E+20	4.53%	--	2.83%	9.27%	6.13%
	3	237.18	206.44	3.46E+20	4.72%	--	2.83%	7.46%	--
	4	196.17	172.36	2.82E+20	4.78%	--	3.50%	10.47%	4.56%
	5	159.46	164.99	2.28E+20	5.76%	--	3.37%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1F E-2 14.0 EFPDs</b>	1	180.67	131.87	6.48E+19	0.69%	0.60%	0.49%	1.61%	1.08%
	2	233.47	146.34	8.11E+19	0.70%	0.83%	0.43%	1.97%	1.25%
	3	248.30	199.35	8.96E+19	1.02%	0.86%	0.75%	2.60%	1.54%
	4	280.60	199.18	9.80E+19	0.88%	0.89%	0.68%	2.42%	1.41%
	5	279.17	202.39	9.82E+19	0.89%	0.81%	0.73%	1.97%	0.92%
	6	178.81	147.23	6.45E+19	0.80%	0.67%	0.59%	2.04%	1.18%
<b>AFC-1D E-3 14.0 EFPDs</b>	1	122.50	107.07	1.82E+20	3.19%	--	2.31%	6.78%	1.43%
	2	135.16	119.17	2.03E+20	4.17%	--	2.59%	8.75%	5.70%
	3	225.51	197.70	3.17E+20	4.50%	--	2.73%	--	--
	4	183.03	162.88	2.61E+20	4.53%	--	3.29%	9.92%	4.50%
	5	145.89	155.17	2.10E+20	5.21%	--	3.04%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1/E E-4 14.0 EFPDs</b>	1	110.55	97.68	3.48E+19	0.78%	--	0.72%	1.36%	1.05%
	2	--	--	--	--	--	--	--	--
	3	160.94	140.74	4.90E+19	1.03%	--	1.01%	1.91%	1.50%
	4	177.48	164.99	4.88E+19	1.19%	--	1.08%	2.10%	1.65%
	5	154.50	142.67	4.51E+19	1.08%	--	0.77%	2.19%	1.35%
	6	230.71	150.30	6.82E+19	0.66%	--	0.47%	1.60%	1.04%

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1B E-1 28.0 EFPDs</b>	1	132.62	115.64	2.37E+20	4.22%	--	3.09%	9.00%	2.52%
	2	156.82	132.08	2.80E+20	5.52%	--	3.50%	11.27%	7.47%
	3	235.75	205.83	4.30E+20	5.74%	--	3.47%	9.86%	
	4	192.32	169.42	3.49E+20	5.86%	--	4.32%	12.62%	6.11%
	5	163.89	169.96	2.86E+20	7.00%	--	4.12%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1F E-2 28.0 EFPDs</b>	1	195.24	139.19	1.33E+20	1.37%	1.34%	1.03%	3.51%	2.17%
	2	221.34	142.66	1.60E+20	1.48%	1.78%	0.91%	4.23%	2.69%
	3	250.45	195.57	1.77E+20	2.18%	1.96%	1.65%	5.59%	3.23%
	4	265.08	194.67	1.94E+20	1.84%	1.85%	1.41%	5.02%	3.00%
	5	277.84	201.01	1.95E+20	1.85%	1.69%	1.52%	4.27%	1.66%
	6	189.71	152.56	1.31E+20	1.72%	1.52%	1.30%	4.42%	2.50%
<b>AFC-1D E-3 28.0 EFPDs</b>	1	130.64	114.38	2.29E+20	3.96%	--	2.90%	8.35%	2.38%
	2	143.19	126.50	2.54E+20	5.10%	--	3.22%	10.71%	7.01%
	3	221.02	194.30	3.94E+20	5.46%	--	3.34%	--	--
	4	179.12	159.83	3.25E+20	5.56%	--	4.08%	12.03%	5.93%
	5	144.36	153.87	2.62E+20	6.46%	--	3.80%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1Æ E-4 28.0 EFPDs</b>	1	115.92	102.59	7.14E+19	1.64%	--	1.50%	2.95%	2.29%
	2	--	--	--	--	--	--	--	--
	3	157.59	138.13	9.70E+19	2.26%	--	2.14%	4.07%	3.20%
	4	172.58	160.88	9.62E+19	2.57%	--	2.29%	4.53%	3.50%
	5	154.37	142.90	9.02E+19	2.31%	--	1.63%	4.71%	2.86%
	6	233.34	152.39	1.37E+20	1.40%	--	1.01%	3.42%	2.30%
<b>AFC-1B E-1</b>	1	139.56	121.91	2.92E+20	4.22%	--	3.00%	9.00%	2.02%
	2	157.35	132.79	3.43E+20	5.52%	--	3.35%	11.23%	7.47%
	3	235.65	206.34	5.26E+20	5.74%	--	3.47%	8.48%	

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
44.0 EFPDs	4	194.09	171.41	4.27E+20	5.86%	--	4.19%	12.59%	5.66%
	5	160.90	167.29	3.51E+20	7.00%	--	4.12%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1F E-2 44.0 EFPDs	1	199.81	142.76	2.13E+20	1.37%	1.34%	1.00%	3.41%	2.17%
	2	224.44	144.99	2.51E+20	1.41%	1.78%	0.85%	4.16%	2.60%
	3	250.88	196.46	2.77E+20	2.17%	1.96%	1.61%	5.53%	3.17%
	4	262.81	193.58	3.02E+20	1.84%	1.85%	1.37%	4.97%	2.93%
	5	273.07	198.17	3.04E+20	1.85%	1.69%	1.48%	4.27%	0.84%
	6	190.55	153.58	2.08E+20	1.72%	1.52%	1.27%	4.33%	2.46%
AFC-1D E-3 44.0 EFPDs	1	138.66	121.62	2.85E+20	3.96%	--	2.82%	8.35%	1.90%
	2	144.84	128.19	3.13E+20	5.10%	--	3.08%	10.68%	7.01%
	3	220.91	194.77	4.82E+20	5.46%	--	3.33%	--	--
	4	179.64	160.66	3.97E+20	5.56%	--	3.97%	12.03%	5.60%
	5	152.21	162.58	3.24E+20	6.46%	--	3.80%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1Æ E-4 44.0 EFPDs	1	119.74	106.15	1.15E+20	1.64%	--	1.39%	2.97%	2.11%
	2	--	--	--	--	--	--	--	--
	3	161.06	141.47	1.53E+20	2.26%	--	1.96%	4.09%	3.00%
	4	179.87	168.10	1.53E+20	2.57%	--	2.11%	4.55%	3.24%
	5	156.37	145.06	1.42E+20	2.31%	--	1.46%	4.71%	2.86%
	6	238.36	156.02	2.18E+20	1.31%	--	0.92%	3.45%	2.26%

**Table 13. Cycle 132C As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 111.6 MW, E-lobe 23.9 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1D E-1 15.0 EFPDs</b>	1	133.36	114.82	3.34E+20	4.62%	--	3.32%	9.73%	2.75%
	2	155.99	136.24	3.71E+20	6.05%	--	3.74%	12.52%	8.25%
	3	228.21	207.15	5.69E+20	6.43%	--	3.92%	--	--
	4	193.88	172.11	4.70E+20	6.52%	--	4.72%	14.08%	6.95%
	5	153.08	162.30	3.82E+20	7.55%	--	4.46%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1F E-2 15.0 EFPDs</b>	1	180.36	132.55	2.82E+20	2.04%	1.95%	1.49%	5.02%	3.07%
	2	230.60	145.54	3.37E+20	2.18%	2.63%	1.33%	6.27%	4.03%
	3	247.06	200.27	3.73E+20	3.26%	2.89%	2.42%	8.27%	4.73%
	4	274.34	196.62	4.04E+20	2.80%	2.81%	2.12%	7.53%	4.46%
	5	272.41	199.39	4.07E+20	2.81%	2.51%	2.23%	6.30%	1.49%
	6	192.55	142.22	2.74E+20	2.52%	2.27%	1.90%	6.36%	3.64%
<b>AFC-1Æ E-3 15.0 EFPDs</b>	1	97.48	86.57	1.47E+20	2.26%	--	1.96%	4.19%	3.06%
	2	--	--	--	--	--	--	--	--
	3	148.86	129.13	2.02E+20	3.29%	--	2.90%	5.89%	4.37%
	4	162.37	143.60	2.00E+20	3.71%	--	3.13%	6.65%	4.77%
	5	138.65	125.04	1.86E+20	3.32%	--	2.22%	6.78%	4.13%
	6	202.12	132.13	2.81E+20	1.97%	--	1.39%	4.96%	3.21%
<b>AFC-1D E-1 30.0 EFPDs</b>	1	142.50	122.93	3.87E+20	5.33%	--	3.86%	11.24%	3.70%
	2	156.93	137.39	4.30E+20	6.98%	--	4.34%	14.37%	9.44%
	3	225.15	205.04	6.55E+20	7.31%	--	4.47%	--	--
	4	187.02	166.51	5.40E+20	7.42%	--	5.41%	16.02%	8.39%
	5	155.24	164.99	4.41E+20	8.72%	--	5.18%	--	--
	6	--	--	--	--	--	--	--	--

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1F E-2 30.0 EFPDs	1	196.09	140.76	3.55E+20	2.64%	2.62%	1.96%	6.66%	4.15%
	2	219.68	142.62	4.21E+20	2.89%	3.46%	1.75%	8.16%	5.28%
	3	244.40	192.71	4.64E+20	4.31%	3.83%	3.21%	10.80%	6.12%
	4	261.99	194.28	5.06E+20	3.76%	3.71%	2.82%	9.86%	5.84%
	5	263.62	192.61	5.06E+20	3.69%	3.32%	2.95%	8.33%	1.43%
	6	186.12	150.78	3.44E+20	3.34%	3.03%	2.53%	8.48%	4.76%
AFC-1/E E-3 30.0 EFPDs	1	106.93	95.11	1.84E+20	3.04%	--	2.61%	5.48%	4.04%
	2	--	--	--	--	--	--	--	--
	3	145.27	126.35	2.49E+20	4.32%	--	3.77%	7.60%	5.74%
	4	155.08	137.53	2.46E+20	4.80%	--	4.06%	8.62%	6.29%
	5	132.91	120.14	2.27E+20	4.28%	--	2.87%	8.73%	5.40%
	6	203.50	133.32	6.44E+19	2.64%	--	1.85%	6.47%	4.20%
AFC-1D E-1 50.3 EFPDs	1	146.91	127.00	4.60E+20	6.29%	--	4.56%	13.18%	5.04%
	2	154.32	135.42	5.06E+20	8.13%	--	5.06%	16.67%	11.06%
	3	228.11	208.38	7.72E+20	8.59%	--	5.29%	--	--
	4	193.88	173.08	6.37E+20	8.70%	--	6.38%	18.67%	10.25%
	5	154.62	164.78	5.19E+20	10.15%	--	6.08%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1F E-1 50.3 EFPDs	1	189.41	136.25	4.50E+20	3.48%	3.52%	2.61%	8.78%	5.50%
	2	223.62	145.50	5.35E+20	3.85%	4.61%	2.34%	10.81%	7.08%
	3	249.60	197.45	5.89E+20	5.71%	5.08%	4.25%	14.13%	7.94%
	4	256.64	190.94	6.38E+20	4.97%	4.89%	3.73%	12.89%	7.67%
	5	264.47	193.87	6.38E+20	4.84%	4.39%	3.87%	11.02%	0.88%
	6	182.52	148.25	4.36E+20	4.42%	4.03%	3.34%	10.93%	6.23%
AFC-1/E E-3	1	106.05	94.50	2.31E+20	3.91%	--	3.38%	7.24%	5.34%
	2	--	--	--	--	--	--	--	--
	3	146.47	127.70	3.13E+20	5.63%	--	4.89%	9.92%	7.57%

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
50.3 EFPDs	4	159.72	141.99	3.09E+20	6.28%	--	5.30%	11.30%	8.33%
	5	135.90	123.10	2.84E+20	5.56%	--	3.70%	11.29%	7.03%
	6	206.26	135.47	8.71E+19	3.39%	--	2.38%	8.41%	5.42%

**Table 14. Cycle 133B As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 113.4 MW, E-lobe 23.9 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1D E-2 20.0 EFPDs	1	126.61	113.60	5.07E+20	6.89%	--	4.83%	14.39%	5.21%
	2	146.71	149.26	5.63E+20	9.00%	--	5.42%	18.29%	12.22%
	3	239.96	203.17	8.62E+20	9.56%	--	5.90%	--	--
	4	203.00	186.84	7.14E+20	9.66%	--	6.86%	20.54%	11.18%
	5	165.38	196.00	5.77E+20	11.24%	--	6.75%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-2 40.0 EFPDs	1	145.97	130.54	5.61E+20	7.60%	--	5.35%	15.83%	6.17%
	2	158.60	157.66	6.22E+20	9.86%	--	5.96%	20.03%	13.37%
	3	233.10	202.10	9.51E+20	10.52%	--	6.52%	--	--
	4	194.82	178.01	7.87E+20	10.64%	--	7.57%	22.44%	12.54%
	5	155.55	198.56	6.36E+20	12.34%	--	7.45%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-2 61.4.3 EFPDs	1	143.66	128.76	6.37E+20	8.62%	--	6.06%	17.71%	7.46%
	2	164.67	164.11	7.09E+20	11.15%	--	6.77%	22.41%	15.03%
	3	235.65	204.97	1.08E+21	11.89%	--	7.40%	--	--
	4	197.42	180.94	8.93E+20	11.96%	--	8.53%	25.05%	14.48%
	5	167.18	214.07	7.26E+20	14.01%	--	8.52%	--	--
	6	--	--	--	--	--	--	--	--

**Table 15. Cycle 135B As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 109.0 MW, E-lobe 22.7 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1D E-1 18.0 EFPDs</b>	1	132.31	115.49	6.96E+20	9.34%	--	5.67%	18.82%	3.79%
	2	157.87	140.07	7.80E+20	12.17%	--	6.42%	23.95%	16.26%
	3	223.83	207.80	1.18E+21	12.93%	--	8.04%	--	--
	4	197.10	178.44	9.82E+20	13.11%	--	8.12%	26.57%	12.46%
	5	154.31	166.54	7.97E+20	15.27%	--	9.32%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1H E-2 18.0 EFPDs</b>	1	174.00	127.96	7.66E+19	0.75%	0.76%	0.59%	1.89%	1.24%
	2	228.41	146.09	9.89E+19	0.96%	1.10%	0.58%	2.61%	1.55%
	3	241.66	189.91	1.05E+20	1.28%	1.15%	0.99%	3.22%	1.97%
	4	262.22	185.16	1.15E+20	1.08%	1.15%	0.90%	2.93%	1.84%
	5	265.92	191.22	1.17E+20	1.10%	1.02%	0.93%	2.52%	1.35%
	6	178.17	141.69	7.77E+19	0.95%	0.90%	0.76%	2.56%	1.57%
<b>AFC-1G E-3 18.0 EFPDs</b>	1	125.07	101.32	5.84E+19	0.83%	--	0.46%	--	--
	2	--	--	--	--	--	--	--	--
	3	260.77	169.37	1.10E+20	0.99%	1.11%	0.74%	2.39%	1.56%
	4	186.45	149.85	8.71E+19	1.09%	--	0.59%	--	1.77%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-1 36.0 EFPDs</b>	1	138.93	121.54	7.58E+20	10.11%	--	6.29%	20.36%	4.93%
	2	154.73	137.68	8.49E+20	13.17%	--	7.11%	25.91%	17.57%
	3	219.65	204.71	1.28E+21	13.98%	--	8.73%	--	--
	4	197.83	179.78	1.07E+21	14.20%	--	8.97%	28.65%	14.06%
	5	147.93	160.13	8.64E+20	16.53%	--	10.15%	--	--
	6	--	--	--	--	--	--	--	--



Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1H E-2 36.0 EFPDs	1	184.41	135.96	1.58E+20	1.57%	1.53%	1.20%	3.97%	2.51%
	2	226.77	145.48	1.97E+20	1.85%	2.20%	1.11%	5.31%	3.17%
	3	232.75	183.61	2.06E+20	2.50%	2.21%	1.89%	6.24%	3.84%
	4	254.05	180.07	2.26E+20	2.08%	2.20%	1.70%	5.62%	3.58%
	5	259.06	187.01	2.30E+20	2.19%	2.00%	1.82%	4.87%	2.36%
	6	181.35	144.64	1.57E+20	1.91%	1.72%	1.48%	5.03%	3.04%
AFC-1G E-3 36.0 EFPDs	1	125.97	102.26	1.17E+20	1.56%	--	0.84%	--	2.36%
	2	--	--	--	--	--	--	--	--
	3	254.53	165.90	2.16E+20	1.97%	2.20%	1.43%	4.69%	3.04%
	4	184.64	148.80	1.73E+20	2.27%	--	1.22%	--	--
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-1 48.0 EFPDs	1	135.14	118.51	7.98E+20	10.58%	--	6.66%	21.37%	5.70%
	2	153.90	137.32	8.95E+20	13.75%	--	7.52%	27.16%	18.46%
	3	221.59	207.33	1.35E+21	14.70%	--	9.22%	--	--
	4	195.02	177.86	1.13E+21	14.92%	--	9.53%	29.92%	15.17%
	5	155.03	168.35	9.11E+20	17.38%	--	10.72%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1H E-1 48.0 EFPDs	1	184.08	136.08	2.12E+20	2.12%	2.06%	1.61%	5.29%	3.31%
	2	224.80	144.61	2.62E+20	2.47%	2.89%	1.48%	6.92%	4.25%
	3	240.01	190.01	2.75E+20	3.33%	2.94%	2.51%	8.30%	5.05%
	4	254.81	181.24	3.01E+20	2.80%	2.88%	2.24%	7.42%	4.70%
	5	261.89	189.76	3.07E+20	2.93%	2.64%	2.41%	6.54%	2.69%
	6	191.31	153.01	2.12E+20	2.59%	2.30%	1.98%	6.67%	4.03%
AFC-1G E-3	1	136.10	110.71	1.60E+20	2.11%	--	1.12%	--	3.18%
	2	--	--	--	--	--	--	--	--
	3	250.68	163.97	2.87E+20	2.53%	2.92%	1.85%	6.16%	4.08%

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
48.0 EFPDs	4	185.04	149.58	2.31E+20	3.00%	--	1.61%	--	4.69%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--

**Table 16. Cycle 135C As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 109.0 MW, E-lobe 22.7 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1D E-1 15.0 EFPDs</b>	1	129.36	113.64	8.46E+20	11.19%	--	7.05%	22.48%	6.14%
	2	160.28	143.23	9.55E+20	14.61%	--	8.03%	28.74%	19.58%
	3	233.92	219.42	1.44E+21	15.58%	--	9.81%	--	--
	4	208.03	190.15	1.21E+21	15.89%	--	10.18%	31.62%	16.28%
	5	160.69	174.87	9.72E+20	18.47%	--	11.43%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1H E-2 15.0 EFPDs</b>	1	174.98	129.59	2.76E+20	2.67%	2.68%	2.03%	6.85%	4.25%
	2	226.77	146.19	3.44E+20	3.22%	3.78%	1.90%	8.99%	5.51%
	3	247.71	196.60	3.65E+20	4.41%	3.91%	3.30%	10.76%	6.53%
	4	266.25	189.84	3.98E+20	3.70%	3.79%	2.91%	9.70%	6.05%
	5	264.61	192.18	4.03E+20	3.75%	3.47%	3.09%	8.49%	2.55%
	6	190.21	152.44	2.81E+20	3.42%	3.04%	2.58%	8.69%	5.27%
<b>AFC-1G E-3 15.0 EFPDs</b>	1	126.97	103.44	2.09E+20	2.76%	--	1.46%	--	4.12%
	2	--	--	--	--	--	--	--	--
	3	267.45	175.27	3.80E+20	3.27%	3.83%	2.37%	8.17%	5.41%
	4	198.58	160.83	3.08E+20	4.00%	--	2.14%	--	6.12%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-1 30.0 EFPDs</b>	1	131.68	115.87	8.95E+20	11.78%	--	7.50%	23.62%	6.96%
	2	163.31	146.32	1.02E+21	15.48%	--	8.60%	30.29%	20.62%
	3	239.42	225.36	1.53E+21	16.55%	--	10.46%	--	--
	4	212.39	194.79	1.29E+21	16.86%	--	10.92%	33.35%	17.67%
	5	167.70	183.00	1.04E+21	19.63%	--	12.20%	--	--
	6	--	--	--	--	--	--	--	--

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1H E-2 30.0 EFPDs	1	177.36	131.64	3.41E+20	3.31%	3.30%	2.51%	8.39%	5.21%
	2	230.05	148.66	4.27E+20	3.98%	4.67%	2.35%	11.06%	6.79%
	3	251.12	199.99	4.56E+20	5.50%	4.90%	4.12%	13.22%	7.98%
	4	265.92	190.21	4.95E+20	4.60%	4.71%	3.62%	12.06%	7.39%
	5	268.97	196.00	5.02E+20	4.68%	4.30%	3.83%	10.44%	--
	6	192.73	154.86	3.51E+20	4.29%	3.79%	3.22%	10.67%	6.52%
AFC-1G E-3 30.0 EFPDs	1	128.28	104.67	2.59E+20	3.40%	--	1.80%	--	5.11%
	2	--	--	--	--	--	--	--	0.00%
	3	269.27	177.03	4.74E+20	4.09%	4.76%	2.93%	10.10%	6.75%
	4	203.30	165.09	3.87E+20	5.00%	--	2.67%	--	7.51%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-1 40.6 EFPDs	1	143.55	126.56	9.33E+20	12.26%	--	7.87%	24.52%	7.59%
	2	167.49	150.44	1.06E+21	16.05%	--	8.99%	31.38%	21.43%
	3	233.81	220.91	1.60E+21	17.19%	--	10.90%	--	--
	4	208.65	191.97	1.34E+21	17.52%	--	11.42%	34.51%	18.57%
	5	158.33	173.27	1.08E+21	20.38%	--	12.70%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1H E-1 40.6 EFPDs	1	184.30	137.09	3.89E+20	3.79%	3.76%	2.85%	9.46%	5.94%
	2	233.77	151.44	4.86E+20	4.53%	5.31%	2.65%	12.58%	7.69%
	3	243.75	194.78	5.18E+20	6.27%	5.47%	4.64%	14.96%	8.99%
	4	264.72	189.97	5.63E+20	5.23%	5.31%	4.08%	13.53%	8.35%
	5	265.05	193.78	5.70E+20	5.32%	4.89%	4.35%	11.87%	--
	6	189.78	152.88	4.00E+20	4.90%	4.28%	3.65%	12.08%	7.34%
AFC-1G E-3	1	136.60	111.66	2.97E+20	3.86%	--	2.04%	--	5.79%
	2	--	--	--	--	--	--	--	--
	3	260.77	171.95	5.39E+20	4.66%	5.30%	3.30%	11.42%	7.56%

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
40.6 EFPDs	4	194.37	158.26	--	5.64%	--	3.01%		8.51%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--

**Table 17. Cycle 136A As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 106.0 MW, E-lobe 21.7 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1D E-1 20.0 EFPDs</b>	1	125.69	110.97	9.95E+20	13.03%	--	8.42%	25.96%	8.51%
	2	145.64	131.01	1.13E+21	17.06%	--	9.60%	33.20%	22.70%
	3	204.37	193.55	1.70E+21	18.23%	--	11.62%	--	--
	4	187.02	172.43	1.44E+21	18.61%	--	12.20%	36.49%	20.15%
	5	146.28	160.40	1.15E+21	21.66%	--	13.58%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1H E-2 20.0 EFPDs</b>	1	166.53	124.07	4.70E+20	4.61%	4.45%	3.39%	11.34%	7.12%
	2	204.33	132.58	5.84E+20	5.35%	6.34%	3.14%	14.93%	9.14%
	3	225.71	180.75	6.27E+20	7.55%	6.60%	5.56%	17.73%	10.52%
	4	248.82	178.95	6.84E+20	6.42%	6.45%	4.94%	16.14%	9.92%
	5	250.89	183.85	6.92E+20	6.51%	5.91%	5.25%	14.33%	--
	6	171.83	138.67	4.83E+20	5.86%	5.11%	4.33%	14.27%	8.56%
<b>AFC-1G E-3 20.0 EFPDs</b>	1	121.05	99.06	3.59E+20	4.69%	--	2.48%	--	6.95%
	2	--	--	--	--	--	--	--	--
	3	240.03	158.60	6.51E+20	5.56%	6.48%	3.92%	13.69%	9.04%
	4	183.84	149.95	5.36E+20	6.82%	--	3.66%	--	10.23%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-1 40.0 EFPDs</b>	1	130.73	115.73	1.06E+21	13.81%	--	8.98%	27.41%	9.60%
	2	148.15	133.69	1.21E+21	17.99%	--	10.22%	34.97%	24.08%
	3	209.16	198.88	1.81E+21	19.28%	--	12.34%	--	--
	4	189.41	175.32	1.53E+21	19.69%	--	13.02%	38.46%	21.83%
	5	147.72	162.54	1.23E+21	22.97%	--	14.48%	--	--
	6	--	--	--	--	--	--	--	--

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1H E-2 40.0 EFPDs	1	171.19	127.88	5.54E+20	5.44%	5.29%	4.01%	13.28%	8.27%
	2	208.93	135.97	6.85E+20	6.23%	7.40%	3.68%	17.40%	10.58%
	3	224.28	180.34	7.35E+20	8.81%	7.74%	6.50%	20.56%	12.05%
	4	243.16	175.62	8.02E+20	7.41%	7.52%	5.71%	18.67%	11.42%
	5	245.88	180.98	8.12E+20	7.51%	6.87%	6.07%	16.69%	
	6	174.02	140.85	5.68E+20	6.82%	6.01%	5.06%	16.42%	9.86%
AFC-1G E-3 40.0 EFPDs	1	127.47	104.56	4.26E+20	5.51%	--	2.91%	--	8.15%
	2	--	--	--	--	--	--	--	--
	3	236.63	156.96	7.61E+20	6.45%	7.48%	4.51%	15.91%	10.53%
	4	185.64	151.95	6.33E+20	8.01%	--	4.32%	--	11.91%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-1 50.9 EFPDs	1	137.46	122.00	1.10E+21	14.23%	--	9.29%	28.21%	10.23%
	2	146.68	132.74	1.25E+21	18.58%	--	10.59%	35.95%	24.82%
	3	213.03	203.43	1.87E+21	19.85%	--	12.74%	--	--
	4	189.93	176.48	1.58E+21	20.30%	--	13.48%	39.56%	22.72%
	5	149.58	165.14	1.27E+21	23.67%	--	14.96%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1H E-1 50.9 EFPDs	1	170.65	127.87	5.99E+20	5.90%	5.67%	4.32%	14.35%	8.86%
	2	216.04	141.05	7.41E+20	6.71%	7.97%	3.95%	18.74%	11.34%
	3	217.24	175.39	7.92E+20	9.47%	8.32%	6.99%	22.03%	12.85%
	4	243.71	176.66	8.67E+20	8.04%	8.12%	6.18%	20.09%	12.23%
	5	245.01	181.02	8.77E+20	8.17%	7.46%	6.57%	17.89%	--
	6	179.16	145.47	6.15E+20	7.35%	6.50%	5.46%	17.63%	10.58%
AFC-1G E-3	1	130.18	107.02	4.62E+20	5.97%	--	3.16%	--	8.80%
	2	--	--	--	--	--	--	--	--
	3	236.74	157.56	8.21E+20	6.94%	8.12%	4.86%	17.09%	11.27%

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
50.9 EFPDs	4	182.94	150.22	--	8.55%	--	4.61%	--	12.77%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--



**Table 18. Cycle 136B As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 105.9 MW, E-lobe 21.6 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1D E-1 15.0 EFPDs</b>	1	130.31	115.81	1.15E+21	14.83%	--	9.63%	29.25%	10.75%
	2	153.27	138.95	1.30E+21	19.29%	--	10.96%	37.27%	25.82%
	3	215.07	205.86	1.95E+21	20.67%	--	13.30%	--	--
	4	198.87	185.19	1.66E+21	21.15%	--	13.98%	40.97%	23.77%
	5	152.15	168.30	1.32E+21	24.66%	--	15.64%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1H E-2 15.0 EFPDs</b>	1	166.85	125.22	6.60E+20	6.45%	6.30%	4.72%	15.67%	9.68%
	2	204.22	133.55	8.15E+20	7.40%	8.73%	4.31%	20.37%	12.32%
	3	224.06	181.28	8.73E+20	10.39%	9.13%	7.62%	23.88%	13.85%
	4	249.26	181.12	9.58E+20	8.85%	8.95%	6.74%	21.91%	13.29%
	5	247.63	183.40	9.67E+20	8.96%	8.16%	7.13%	19.67%	--
	6	175.00	142.35	6.79E+20	8.09%	7.17%	5.98%	19.14%	11.43%
<b>AFC-1G E-3 15.0 EFPDs</b>	1	127.27	104.76	5.12E+20	6.53%	--	3.44%	--	9.66%
	2	--	--	--	--	--	--	--	--
	3	246.94	164.68	9.08E+20	7.59%	8.92%	5.22%	18.76%	12.31%
	4	193.97	159.56	7.60E+20	9.47%	--	5.13%	--	14.06%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-1 30.0 EFPDs</b>	1	131.26	116.90	1.19E+21	15.42%	--	10.07%	30.36%	11.55%
	2	152.54	138.60	1.36E+21	20.01%	--	11.42%	38.59%	26.78%
	3	217.11	208.50	2.03E+21	21.49%	--	13.88%	--	--
	4	195.86	182.95	1.73E+21	21.99%	--	14.60%	42.38%	24.98%
	5	153.08	169.79	1.38E+21	25.67%	--	16.35%	--	--
	6	--	--	--	--	--	--	--	--

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1H E-2 30.0 EFPDs	1	171.30	128.83	7.23E+20	7.09%	6.83%	5.16%	17.03%	10.55%
	2	218.12	142.98	8.94E+20	8.02%	9.55%	4.69%	22.17%	13.37%
	3	218.23	177.10	9.52E+20	11.28%	9.95%	8.28%	25.74%	14.95%
	4	240.44	175.25	1.05E+21	9.58%	9.71%	7.31%	23.72%	14.36%
	5	242.51	180.15	1.06E+21	9.75%	8.93%	7.77%	21.27%	--
	6	168.54	137.42	7.40E+20	8.81%	7.83%	6.52%	20.64%	12.30%
AFC-1G E-3 30.0 EFPDs	1	126.37	104.19	5.61E+20	7.17%	--	3.80%	--	10.56%
	2	--	--	--	--	--	--	--	--
	3	242.86	162.43	9.92E+20	8.34%	9.73%	5.69%	20.40%	13.42%
	4	188.75	155.66	8.33E+20	10.35%	--	5.62%	--	15.26%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-1 39.0 EFPDs	1	132.83	118.54	1.22E+21	15.72%	--	10.31%	31.06%	12.02%
	2	156.09	142.14	1.40E+21	20.51%	--	11.75%	39.38%	27.40%
	3	223.01	214.90	2.08E+21	21.98%	--	14.22%	--	--
	4	201.06	188.37	1.78E+21	22.53%	--	14.99%	43.19%	25.71%
	5	158.64	176.42	1.42E+21	26.30%	--	16.78%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1H E-1 39.0 EFPDs	1	172.27	129.85	7.61E+20	7.36%	7.21%	5.40%	17.83%	11.06%
	2	220.53	144.87	9.41E+20	8.50%	10.03%	4.94%	23.23%	13.99%
	3	220.98	179.86	1.00E+21	11.82%	10.43%	8.68%	26.85%	15.57%
	4	242.62	177.32	1.10E+21	10.09%	10.16%	7.66%	24.81%	14.99%
	5	245.12	182.66	1.11E+21	10.24%	9.38%	8.15%	22.25%	--
	6	169.64	138.64	7.77E+20	9.22%	8.24%	6.84%	21.55%	12.82%
AFC-1G E-3	1	127.97	105.70	5.91E+20	7.54%	--	3.99%	--	11.07%
	2	--	--	--	--	--	--	--	--
	3	244.56	164.04	1.04E+21	8.74%	10.20%	5.95%	21.38%	14.08%

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
39.0 EFPDs	4	192.16	158.88	8.78E+20	10.89%	--	5.94%	--	15.97%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--

**Table 19. Cycle 137A As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 105.7 MW, E-lobe 22.6 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1D E-4 16.0 EFPDs</b>	1	135.67	121.19	1.28E+21	16.37%	--	10.70%	32.24%	12.73%
	2	159.33	145.32	1.46E+21	21.30%	--	12.18%	40.70%	28.44%
	3	225.05	217.29	2.17E+21	22.84%	--	14.83%	--	--
	4	191.49	179.75	1.85E+21	23.38%	--	15.51%	44.57%	26.81%
	5	152.77	170.19	1.48E+21	27.33%	--	17.50%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1H E-2 16.0 EFPDs</b>	1	170.97	129.03	8.28E+20	8.03%	7.82%	5.84%	19.19%	11.86%
	2	215.93	142.06	1.02E+21	9.18%	10.88%	5.34%	24.97%	15.09%
	3	236.93	193.19	1.09E+21	12.86%	11.41%	9.44%	28.82%	16.67%
	4	257.75	188.73	1.20E+21	10.98%	11.08%	8.30%	26.76%	16.12%
	5	254.38	189.91	1.21E+21	11.11%	10.22%	8.80%	23.97%	--
	6	175.44	143.59	8.45E+20	10.00%	8.98%	7.41%	23.06%	13.70%
<b>AFC-1G E-3 16.0 EFPDs</b>	1	120.55	99.68	6.41E+20	8.12%	--	4.31%	--	11.97%
	2	--	--	--	--	--	--	--	--
	3	245.35	164.84	1.14E+21	9.47%	11.06%	6.37%	23.07%	15.20%
	4	192.16	159.14	9.58E+20	11.83%	--	6.48%	--	17.31%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-4 32.0 EFPDs</b>	1	147.96	132.48	1.34E+21	17.04%	--	11.21%	33.55%	13.72%
	2	165.40	151.25	1.52E+21	22.18%	--	12.73%	42.14%	29.48%
	3	234.73	227.46	2.27E+21	23.76%	--	15.49%	--	--
	4	202.31	190.54	1.93E+21	24.29%	--	16.19%	46.01%	28.09%
	5	155.44	173.66	1.54E+21	28.37%	--	18.25%	--	--
	6	--	--	--	--	--	--	--	--

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1H E-2 32.0 EFPDs	1	181.26	137.12	8.99E+20	8.71%	8.44%	6.31%	20.73%	12.75%
	2	217.90	143.76	1.11E+21	9.86%	11.70%	5.74%	26.82%	16.30%
	3	239.02	195.60	1.18E+21	13.90%	12.31%	10.21%	30.94%	17.86%
	4	260.15	191.14	1.30E+21	11.89%	11.98%	8.97%	28.73%	17.23%
	5	257.32	192.78	1.31E+21	11.97%	11.06%	9.51%	25.80%	--
	6	174.23	142.98	9.12E+20	10.75%	9.64%	7.97%	24.79%	14.58%
AFC-1G E-3 32.0 EFPDs	1	129.88	107.57	6.95E+20	8.78%	--	4.68%	--	12.96%
	2	--	--	--	--	--	--	--	--
	3	249.32	168.05	1.23E+21	10.12%	11.95%	6.83%	24.74%	16.38%
	4	192.76	160.10	1.04E+21	12.76%	--	7.03%	--	18.70%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-4 54.0 EFPDs	1	148.91	133.63	1.42E+21	17.99%	--	11.90%	35.19%	15.03%
	2	161.95	148.49	1.61E+21	23.25%	--	13.44%	44.02%	30.94%
	3	226.89	220.70	2.40E+21	24.97%	--	16.37%	--	--
	4	192.94	182.33	2.04E+21	25.43%	--	17.02%	47.85%	29.76%
	5	152.46	170.83	1.63E+21	29.75%	--	19.26%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1H E-2 54.0 EFPDs	1	184.30	139.75	9.98E+20	9.65%	9.35%	6.99%	22.83%	13.93%
	2	223.59	147.87	1.23E+21	10.90%	12.80%	6.32%	29.24%	17.81%
	3	220.98	181.46	1.30E+21	15.19%	13.53%	11.19%	33.49%	19.32%
	4	250.89	184.98	1.43E+21	13.09%	13.19%	9.86%	31.28%	18.62%
	5	255.14	191.82	1.45E+21	13.19%	12.14%	10.45%	28.33%	--
	6	179.16	147.38	1.01E+21	11.79%	10.64%	8.77%	26.93%	15.82%
AFC-1G E-3	1	134.49	111.60	7.72E+20	9.72%	--	5.22%	--	14.33%
	2	--	--	--	--	--	--	--	--
	3	243.54	164.63	1.35E+21	11.10%	13.12%	7.49%	26.99%	17.87%

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
54.0 EFPDs	4	190.36	158.55	1.15E+21	13.97%	--	7.73%	--	20.42%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--

**Table 20. Cycle 138B As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 107.3 MW, E-lobe 22.1 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
<b>AFC-1D E-4 18.0 EFPDs</b>	1	145.23	130.76	1.48E+21	18.76%	--	12.22%	36.36%	15.60%
	2	170.21	156.63	1.69E+21	24.18%	--	13.82%	45.49%	32.18%
	3	247.36	241.89	2.51E+21	26.09%	--	17.17%	--	--
	4	218.84	207.71	2.14E+21	26.53%	--	17.57%	49.47%	30.93%
	5	171.92	193.41	1.71E+21	31.06%	--	20.19%	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1H E-2 18.0 EFPDs</b>	1	172.49	131.26	1.07E+21	10.33%	10.05%	7.42%	24.19%	14.75%
	2	222.17	147.45	1.32E+21	11.65%	13.77%	6.71%	30.86%	19.04%
	3	242.76	200.27	1.41E+21	16.36%	14.59%	11.97%	35.37%	20.49%
	4	261.13	193.44	1.55E+21	14.11%	14.17%	10.49%	33.19%	19.73%
	5	267.88	202.35	1.56E+21	14.21%	13.11%	11.11%	30.22%	--
	6	179.49	148.19	1.09E+21	12.68%	11.46%	9.37%	28.54%	16.72%
<b>AFC-1G E-3 18.0 EFPDs</b>	1	132.49	110.25	8.33E+20	10.44%	--	5.61%	--	15.36%
	2	--	--	--	--	--	--	--	--
	3	264.85	179.85	1.46E+21	12.01%	14.12%	7.85%	28.94%	19.13%
	4	204.60	171.06	1.24E+21	15.06%	--	8.38%	--	21.95%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
<b>AFC-1D E-4 36.0 EFPDs</b>	1	144.08	130.08	1.55E+21	19.48%	--	12.75%	37.67%	16.60%
	2	165.82	153.08	1.76E+21	25.13%	--	14.43%	47.00%	33.37%
	3	235.75	231.64	2.62E+21	27.10%	--	17.90%	--	--
	4	211.46	201.55	2.23E+21	27.55%	--	18.33%	51.02%	32.32%
	5	165.43	186.80	1.78E+21	32.27%	--	21.09%	--	--
	6	--	--	--	--	--	--	--	--

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1H E-2 36.0 EFPDs	1	176.82	134.91	1.15E+21	11.03%	10.74%	7.94%	25.73%	15.62%
	2	221.08	147.19	1.42E+21	12.53%	14.68%	7.19%	32.65%	20.23%
	3	225.27	186.60	1.50E+21	17.44%	15.58%	12.78%	37.41%	21.59%
	4	245.34	182.46	1.65E+21	15.04%	15.09%	11.17%	35.16%	20.86%
	5	247.08	187.43	1.67E+21	15.17%	13.95%	11.84%	32.00%	--
	6	176.53	146.19	1.16E+21	13.53%	12.28%	10.03%	30.14%	17.69%
AFC-1G E-3 36.0 EFPDs	1	136.50	113.83	8.97E+20	11.16%	--	6.00%	--	16.44%
	2	--	--	--	--	--	--	--	--
	3	251.93	171.69	1.57E+21	12.82%	15.07%	8.39%	30.72%	20.39%
	4	196.48	164.83	1.33E+21	16.04%	--	8.95%	--	23.34%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-4 57.6 EFPDs	1	147.12	133.17	1.62E+21	20.38%	--	13.41%	39.25%	17.91%
	2	170.42	157.80	1.85E+21	26.28%	--	15.18%	48.81%	34.76%
	3	233.20	230.13	2.75E+21	28.31%	--	18.78%	--	--
	4	217.91	208.51	2.35E+21	28.88%	--	19.28%	52.89%	33.98%
	5	163.78	185.60	1.87E+21	33.72%	--	22.17%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1H E-2 57.6 EFPDs	1	178.66	136.69	1.25E+21	11.90%	11.58%	8.57%	27.60%	16.72%
	2	219.98	146.91	1.53E+21	13.50%	15.76%	7.73%	34.84%	21.61%
	3	228.57	190.05	1.62E+21	18.77%	16.63%	13.71%	39.82%	22.84%
	4	240.00	179.14	1.78E+21	16.12%	16.15%	11.98%	37.32%	22.08%
	5	240.98	183.49	1.80E+21	16.26%	14.97%	12.70%	34.06%	--
	6	179.93	149.45	1.26E+21	14.61%	13.18%	10.80%	32.18%	18.88%
AFC-1G E-3	1	135.30	113.06	9.73E+20	12.04%	--	6.52%	--	17.73%
	2	--	--	--	--	--	--	--	--
	3	254.08	173.78	1.70E+21	13.88%	16.18%	9.02%	32.83%	21.87%



Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
57.6 EFPDs	4	196.07	165.00	1.44E+21	17.31%	--	9.71%		25.06%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--

**Table 21. Cycle 139A As-Run Linear and Fission Heat Rates and Burnup Distribution of the AFC-1 Fuel in the East Flux Trap Position (Core Power 107.9 MW, E-lobe 22.3 MW)**

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1D E-4 15.0 EFPDs	1	132.94	121.50	1.83E+21	22.71%	--	14.59%	42.94%	19.81%
	2	162.37	152.06	2.10E+21	29.10%	--	16.54%	52.89%	38.46%
	3	224.75	225.36	3.09E+21	31.45%	--	21.12%	--	--
	4	209.90	203.90	2.66E+21	32.15%	--	21.12%	57.20%	37.55%
	5	151.84	174.26	2.10E+21	37.29%	--	24.95%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1H E-2 15.0 EFPDs	1	163.71	126.56	1.50E+21	14.19%	13.89%	10.11%	31.93%	19.28%
	2	208.82	140.99	1.85E+21	16.02%	18.87%	9.08%	39.78%	25.23%
	3	225.38	190.13	1.96E+21	22.39%	19.96%	16.27%	45.32%	26.19%
	4	242.73	183.78	2.15E+21	19.26%	19.34%	14.10%	42.77%	25.32%
	5	243.81	188.38	2.16E+21	19.35%	17.80%	14.79%	39.33%	--
	6	167.78	140.94	1.52E+21	17.44%	15.74%	12.78%	36.91%	21.76%
AFC-1G E-3 15.0 EFPDs	1	126.17	106.32	1.18E+21	14.42%	--	7.89%	--	20.94%
	2	--	--	--	--	--	--	--	--
	3	250.57	173.69	2.05E+21	16.49%	19.36%	10.32%	38.35%	25.80%
	4	197.68	168.40	1.75E+21	20.59%	--	11.74%	--	29.79%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-4 35.0 EFPDs	1	140.40	128.59	1.90E+21	23.48%	--	15.18%	44.21%	20.84%
	2	159.33	149.61	2.18E+21	30.02%	--	17.18%	54.32%	39.65%
	3	216.70	218.08	3.20E+21	32.47%	--	21.91%	--	--
	4	200.23	195.15	2.76E+21	33.23%	--	21.93%	58.65%	38.96%
	5	152.46	175.46	2.18E+21	38.49%	--	25.89%	--	--
	6	--	--	--	--	--	--	--	--

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
AFC-1H E-2 35.0 EFPDs	1	172.16	133.38	1.59E+21	14.94%	14.58%	10.65%	33.47%	20.16%
	2	220.31	149.11	1.96E+21	16.92%	19.84%	9.61%	41.57%	26.42%
	3	214.27	181.35	2.06E+21	23.48%	20.96%	17.11%	47.15%	27.30%
	4	233.69	177.50	2.26E+21	20.19%	20.24%	14.80%	44.54%	26.32%
	5	241.96	187.53	2.28E+21	20.34%	18.77%	15.62%	41.11%	--
	6	171.50	144.41	1.60E+21	18.37%	16.56%	13.47%	38.57%	22.64%
AFC-1G E-3 35.0 EFPDs	1	130.18	109.90	1.25E+21	15.19%	--	8.35%	--	22.06%
	2	--	--	--	--	--	--	--	--
	3	241.16	167.71	2.16E+21	17.31%	20.35%	10.87%	40.07%	26.96%
	4	187.75	160.39	1.85E+21	21.64%	--	12.40%	--	31.23%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
AFC-1D E-4 51.4 EFPDs	1	150.91	138.62	1.96E+21	24.13%	--	15.68%	45.35%	21.83%
	2	165.40	155.82	2.24E+21	30.79%	--	17.70%	55.49%	40.62%
	3	228.72	231.28	3.30E+21	33.34%	--	22.57%	--	--
	4	203.24	198.97	2.84E+21	34.08%	--	22.59%	59.84%	40.12%
	5	163.68	189.08	2.25E+21	39.55%	--	26.71%	--	--
	6	--	--	--	--	--	--	--	--
AFC-1H E-2 51.4 EFPDs	1	180.40	140.15	1.66E+21	15.56%	15.27%	11.14%	34.71%	20.86%
	2	221.51	150.46	2.04E+21	17.67%	20.64%	10.04%	43.03%	27.38%
	3	215.48	183.11	2.15E+21	24.36%	21.79%	17.81%	48.69%	28.10%
	4	237.72	181.25	2.36E+21	21.00%	21.09%	15.43%	45.91%	27.16%
	5	246.97	192.26	2.38E+21	21.16%	19.54%	16.28%	42.49%	--
	6	178.72	150.97	1.67E+21	19.15%	17.22%	14.04%	39.94%	23.39%
AFC-1G E-3	1	142.42	120.52	1.31E+21	15.86%	--	8.75%	--	23.00%
	2	--	--	--	--	--	--	--	--
	3	242.86	169.53	2.25E+21	18.04%	21.15%	11.34%	41.46%	27.95%

Test ID, EFT Position, and Interval	Rodlet No.	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	Fission Density fissions/cc	<sup>239</sup> Pu Depletion (atom%)	<sup>235</sup> U Depletion (atom%)	HM Depletion (atom%)	<sup>241</sup> Am Depletion (atom%)	<sup>237</sup> Np Depletion (atom%)
51.4 EFPDs	4	188.35	161.47	1.93E+21	22.51%	--	12.95%	--	32.33%
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--

## 9. IRRADIATION SUMMARY

The projected evaluations of the AFCI test assembly irradiations, as seen in Section 7 of this report, established that safety and programmatic LHGR limits for the AFC-1D, AFC-1G, and AFC-1H irradiated fuel rodlets were met.

Programmatic burnup limits for the AFC-1D, AFC-1G and AFC-1H tests have been set at 40 at.%. As-run analysis reported in Section 8 of this report, show that the AFC-1D experiment reached 39.55 at.% burnup at the completion of ATR cycle 139A. The test assembly was removed to the ATR canal and placed in the fuel storage grid awaiting shipment to MFC. The AFC-1G experiment is scheduled to remain in the reactor one additional cycle (~50 EFPDs) and the AFC-1H experiments will require approximately four additional cycles of irradiation to reach the desired burnup.

## 10. FUTURE AFC-1 IRRADIATIONS

The high burnup AFC-1G and AFC-1H test assemblies will continue irradiation into the second quarter of FY-08. The AFC-2A and AFC-2B capsules are fabricated and currently scheduled to be inserted into the reactor to begin irradiation for ATR cycle 140A in October. The AFC-2A and AFC-2B irradiation experiments are a continuation of the metallic fuel test series currently in progress in the ATR. These experiments will consist of metallic fuel alloys of U, Pu, Np, Am and Zr, some with minor additions of rare earth elements meant to simulate expected fission product carry-over from pyro-metallurgical reprocessing. These AFC-2 tests are planned to be irradiated to burnup levels of  $\geq 10$  at.% and  $\geq 25$  at.% burnup, respectively. Table 22 shows the planned irradiation schedule through FY 2008.

**Table 22. AFCI FY-08 Planned Irradiation Schedule**

[illegible]

## 11. REFERENCES

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