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Advanced Fuel Cycle Initiative AFC-1D, AFC-1G and AFC-1H End of FY-06 Irradiation Report

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September 2006

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ABSTRACT

The U. S. Advanced Fuel Cycle Initiative (AFCI) seeks to develop and demonstrate the technologies needed to transmute the long-lived transuranic actinide isotopes contained in spent nuclear fuel into shorter-lived fission products, thereby dramatically decreasing the volume of material requiring disposition and the long-term radiotoxity and heat load of high-level waste sent to a geologic repository.

The AFC-1 irradiation experiments on 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 and $\leq$ 25 at.% burnup, respectively.

Based on the results of the physics evaluations it has been determined that the AFC-1D experiment will remain in the ATR for approximately 4 additional cycles, the AFC-1G experiment for an additional 4-5 cycles, and the AFC-1H experiment for approximately 8 additional cycles, 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 experiment programmatic maximum allowable burnup specified for AFC-1AE and -1B, and -1F is 5 % burnup (not to exceed 10 % burnup). For AFC-1D, and AFC-1H, the maximum burnup is 40 % burnup, and for AFC-1G, the maximum burnup is 25 % burnup. In all cases, burnup is defined for these experiments to be percent depletion of initial fissile material.

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)[1] for Post Irradiation Examination. The irradiation history for AFC-1B, -1AE, and -1F is detailed in INEEL/EXT-04-02380.[1]

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.

This report will provide to-date irradiation history on the AFC-1D, AFC-1G, and AFC-1H tests irradiated in FY-06.

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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. ATR Primary Coolant System 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 μCi/ml. Control of pH, solids, and chlorides are maintained using ion exchange columns, filters, and chemistry control additives within the system boundaries.

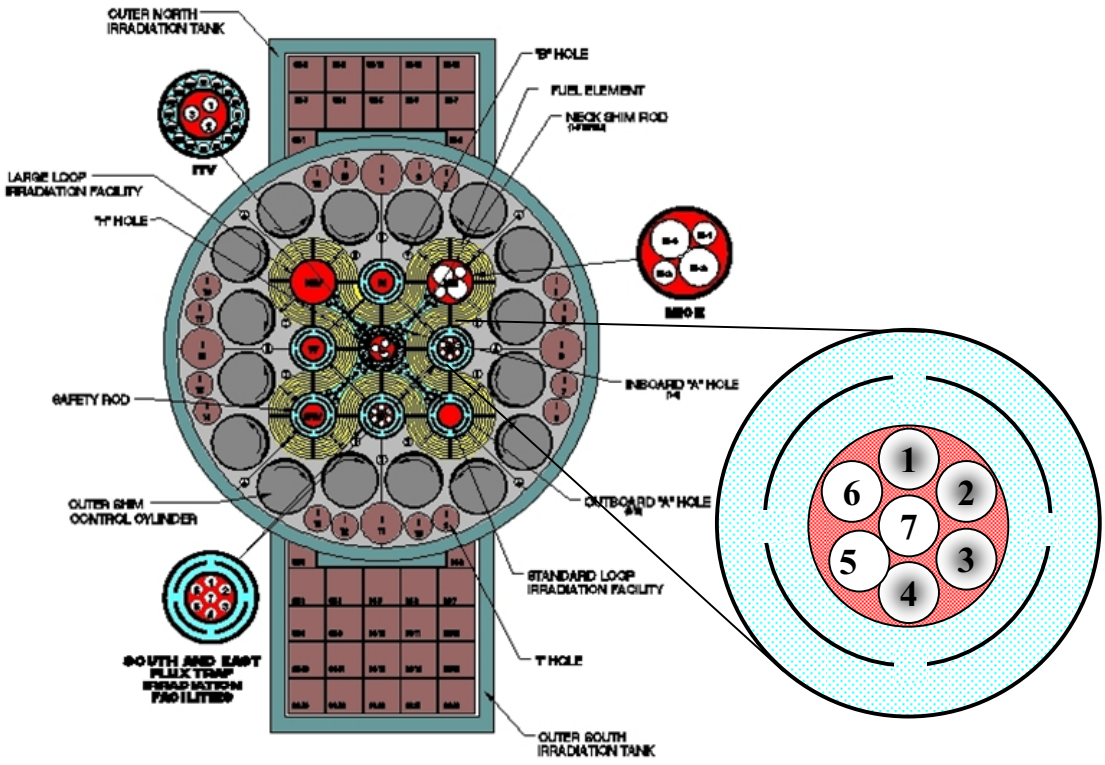


Figure 1. ATR Cross Section with Magnified East Flux Trap.

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,"[2]
- W7520-0481-ES-02 "Final Experiment Description and Design and Data Package for AFC-1A, AFC-1B, AFC-1C and AFC-1D,"[3]
- W7520-0594-ES-00 "Final Experiment Description and Design and Data Package for GFR-F1."[4]
- B. A. Hilton, "Revised Programmatic Burnup Limit of AFC-1D," EDF-6575, January 18, 2006.[7]

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 powers of the fuel rodlets increase with time due to depletion of the neutron absorber in the cadmium shrouded aluminum baskets. A maximum basket lifetime has been established to be 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.

For conservatism and consistency, the fuel powers used in the following analyses are those reported at basket end-of-life.

Table 1. AFCI test assembly experiment specifications.

Experiment Specifications for Irradiation in the ATR			
Performance Parameter	**AFC-1D (Metallic Fuel)**	**AFC-1G (Nitride Fuel)**	**AFC-1H (Metallic Fuel)**
Maximum Burnup	40%	25%	40%
Peak Rodlet Linear Power	400 W/cm	400 W/cm	400 W/cm
Peak Cladding Temperature			
Normal Operation	525°C	550˚C	550˚C
Off-Normal Limit	650°C	650˚C	650˚C
Fuel Temperature			
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,[b] 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 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 2006 (FY-06), 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 135C (startup September 26, 2005), Cycle 136A, Cycle 136B, and Cycle 137A (shutdown June 2006).Table 2 shows the to-date irradiation details and history for the AFC-1 and GFR-F test assemblies.

Table 2. AFCI Test Assembly East Flux Trap Irradiations.

ATR Operating Cycle	Cycle Start Date	EFPDs	East Flux Trap Housing Loading	Test Capsule	Cd Basket Condition
131A	6/7/2003	48.5 Days	E1	AFC-1B	New
			E2	AFC-1D	New
			E3	Dummy	New
			E4	Dummy	New
131B	8/10/2003	13.8 Day PALM	All tests removed for high power Palm Cycle		
132A	12/07/2003	44.1 Days	E1	AFC-1B	New
			E2	AFC-1F	New
			E3	AFC-1D	New
			E4	AFC-1Æ	New
132B	2/21/2004	1.6 Day PALM	All tests removed for high power Palm Cycle		
132C	2/29/2004	50.3 Days	E1	AFC-1D	New
			E2	AFC-1F	New
			E3	AFC-1Æ	New
			E4	GFR-F1-1, -2, -3	Depleted*
133A	5/2/2004	13 Day PALM	All tests removed for high power Palm Cycle		
133B	5/30/2004	61.4 Days	E1	Dummy	Depleted*
			E2	AFC-1D	Depleted*
			E3	Dummy	Depleted*
			E4	GFR-F1-1, -2, -3	Depleted*
CIC		250 Days	All tests removed for Core Internal Changout		
134AB-2	04/14/05	46.6 Days	Backup test		
135A	06/26/05	13 Day PALM	All tests removed for high power Palm Cycle		
135B-1 and -2	07/23/05	48.0 Days	E1	AFC-1D	New
			E2	AFC-1H	New
			E3	AFC-1G	New
			E4	GFR-F1-2	New

Table 2. AFCI Test Assembly East Flux Trap Irradiations. (continued)

ATR Operating Cycle	Cycle Start Date	EFPDs	East Flux Trap Housing Loading	Test Capsule	Cd Basket Condition
135C	9-26-05	40.6 Days	E1	AFC-1D	Depleted*
			E2	AFC-1H	Depleted*
			E3	AFC-1G	Depleted*
			E4	GFR-F2	Depleted*
136A	11-24-05	50.9	E1	AFC-1D	New
			E2	AFC-1H	New
			E3	AFC-1G	New
			E4	GFR-F2	New
136B	01-29-06	39.0	E1	AFC-1D	Depleted*
			E2	AFC-1H	New
			E3	AFC-1G	Depleted*
			E4	GFR-F2	Depleted*
137A	04-18-06	**54.1**	E1	GFR-F2	Depleted*
			E2	AFC-1H	New
			E3	AFC-1G	New
			E4	AFC-1D	New
137B	06/27/06	12.1 Day PALM	All tests removed for high power Palm Cycle		

Depleted = ~50 EFPD of Irradiation

5. ANALYSIS AND CALCULATIONS

MCNP[5] was used to calculate the LHGR for the AFC-1 rodlets. The depletion methodology MCWO (using ORIGEN2) was used to evaluate the AFC-1 fuel rodlet burnup behavior versus EFPD's within the ATR EFT positions.

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. 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^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 or f7 tally has units of MeV/g per source neutron.

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

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

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 3. INL Qualified Analysis Software Version and Tracking Number

Code Name	Version	V&V Tracking Number	Computer System Model	Processor	Operating System
MCNP	5, release 1.30	171103	Dell Precision 670	Dual Intel Xeon	Windows XP
		198740	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
MCWO	0	149879	Dell Precision 670	Dual Intel Xeon	Windows XP
ORIGEN2	2.1	64556	Dell Precision 670	Dual Intel Xeon	Windows XP

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[5] (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 4 shows the total projected and actual EFPDs of irradiation and East Lobe power for each cycle.

Table 4. 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)
Cycle 135C	42	22.3	40.0	22.9
Cycle 136A	56	21.0	50.9	21.7
Cycle 136B	49	21.0	39.0	21.7
Cycle 137A	55	22.0	54.1	22.8

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 5 – 8 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 135C, 136A, 136B, and 137A.

Table 5. Projected Linear and Fission Heat Rate and Burnup Distribution of the AFC-1 Fuel Experiments in the East Flux Trap position at the End of Cycle 135C Irradiation (42 EFPD).

ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metals Depletion (atom%)	Am Depletion (atom%)	^{235}U Depletion (atom%)
E1 AFC-1D (Metal)	Rodlet 1	147.59	129.65	13.71%	7.06%	27.01%	--
	Rodlet 2	148.83	132.63	17.17%	7.74%	33.21%	--
	Rodlet 3	232.16	210.71	18.48%	11.21%	24.87%	--
	Rodlet 4	207.45	186.49	19.19%	10.01%	36.17%	--
	Rodlet 5	156.79	165.69	21.97%	13.26%	0.00%	--
	Dummy	--	--	--	--	--	--
E2 AFC-1H (Metal)	Rodlet 1	213.01	150.76	4.13%	2.62%	10.00%	3.82%
	Rodlet 2	241.22	152.38	4.39%	2.23%	12.27%	5.08%
	Rodlet 3	271.79	211.70	6.33%	4.37%	14.39%	5.75%
	Rodlet 4	294.88	208.59	5.62%	3.66%	13.29%	5.41%
	Rodlet 5	293.71	210.22	5.26%	3.70%	12.34%	4.88%
	Rodlet 6	219.82	172.04	5.16%	3.43%	12.59%	4.42%
E3 AFC-1G (Nitride)	Rodlet 1	138.41	118.47	3.77%	1.90%	--	--
	Dummy	--	--	--	--	--	--
	Rodlet 3	263.99	176.41	4.39%	2.43%	11.44%	4.86%
	Rodlet 4	204.36	174.51	5.55%	2.89%	--	--
	Dummy	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--

Note: All the MCNP tallies are normalized to an E-lobe source power of 22.3 MW.

Table 6. 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 136A Irradiation (56 EFPD).

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metals Depletion (atom%)	Am Depletion (atom%)	^{235}U Depletion (atom%)
E-1 AFC-1D (Metal)	Rodlet 1	128.76	113.90	15.58%	8.12%	30.15%	--
	Rodlet 2	148.85	133.82	19.74%	9.08%	38.05%	--
	Rodlet 3	235.41	216.55	21.47%	13.23%	25.16%	--
	Rodlet 4	197.26	179.38	22.03%	11.73%	41.30%	--
	Rodlet 5	151.11	161.23	25.11%*	15.49%	--	--
	Dummy	--	--	--	--	--	--
E-2 AFC-1H (Metal)	Rodlet 1	195.18	139.59	6.28%	4.03%	15.17%	5.85%
	Rodlet 2	233.59	149.16	6.96%	3.52%	18.39%	8.02%
	Rodlet 3	248.60	196.53	9.69%	6.73%	22.72%	8.79%
	Rodlet 4	277.37	199.18	8.76%	5.74%	20.52%	8.41%
	Rodlet 5	275.16	200.07	8.51%	5.84%	18.52%	7.61%
	Rodlet 6	187.85	148.69	7.71%	5.22%	18.56%	6.78%
E-3 AFC-1G (nitride)	Rodlet 1	129.57	111.62	5.88%	3.03%	--	--
	Dummy	--	--	--	--	--	--
	Rodlet 3	248.68	168.38	6.67%	3.74%	17.12%	8.29%
	Rodlet 4	196.10	169.14	8.55%	4.50%	--	--
	Dummy	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--

Note: All the MCNP tallies for Cycle 136A are normalized to an East lobe source power of 21.0 MW.

Table 7. 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 136B Irradiation (49 EFPD).

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metals Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)
E-1 AFC-1D (Metal)	Rodlet 1	141.37	125.94	17.63%	9.31%	33.79%	--
	Rodlet 2	153.63	139.11	21.91%	10.24%	41.68%	--
	Rodlet 3	246.45	229.31	24.19%	15.11%	18.56%	--
	Rodlet 4	207.41	190.48	24.60%	13.35%	45.71%	--
	Rodlet 5	155.71	167.54	27.98%	17.56%	--	--
	Dummy	--	--	--	--	--	--
E-2 AFC-1H (Metal)	Rodlet 1	189.80	136.94	8.09%	5.34%	19.55%	7.79%
	Rodlet 2	223.44	143.91	9.26%	4.65%	23.55%	10.53%
	Rodlet 3	234.22	187.43	12.78%	8.84%	29.19%	11.51%
	Rodlet 4	261.15	189.94	11.71%	7.62%	26.39%	11.18%
	Rodlet 5	275.40	203.03	11.73%	7.88%	24.24%	10.15%
	Rodlet 6	191.60	153.27	10.62%	7.06%	23.80%	9.07%
E-3 AFC-1G (nitride)	Rodlet 1	130.93	113.41	7.63%	3.92%	--	--
	Dummy	--	--	--	--	--	--
	Rodlet 3	248.73	170.26	8.79%	4.95%	22.51%	10.96%
	Rodlet 4	192.41	167.38	11.34%	6.03%	--	--
	Dummy	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--

Note: All the MCNP tallies for Cycle 136B are normalized to an East lobe source power of 21.0 MW.

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 137A Irradiation (55.0 EFPD).

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metals Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)
E-4 AFC-1D (Metal)	Rodlet 1	138.95	124.05	19.24%	10.27%	36.57%	--
	Rodlet 2	169.02	153.58	24.15%	11.48%	45.67%	--
	Rodlet 3	258.31	241.32	26.46%	16.69%	16.78%	--
	Rodlet 4	208.88	192.40	26.65%	14.67%	49.51%	--
	Rodlet 5	163.95	176.88	30.40%	19.33%	--	--
	Dummy	--	--	--	--	--	--
E-2 AFC-1H (Metal)	Rodlet 1	181.86	131.61	9.79%	6.43%	22.61%	9.30%
	Rodlet 2	237.76	153.63	11.29%	5.64%	28.05%	12.63%
	Rodlet 3	261.77	210.60	15.51%	10.76%	34.27%	13.91%
	Rodlet 4	285.18	208.38	13.82%	9.14%	30.90%	13.36%
	Rodlet 5	274.80	203.40	13.67%	9.36%	28.60%	12.06%
	Rodlet 6	199.11	159.80	12.48%	8.48%	27.91%	10.95%
E-3 AFC-1G (nitride)	Rodlet 1	125.49	108.90	9.16%	4.78%	--	--
	Dummy	--	--	--	--	--	--
	Rodlet 3	256.11	176.00	10.57%	5.97%	26.52%	13.18%
	Rodlet 4	195.87	170.90	13.47%	7.29%	--	--
	Dummy	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--

Note: All the MCNP tallies for Cycle 137A are normalized to an East lobe source power of 22.0 MW.

As noted 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

The 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. The as-built constituent data was received from the fuel fabricators for the AFC-1B and AFC-1D test in mid May, and the as-built constituent data received for the AFC-1G and AFC-1H test in mid July.

The as-run re-analysis for ATR Cycles 131A through 137A are based upon the as-run conditions summarized in Table 9.

Table 9. ATR Power History and Calculated East Lobe Power (Powers used to scale MCNP results)

Cycle	NW (MW)	NE (MW)	C (MW)	SW (MW)	SE (MW)	Core Power (MW)	E (MW)	EFPD
131A	18.0	17.0	24.3	23.0	24.6	106.9	22.0	48.5
132A	18.0	18.0	25.7	23.0	27.0	111.7	23.6	44.1
132C	18.0	18.0	25.6	23.0	27.0	111.6	23.5	50.3
133B	18.1	18.0	26.6	23.7	27.0	113.4	23.9	61.4
135B	18.0	18.0	25.0	23.0	25.0	109.0	22.7	48.0
135C	18.0	18.0	25.0	23.0	25.0	109.0	22.7	40.6
136A	18.0	18.0	24.0	23.0	23.0	106.0	21.7	50.9
136B	18.0	18.0	23.9	23.0	23.0	105.9	21.6	39.0
137A	18.0	18.0	24.7	20.0	25.0	105.7	22.6	54.1

[(b)] Average C Lobe Power for cycles 135B-1 and 135B-2 was calculated as follows:
C = (24.8 MW*(25.5 EFPD/48.0 EFPD)+ 25.2 MW*(22.5 EFPD/48.0 EFPD) = 25.0 MW

The ATR Cycle 131A thru 137A as-run calculations were performed for AFC-1D, AFC-1G, and AFC-1H. These results are tabulated in Table 10 through Table 18, respectively.

Table 10. 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 106.89 MW, E-lobe 21.97 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
14.0 EFPDs								
E-2 AFC-1D	Rodlet 1	109.74	93.66	0.54%	0.28%	1.15%	--	3.84E+19
	Rodlet 2	122.43	103.80	0.72%	0.35%	1.47%	--	4.29E+19
	Rodlet 3	202.31	172.49	0.88%	0.52%	2.10%	--	7.09E+19
	Rodlet 4	160.91	135.58	0.79%	0.42%	1.88%	--	5.64E+19
	Rodlet 5	130.54	132.07	0.94%	0.50%	--	--	4.57E+19
	Dummy	--	--	--	--	--	--	4.31E+19
28.0 EFPDs								
E-2 AFC-1D	Rodlet 1	115.67	98.89	1.08%	0.55%	2.34%	--	7.90E+19
	Rodlet 2	128.04	108.78	1.51%	0.69%	3.06%	--	8.78E+19
	Rodlet 3	192.33	164.42	1.60%	0.92%	4.10%	--	1.38E+20
	Rodlet 4	158.62	133.98	1.58%	0.82%	3.58%	--	1.12E+20
	Rodlet 5	126.80	128.53	1.88%	1.02%	--	--	9.01E+19
	Dummy	--	--	--	--	--	--	8.88E+19
48.5 EFPDs								
E-2 AFC-1D	Rodlet 1	118.27	101.26	1.93%	0.98%	4.00%	--	1.38E+20
	Rodlet 2	131.16	111.67	2.59%	1.16%	5.21%	--	1.54E+20
	Rodlet 3	192.22	164.76	2.71%	1.57%	6.66%	--	2.35E+20
	Rodlet 4	159.25	134.81	2.73%	1.40%	5.99%	--	1.92E+20
	Rodlet 5	125.76	127.74	3.26%	1.82%	--	--	1.53E+20
	Dummy	--	--	--	--	--	--	1.51E+20

Table 11. 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 114.47 MW, E-lobe 23.57 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
14.0 EFPDs								
E-3 AFC-1D	Rodlet 1	118.84	93.39	2.54%	1.29%	5.25%	--	1.79E+20
	Rodlet 2	139.00	108.35	3.38%	1.50%	6.79%	--	2.01E+20
	Rodlet 3	231.81	182.22	3.59%	2.08%	8.75%	--	3.14E+20
	Rodlet 4	188.24	149.34	3.64%	1.87%	7.87%	--	2.56E+20
	Rodlet 5	153.59	160.10	4.28%	2.40%	--	--	2.06E+20
	Dummy	--	--	--	--	--	--	--
28.0 EFPDs								
E-3 AFC-1D	Rodlet 1	127.03	100.00	3.14%	1.60%	6.47%	--	2.22E+20
	Rodlet 2	139.42	108.89	4.17%	1.85%	8.45%	--	2.49E+20
	Rodlet 3	218.16	172.02	4.47%	2.60%	10.53%	--	3.88E+20
	Rodlet 4	187.82	149.40	4.56%	2.35%	9.74%	--	3.20E+20
	Rodlet 5	145.93	152.48	5.31%	3.00%		--	2.55E+20
	Dummy	--	--	--	--	--	--	--
44.1 EFPDs								
E-3 AFC-1D	Rodlet 1	136.69	107.79	3.86%	1.96%	7.97%	--	2.75E+20
	Rodlet 2	150.24	117.56	5.10%	2.25%	10.41%	--	3.07E+20
	Rodlet 3	221.31	174.96	5.43%	3.18%	12.40%	--	4.75E+20
	Rodlet 4	182.99	145.94	5.53%	2.84%	11.76%	--	3.91E+20
	Rodlet 5	153.59	160.88	6.52%	3.71%	--	--	3.15E+20
	Dummy	--	--	--	--	--	--	--

Table 12. 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 111.15 MW, E-lobe 23.53 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
15.0 EFPDs								
E-1 AFC-1D	Rodlet 1	132.18	115.59	4.52%	2.32%	9.39%	--	3.25E+20
	Rodlet 2	158.21	138.69	5.98%	2.55%	12.07%	--	3.66E+20
	Rodlet 3	238.00	210.35	6.30%	3.66%	14.56%	--	5.63E+20
	Rodlet 4	198.42	176.58	6.56%	3.45%	14.00%	--	4.65E+20
	Rodlet 5	151.08	159.75	7.80%	4.41%	--	--	3.72E+20
	Dummy	--	--	--	--	--	--	--
30.0 EFPDs								
E-1 AFC-1D	Rodlet 1	135.75	118.96	5.25%	2.71%	10.88%	--	3.75E+20
	Rodlet 2	157.06	138.02	6.91%	2.97%	13.96%	--	4.24E+20
	Rodlet 3	236.53	209.79	7.26%	4.24%	16.19%	--	6.51E+20
	Rodlet 4	189.29	168.98	7.54%	3.97%	16.05%	--	5.36E+20
	Rodlet 5	153.80	163.07	8.91%	5.09%	--	--	4.29E+20
	Dummy	--	--	--	--	--	--	--
50.3 EFPDs								
E-1 AFC-1D	Rodlet 1	138.79	121.91	6.22%	3.20%	12.81%	--	4.45E+20
	Rodlet 2	153.17	134.96	8.13%	3.51%	16.18%	--	5.01E+20
	Rodlet 3	235.06	209.23	8.54%	5.02%	18.20%	--	7.69E+20
	Rodlet 4	197.27	176.66	8.87%	4.68%	18.71%	--	6.35E+20
	Rodlet 5	151.18	160.74	10.37%	5.99%	--	--	5.05E+20
	Dummy	--	--	--	--	--	--	--

Table 13. 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 112.36 MW, E-lobe 23.87 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
20.0 EFPDs								
E-2 AFC-1D	Rodlet 1	121.70	108.18	6.82%	3.52%	14.10%	--	4.90E+20
	Rodlet 2	151.86	135.47	8.93%	3.88%	17.80%	--	5.58E+20
	Rodlet 3	235.60	212.77	9.42%	5.55%	19.45%	--	8.56E+20
	Rodlet 4	194.51	176.60	9.85%	5.20%	20.45%	--	7.07E+20
	Rodlet 5	161.85	174.40	11.48%	6.64%	--	--	5.65E+20
	Dummy	--	--	--	--	--	--	--
40.0 EFPDs								
E-2 AFC-1D	Rodlet 1	135.22	120.45	7.48%	3.86%	15.42%	--	5.40E+20
	Rodlet 2	162.58	145.45	9.86%	4.32%	19.54%	--	6.18E+20
	Rodlet 3	244.44	221.54	10.38%	6.15%	20.60%	--	9.46E+20
	Rodlet 4	188.06	171.30	10.75%	5.71%	22.32%	--	7.76E+20
	Rodlet 5	159.66	172.52	12.68%	7.39%	--	--	6.23E+20
	Dummy	--	--	--	--	--	--	
61.4 EFPDs								
E-2 AFC-1D	Rodlet 1	139.49	124.54	8.51%	4.40%	17.19%	--	6.13E+20
	Rodlet 2	168.92	151.53	11.23%	4.93%	21.80%	--	7.07E+20
	Rodlet 3	249.22	226.71	11.81%	7.05%	22.15%	--	1.08E+21
	Rodlet 4	192.22	175.63	12.09%	6.43%	24.81%	--	8.77E+20
	Rodlet 5	173.19	187.66	14.43%	8.45%	--	--	7.15E+20
	Dummy	--	--	--	--	--	--	

Table 14. 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 108.73 MW, E-lobe 22.67 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
18.0 EFPDs								
E-1 AFC-1D	Rodlet 1	131.76	111.17	9.23%	4.78%	18.58%	--	6.69E+20
	Rodlet 2	147.67	125.21	12.17%	5.40%	23.61%	--	7.69E+20
	Rodlet 3	227.96	196.33	12.85%	7.72%	23.04%	--	1.17E+21
	Rodlet 4	191.85	165.83	13.12%	7.01%	26.79%	--	9.58E+20
	Rodlet 5	142.04	145.58	15.54%	9.15%	--	--	7.75E+20
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	191.52	136.50	0.81%	0.54%	1.94%	0.75%	8.27E+19
	Rodlet 2	223.33	140.01	0.94%	0.47%	2.56%	1.06%	9.59E+19
	Rodlet 3	248.51	192.53	1.30%	0.87%	3.25%	1.12%	1.07E+20
	Rodlet 4	272.81	190.11	1.07%	0.75%	2.91%	1.13%	1.18E+20
	Rodlet 5	274.57	194.15	1.09%	0.77%	2.56%	1.02%	1.19E+20
	Rodlet 6	190.85	148.99	1.00%	0.70%	2.43%	0.90%	8.25E+19
E-3 AFC-1G	Rodlet 1	116.75	99.98	0.74%	0.40%	--	--	5.42E+19
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	252.16	165.45	0.99%	0.55%	2.32%	1.11%	1.06E+20
	Rodlet 4	179.32	153.94	1.12%	0.60%	--	--	8.33E+19
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
36.0 EFPDs								
E-1 AFC-1D	Rodlet 1	136.51	115.45	9.96%	5.17%	20.00%	--	7.27E+20
	Rodlet 2	144.80	123.13	13.03%	5.82%	25.50%	--	8.31E+20
	Rodlet 3	227.74	196.95	13.81%	8.34%	23.86%	--	1.27E+21
	Rodlet 4	190.96	165.67	14.15%	7.59%	28.77%	--	1.04E+21
	Rodlet 5	140.93	144.88	16.63%	9.86%	--	--	8.35E+20
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	196.82	140.79	1.71%	1.10%	4.17%	1.59%	1.68E+20
	Rodlet 2	221.78	139.54	1.81%	0.90%	5.12%	2.07%	1.91E+20
	Rodlet 3	247.62	192.84	2.56%	1.73%	6.49%	2.25%	2.14E+20
	Rodlet 4	271.81	190.34	2.24%	1.51%	5.75%	2.27%	2.35E+20
	Rodlet 5	268.17	190.62	2.19%	1.51%	4.95%	1.97%	2.35E+20
	Rodlet 6	197.26	154.61	2.01%	1.38%	4.85%	1.79%	1.68E+20
E-3 AFC-1G	Rodlet 1	120.18	103.14	1.58%	0.83%	--	--	1.10E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	245.70	162.01	1.80%	1.02%	4.57%	2.20%	2.09E+20

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
	Rodlet 4	175.89	151.50	2.23%	1.16%	--	--	1.65E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
48.0 EFPDs								
E-1 AFC-1D	Rodlet 1	138.61	117.51	10.51%	5.48%	21.05%	--	7.66E+20
	Rodlet 2	148.55	126.67	13.60%	6.10%	26.71%	--	8.72E+20
	Rodlet 3	228.19	198.12	14.45%	8.75%	24.39%	--	1.34E+21
	Rodlet 4	196.60	171.19	14.83%	7.97%	30.09%	--	1.09E+21
	Rodlet 5	144.24	148.73	17.37%	10.35%	--	--	8.75E+20
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	193.84	139.20	2.26%	1.43%	5.56%	2.04%	2.23E+20
	Rodlet 2	221.56	139.87	2.35%	1.19%	6.67%	2.75%	2.54E+20
	Rodlet 3	255.36	199.87	3.41%	2.33%	8.41%	3.05%	2.88E+20
	Rodlet 4	274.90	193.50	2.97%	1.97%	7.61%	2.94%	3.14E+20
	Rodlet 5	261.54	186.85	2.91%	2.01%	6.54%	2.61%	3.10E+20
	Rodlet 6	193.95	152.64	2.70%	1.83%	6.48%	2.36%	2.24E+20
E-3 AFC-1G	Rodlet 1	122.91	105.72	2.04%	1.05%	--	--	1.48E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	249.78	165.43	2.37%	1.34%	6.09%	2.93%	2.79E+20
	Rodlet 4	174.37	150.66	2.88%	1.49%	--	--	2.19E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--

Table 15. 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 109.11 MW, E-lobe 22.67 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
15.0 EFPDs								
E-1 AFC-1D	Rodlet 1	129.56	110.04	11.11%	5.81%	22.10%	--	8.12E+20
	Rodlet 2	151.98	129.82	14.39%	6.49%	28.22%	--	9.26E+20
	Rodlet 3	248.29	216.19	15.32%	9.32%	24.94%	--	1.42E+21
	Rodlet 4	199.14	173.81	15.74%	8.51%	31.68%	--	1.17E+21
	Rodlet 5	157.61	162.84	18.38%	11.00%	--	--	9.31E+20
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	193.17	139.03	2.98%	1.87%	7.13%	2.64%	2.93E+20
	Rodlet 2	235.47	148.99	3.16%	1.57%	8.73%	3.63%	3.39E+20
	Rodlet 3	257.90	202.59	4.50%	3.07%	11.04%	4.01%	3.81E+20
	Rodlet 4	280.65	198.21	3.95%	2.59%	9.96%	3.84%	4.15E+20
	Rodlet 5	287.39	206.02	3.91%	2.66%	8.70%	3.44%	4.14E+20
	Rodlet 6	190.30	150.16	3.48%	2.37%	8.54%	3.09%	2.92E+20
E-3 AFC-1G	Rodlet 1	120.08	103.44	2.70%	1.38%	--	--	1.95E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	256.13	170.15	3.10%	1.74%	7.96%	3.85%	3.69E+20
	Rodlet 4	183.15	158.58	3.81%	1.97%	--	--	2.90E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
30.0 EFPDs								
E-1 AFC-1D	Rodlet 1	132.65	112.90	11.71%	6.14%	23.15%	--	8.59E+20
	Rodlet 2	159.04	136.20	15.18%	6.87%	29.76%	--	9.82E+20
	Rodlet 3	255.02	222.84	16.20%	9.88%	25.50%	--	1.51E+21
	Rodlet 4	207.20	181.46	16.64%	9.03%	33.31%	--	1.24E+21
	Rodlet 5	160.48	166.27	19.39%	11.68%		--	9.88E+20
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	192.95	139.29	3.61%	2.27%	8.71%	3.24%	3.62E+20
	Rodlet 2	237.35	150.64	3.97%	1.96%	10.70%	4.50%	4.23E+20
	Rodlet 3	262.64	207.23	5.63%	3.77%	13.61%	4.89%	4.75E+20
	Rodlet 4	286.39	203.10	4.94%	3.24%	12.31%	4.83%	5.18E+20
	Rodlet 5	285.62	205.68	4.82%	3.31%	10.80%	4.33%	5.17E+20
	Rodlet 6	189.20	149.79	4.26%	2.92%	10.54%	3.81%	3.60E+20
E-3 AFC-1G	Rodlet 1	122.91	106.06	3.25%	1.66%	--	--	2.42E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	257.38	171.62	3.84%	2.15%	9.86%	4.77%	4.59E+20

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
	Rodlet 4	189.31	164.34	4.74%	2.45%	--	--	3.63E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
40.6 EFPDs								
E-1 AFC-1D	Rodlet 1	141.93	121.05	12.13%	6.37%	23.97%	--	8.94E+20
	Rodlet 2	157.94	135.59	15.77%	7.17%	30.82%	--	1.02E+21
	Rodlet 3	243.10	213.23	16.84%	10.30%	25.81%	--	1.57E+21
	Rodlet 4	203.11	178.48	17.25%	9.37%	34.41%	--	1.29E+21
	Rodlet 5	153.19	159.17	20.08%	12.12%	--	--	1.03E+21
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	202.89	146.89	4.15%	2.63%	9.94%	3.77%	4.14E+20
	Rodlet 2	230.06	146.46	4.51%	2.22%	12.19%	5.09%	4.81E+20
	Rodlet 3	253.04	200.50	6.41%	4.32%	15.37%	5.61%	5.40E+20
	Rodlet 4	280.43	199.76	5.65%	3.67%	13.93%	5.43%	5.90E+20
	Rodlet 5	273.69	197.99	5.46%	3.72%	12.17%	4.84%	5.86E+20
	Rodlet 6	201.35	159.93	4.89%	3.36%	11.96%	4.38%	4.12E+20
E-3 AFC-1G	Rodlet 1	125.63	108.61	3.72%	1.89%	--	--	2.76E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	250.35	167.56	4.34%	2.41%	11.13%	5.32%	5.21E+20
	Rodlet 4	188.70	164.28	5.40%	2.78%	--	--	4.15E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--

Table 16. 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 105.50 MW, E-lobe 21.67 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
20.0 EFPDs								
E-1 AFC-1D	Rodlet 1	121.82	104.08	12.86%	6.79%	25.36%	--	9.51E+20
	Rodlet 2	137.29	118.08	16.63%	7.61%	32.40%	--	1.09E+21
	Rodlet 3	219.13	192.72	17.88%	11.01%	25.98%	--	1.68E+21
	Rodlet 4	185.00	162.92	18.29%	10.00%	36.36%	--	1.38E+21
	Rodlet 5	139.61	145.34	21.20%	12.91%	--	--	1.09E+21
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	169.54	123.05	4.87%	3.10%	11.78%	4.44%	4.95E+20
	Rodlet 2	211.51	134.92	5.38%	2.68%	14.51%	6.15%	5.82E+20
	Rodlet 3	227.19	180.62	7.63%	5.18%	18.12%	6.74%	6.49E+20
	Rodlet 4	258.89	184.98	6.83%	4.45%	16.52%	6.56%	7.14E+20
	Rodlet 5	258.89	187.85	6.64%	4.51%	14.44%	5.86%	7.10E+20
	Rodlet 6	184.89	147.24	5.93%	4.06%	14.30%	5.28%	5.00E+20
E-3 AFC-1G	Rodlet 1	109.99	95.22	4.37%	2.22%	--	--	3.33E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	234.36	157.25	5.15%	2.90%	13.34%	6.42%	6.30E+20
	Rodlet 4	173.56	151.41	6.51%	3.38%	--	--	5.04E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
40.0 EFPDs								
E-1 AFC-1D	Rodlet 1	130.77	111.99	13.65%	7.23%	26.81%	--	1.01E+21
	Rodlet 2	143.36	123.66	17.56%	8.10%	33.99%	--	1.15E+21
	Rodlet 3	222.33	196.41	18.91%	11.70%	26.21%	--	1.78E+21
	Rodlet 4	184.23	162.89	19.32%	10.62%	38.20%	--	1.46E+21
	Rodlet 5	139.83	146.06	22.32%	13.68%	--	--	1.16E+21
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	179.92	131.02	5.70%	3.67%	13.62%	5.28%	5.81E+20
	Rodlet 2	218.91	140.16	6.33%	3.14%	16.71%	7.16%	6.87E+20
	Rodlet 3	230.61	184.30	8.86%	6.05%	21.07%	7.86%	7.60E+20
	Rodlet 4	259.66	186.54	8.00%	5.22%	19.03%	7.69%	8.38E+20
	Rodlet 5	256.68	187.25	7.82%	5.31%	16.88%	6.88%	8.34E+20
	Rodlet 6	186.55	149.19	7.00%	4.75%	16.46%	6.17%	5.90E+20
E-3 AFC-1G	Rodlet 1	116.95	101.45	5.20%	2.67%	--	--	3.94E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	232.21	156.51	6.04%	3.40%	15.58%	7.51%	7.38E+20

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
	Rodlet 4	175.38	153.53	7.67%	4.03%	--	--	5.95E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
50.9 EFPDs								
E-1 AFC-1D	Rodlet 1	133.64	114.77	14.07%	7.48%	27.66%	--	1.05E+21
	Rodlet 2	142.92	123.67	17.99%	8.34%	34.93%	--	1.19E+21
	Rodlet 3	222.33	197.32	19.47%	12.07%	26.24%	--	1.84E+21
	Rodlet 4	183.90	163.25	19.86%	10.96%	39.23%	--	1.51E+21
	Rodlet 5	138.06	144.69	22.92%	14.10%	--	--	1.19E+21
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	184.12	134.60	6.15%	3.98%	14.69%	5.73%	6.30E+20
	Rodlet 2	214.82	138.04	6.87%	3.39%	17.86%	7.72%	7.42E+20
	Rodlet 3	225.20	180.94	9.51%	6.49%	22.58%	8.42%	8.18E+20
	Rodlet 4	252.37	182.29	8.62%	5.60%	20.27%	8.23%	9.04E+20
	Rodlet 5	265.30	194.63	8.45%	5.75%	18.14%	7.45%	9.03E+20
	Rodlet 6	187.21	150.35	7.59%	5.14%	17.59%	6.66%	6.39E+20
E-3 AFC-1G	Rodlet 1	119.58	103.97	5.67%	2.92%	--	--	4.27E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	231.98	157.12	6.45%	3.65%	16.68%	8.06%	7.97E+20
	Rodlet 4	165.69	145.57	8.23%	4.33%	--	--	6.41E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--

Table 17. 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 105.80 MW, E-lobe 21.63 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
15.0 EFPDs								
E-1 AFC-1D	Rodlet 1	125.47	107.92	14.61%	7.79%	28.68%	--	1.09E+21
	Rodlet 2	140.71	121.94	18.72%	8.71%	36.06%	--	1.24E+21
	Rodlet 3	231.17	205.63	20.26%	12.61%	26.26%	--	1.92E+21
	Rodlet 4	194.39	172.93	20.66%	11.44%	40.64%	--	1.58E+21
	Rodlet 5	149.55	157.02	23.80%	14.73%	--	--	1.25E+21
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	170.75	125.11	6.69%	4.35%	16.02%	6.26%	6.91E+20
	Rodlet 2	214.05	137.83	7.47%	3.72%	19.52%	8.51%	8.19E+20
	Rodlet 3	227.30	183.12	10.41%	7.17%	24.55%	9.31%	9.00E+20
	Rodlet 4	257.23	186.30	9.43%	6.16%	22.12%	9.05%	9.97E+20
	Rodlet 5	259.00	190.61	9.31%	6.31%	19.73%	8.16%	9.96E+20
	Rodlet 6	183.79	147.95	8.35%	5.65%	19.26%	7.30%	7.05E+20
E-3 AFC-1G	Rodlet 1	113.52	98.85	6.13%	3.15%	--	--	4.71E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	241.05	163.64	7.10%	4.02%	18.35%	8.89%	8.81E+20
	Rodlet 4	184.26	162.17	9.08%	4.79%	--	--	7.12E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
30.0 EFPDs								
E-1 AFC-1D	Rodlet 1	132.21	113.94	15.21%	8.13%	29.69%	--	1.14E+21
	Rodlet 2	144.69	125.69	19.37%	9.05%	37.38%	--	1.29E+21
	Rodlet 3	235.25	210.04	21.08%	13.15%	26.33%	--	2.00E+21
	Rodlet 4	194.83	173.87	21.51%	11.95%	41.99%	--	1.65E+21
	Rodlet 5	146.34	154.07	24.66%	15.34%	--	--	1.30E+21
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	188.42	138.42	7.23%	4.75%	17.47%	6.86%	7.59E+20
	Rodlet 2	216.26	139.62	8.21%	4.09%	21.06%	9.25%	8.96E+20
	Rodlet 3	228.52	184.86	11.30%	7.79%	26.53%	10.11%	9.83E+20
	Rodlet 4	248.73	180.86	10.22%	6.71%	23.83%	9.88%	1.09E+21
	Rodlet 5	246.08	181.82	10.10%	6.85%	21.38%	8.86%	1.08E+21
	Rodlet 6	183.12	147.88	9.12%	6.16%	20.79%	7.95%	7.71E+20
E-3 AFC-1G	Rodlet 1	122.81	107.10	6.78%	3.51%	--	--	5.19E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	234.13	159.51	7.85%	4.39%	19.96%	9.67%	9.63E+20

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
	Rodlet 4	177.60	156.73	9.92%	5.25%	--	--	7.81E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
39.0 EFPDs								
E-1 AFC-1D	Rodlet 1	133.64	115.43	15.58%	8.35%	30.31%	--	1.17E+21
	Rodlet 2	148.00	128.86	19.80%	9.28%	38.17%	--	1.32E+21
	Rodlet 3	243.98	218.62	21.60%	13.51%	26.38%	--	2.05E+21
	Rodlet 4	198.70	177.92	21.99%	12.24%	42.81%	--	1.69E+21
	Rodlet 5	153.19	161.71	25.20%	15.72%	--	--	1.33E+21
	Dummy	--	--	--	--	--	--	--
E-2 AFC-1H	Rodlet 1	189.97	139.95	7.59%	5.00%	18.31%	7.23%	8.00E+20
	Rodlet 2	217.91	141.10	8.62%	4.29%	21.94%	9.71%	9.43E+20
	Rodlet 3	230.06	186.84	11.84%	8.17%	27.72%	10.59%	1.03E+21
	Rodlet 4	249.28	181.97	10.70%	7.02%	24.85%	10.33%	1.14E+21
	Rodlet 5	248.07	184.00	10.58%	7.20%	22.40%	9.30%	1.14E+21
	Rodlet 6	183.67	148.79	9.58%	6.48%	21.68%	8.37%	8.11E+20
E-3 AFC-1G	Rodlet 1	125.13	109.33	7.09%	3.66%	--	--	5.48E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	237.54	162.41	8.25%	4.61%	20.91%	10.16%	1.01E+21
	Rodlet 4	180.53	159.75	10.42%	5.54%	--	--	8.23E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--

Table 18. 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 105.73 MW, E-lobe 22.57 MW)

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
16.0 EFPDs								
E-2 AFC-1H	Rodlet 1	180.25	133.03	8.22%	5.42%	19.81%	7.83%	8.69E+20
	Rodlet 2	214.60	139.18	9.36%	4.66%	23.65%	10.52%	1.02E+21
	Rodlet 3	243.10	197.88	12.90%	8.91%	29.71%	11.54%	1.13E+21
	Rodlet 4	262.53	192.07	11.62%	7.65%	26.75%	11.23%	1.24E+21
	Rodlet 5	260.99	194.07	11.47%	7.84%	24.22%	10.13%	1.24E+21
	Rodlet 6	188.87	153.29	10.46%	7.06%	23.38%	9.10%	8.83E+20
E-3 AFC-1G	Rodlet 1	120.39	105.30	7.70%	3.99%	--	--	5.97E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	240.37	164.69	8.90%	5.00%	22.52%	11.02%	1.10E+21
	Rodlet 4	177.60	157.42	11.31%	6.05%	--	--	8.96E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
E-4 AFC-1D	Rodlet 1	134.41	116.25	16.18%	8.69%	31.39%	--	1.22E+21
	Rodlet 2	154.74	134.93	20.51%	9.69%	39.61%	--	1.38E+21
	Rodlet 3	237.02	212.88	22.43%	14.07%	26.05%	--	2.14E+21
	Rodlet 4	188.31	168.94	22.84%	12.77%	44.22%	--	1.76E+21
	Rodlet 5	143.80	152.04	26.10%	16.37%	--	--	1.38E+21
	Dummy	--	--	--	--	--	--	--
32.0 EFPDs								
E-2 AFC-1H	Rodlet 1	187.98	139.15	8.94%	5.91%	21.26%	8.52%	9.41E+20
	Rodlet 2	225.09	146.43	10.03%	5.05%	25.52%	11.37%	1.11E+21
	Rodlet 3	241.00	197.09	13.93%	9.61%	31.71%	12.42%	1.22E+21
	Rodlet 4	262.98	193.26	12.52%	8.27%	28.51%	12.15%	1.34E+21
	Rodlet 5	266.84	199.33	12.38%	8.48%	25.92%	10.96%	1.34E+21
	Rodlet 6	191.52	156.00	11.31%	7.63%	25.00%	9.82%	9.56E+20
E-3 AFC-1G	Rodlet 1	124.22	108.86	8.32%	4.32%	--	--	6.49E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	241.73	166.27	9.56%	5.39%	24.19%	11.91%	1.19E+21
	Rodlet 4	180.93	160.86	12.16%	6.52%	--	--	9.71E+20
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
E-4 AFC-1D	Rodlet 1	143.69	124.55	16.85%	9.08%	32.54%	--	1.27E+21
	Rodlet 2	159.93	139.82	21.30%	10.12%	41.04%	--	1.44E+21
	Rodlet 3	240.44	216.77	23.29%	14.68%	25.75%	--	2.23E+21

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
	Rodlet 4	188.20	169.43	23.64%	13.28%	45.64%	--	1.83E+21
	Rodlet 5	149.33	158.33	27.02%	17.03%	--	--	1.44E+21
	Dummy	--	--	--	--	--	--	--
54.1 EFPDs								
E-2 AFC-1H	Rodlet 1	187.76	139.46	9.82%	6.49%	23.16%	9.35%	1.04E+21
	Rodlet 2	227.85	148.70	11.04%	5.58%	27.88%	12.54%	1.23E+21
	Rodlet 3	238.24	195.70	15.34%	10.58%	34.33%	13.64%	1.34E+21
	Rodlet 4	255.58	188.65	13.73%	9.07%	30.95%	13.27%	1.48E+21
	Rodlet 5	265.63	199.35	13.63%	9.33%	28.25%	12.04%	1.48E+21
	Rodlet 6	190.08	155.38	12.48%	8.37%	27.33%	10.71%	1.06E+21
E-3 AFC-1G	Rodlet 1	129.27	113.51	9.22%	4.81%	--	--	7.22E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	234.70	162.02	10.53%	5.92%	26.32%	13.05%	1.31E+21
	Rodlet 4	178.41	159.06	13.33%	7.21%	--	--	1.07E+21
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
E-4 AFC-1D	Rodlet 1	139.16	120.93	17.69%	9.59%	34.14%	--	1.34E+21
	Rodlet 2	162.69	142.65	22.32%	10.69%	42.85%	--	1.53E+21
	Rodlet 3	235.70	213.35	24.45%	15.48%	25.20%	--	2.36E+21
	Rodlet 4	189.31	170.98	24.66%	13.95%	47.52%	--	1.93E+21
	Rodlet 5	146.45	155.74	28.27%	17.94%	--	--	1.52E+21
	Dummy	--	--	--	--	--	--	--

9. PROJECTED AND AS-RUN COMPARISON

The AFC-1D, AFC-1G, and AFC-1H test assembly irradiation data consist of projected and as-run LHGR, ^{239}Pu depletion, heavy metals depletion, Am depletion, and ^{235}U during cycles 135C, 136A, 136B and 137A.

As-Run cycle analysis was used to determine individual specimen heat rate and depletion cumulatively for each rodlet through the end of ATR Cycle 137A irradiation. All decisions regarding the experiment were based on these as-run results and were reviewed approximately 30 days after operating cycle completion. When a rodlet nears the end of its projected irradiation duration, a final projection of the performance expected during the final irradiation cycle will be used to determine if the experiment should be removed from the reactor or re-inserted for subsequent cycles. Thus, the entire irradiation process is guided using the as-run calculated test conditions. Projected data are viewed as confirmatory only.

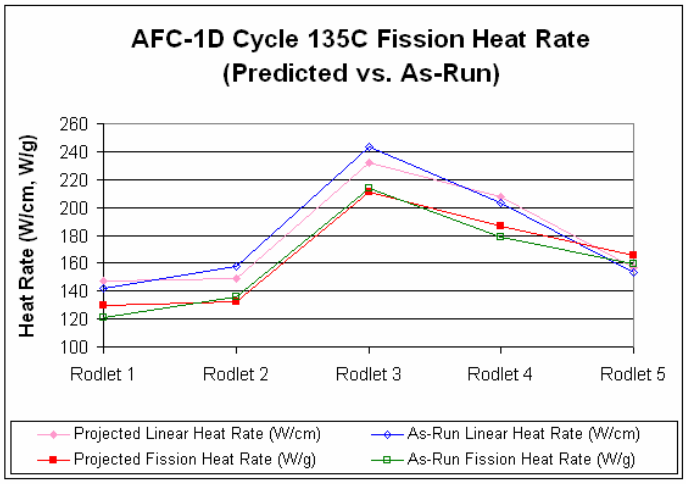
The expected variances and associated causes were analyzed by comparing the projected data to the as-run results. In the case of all cycle predictions, analyses was performed using initial design parameters; the as-run calculations were performed using as-built data. This results in some small variances with respect to the comparison calculations. The MCNP code used employs a Monte Carlo technique that also introduces stochastic variation to the analysis. The results will vary with a magnitude driven by the statistical uncertainty of the analyses. Regions with fewer neutrons, as applicable to these analyses, will have a larger uncertainty. Also, the analysis methodology used for pre-cycle predictions are based on fixed conditions (i.e., fixed outer shim control cylinder position, reactor power, cadmium concentration, effective full power days). This results in a fixed source for predicting depletion. The as-run analyses update these parameters at the end of each analysis increment. This is also expected to cause a variance when projected and as-run calculations are compared. Figures 7 and 9 indicate projected Am depletion data in Rodlet 3 for the AFC-1D EOC 136B and 137A to be suspect. Further evaluation has determined the data to be incorrect. Consequently, these data have been updated with the as-run analysis and will not be used in future calculations.

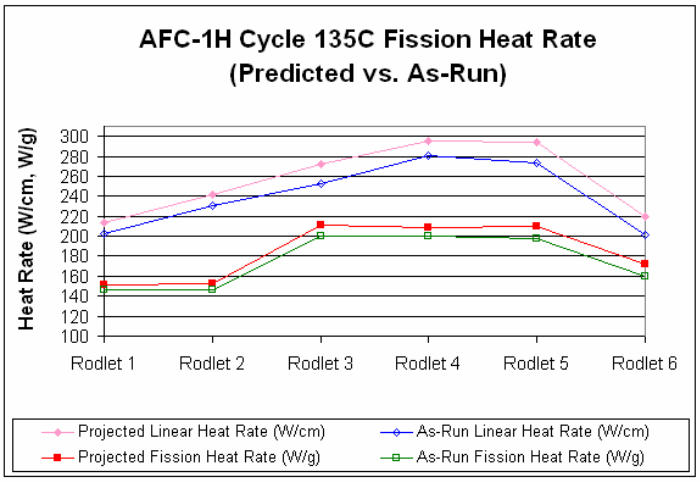
Comparison of the projected calculations and the as-run calculations for each AFC-1 test for each cycle completed in FY-06 can be found in Figures 2-9.

Figure 2. AFC-1D, AFC-G and AFC-1H End of Cycle 135C Fission Heat Rate Calculations

AFC-1D End of Cycle 135C Fission Heat Rate Calculations					
42 EFPDs - Projected Calculations			40.6 EFPDs - As-Run Calculations		
ID		Projected Linear Heat Rate $\bar{}$ (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1D (Metal)	Rodlet 1	147.59	141.93	129.65	121.05
	Rodlet 2	148.83	157.94	132.63	135.59
	Rodlet 3	232.16	243.1	210.71	213.23
	Rodlet 4	207.45	203.11	186.49	178.48
	Rodlet 5	156.79	153.19	165.69	159.17
	Dummy	--	--	--	--

AFC-1H End of Cycle 135C Fission Heat Rate Calculations					
42 EFPDs - Projected Calculations			40.6 EFPDs - As-Run Calculations		
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1H (Metal)	Rodlet 1	213.01	202.89	150.76	146.89
	Rodlet 2	241.22	230.06	152.38	146.46
	Rodlet 3	271.79	253.04	211.7	200.5
	Rodlet 4	294.88	280.43	208.59	199.76
	Rodlet 5	293.71	273.69	210.22	197.99
	Rodlet 6	219.82	201.35	172.04	159.93





AFC-1G End of Cycle 135C Fission Heat Rate Calculations					
42 EFPDs - Projected Calculations			40.6 EFPDs - As-Run Calculations		
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1G	Rodlet 1	138.41	125.63	118.47	108.61
	Rodlet 3	263.99	250.35	176.41	167.56
	Rodlet 4	204.36	188.7	174.51	164.28

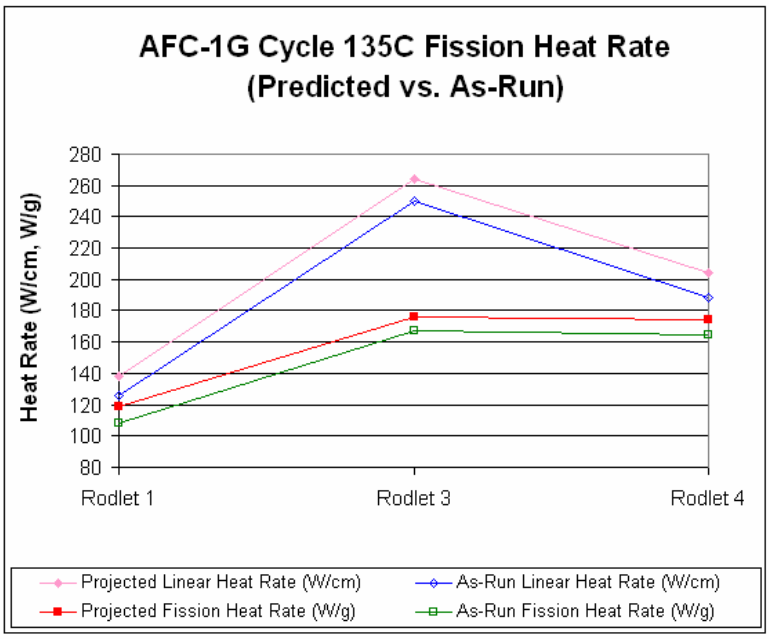
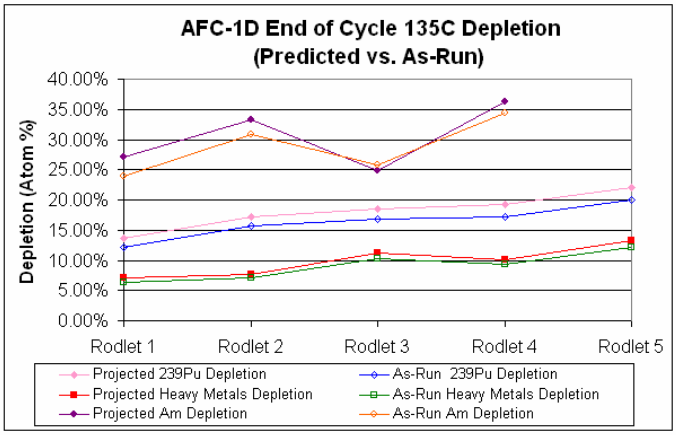
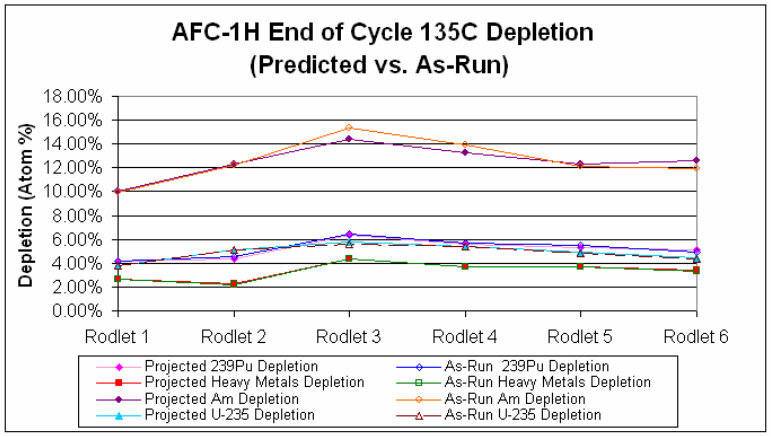


Figure 3. AFC-1D, AFC-G and AFC-1H End of Cycle 135C Depletion

AFC-1D End of Cycle 135C Depletion							
42 EFPDs - Projected Calculations					40.6 EFPDs - As-Run Calculations		
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion
AFC-1D (Metal)	Rodlet 1	13.71%	12.13%	7.06%	6.37%	27.01%	23.97%
	Rodlet 2	17.17%	15.77%	7.74%	7.17%	33.21%	30.82%
	Rodlet 3	18.48%	16.84%	11.21%	10.30%	24.87%	25.81%
	Rodlet 4	19.19%	17.25%	10.01%	9.37%	36.17%	34.41%
	Rodlet 5	21.97%	20.08%	13.26%	12.12%	--	--
	Dummy	--	--	--	--	--	--



AFC-1H End of Cycle 135C Depletion									
42 EFPDs - Projected Calculations					40.6 EFPDs - As-Run Calculations				
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion	Projected U-235 Depletion	As-Run U-235 Depletion
AFC-1H (Metal)	Rodlet 1	4.13%	4.15%	2.62%	2.63%	10.00%	9.94%	3.82%	3.77%
	Rodlet 2	4.39%	4.51%	2.23%	2.22%	12.27%	12.19%	5.08%	5.09%
	Rodlet 3	6.33%	6.41%	4.37%	4.32%	14.39%	15.37%	5.75%	5.61%
	Rodlet 4	5.62%	5.65%	3.66%	3.67%	13.29%	13.93%	5.41%	5.43%
	Rodlet 5	5.26%	5.46%	3.70%	3.72%	12.34%	12.17%	4.88%	4.84%
	Rodlet 6	5.16%	4.89%	3.43%	3.36%	12.59%	11.96%	4.42%	4.38%



AFC-1G End of Cycle 135C Depletion									
42 EFPDs - Projected Calculations					40.6 EFPDs - As-Run Calculations				
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion	Projected U-235 Depletion	As-Run U-235 Depletion
AFC-1G	Rodlet 1	3.77%	3.72%	1.90%	1.89%				
	Rodlet 3	4.39%	4.34%	2.43%	2.41%	11.44%	11.13%	4.86%	5.32%
	Rodlet 4	5.55%	5.40%	2.89%	2.78%				

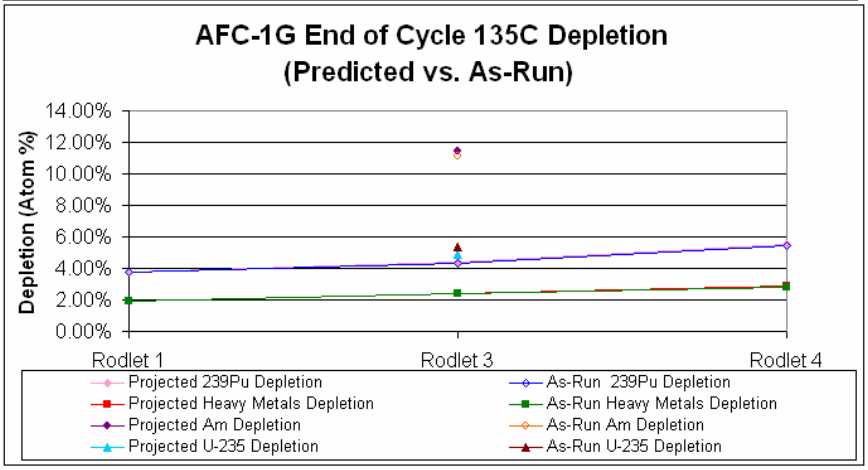
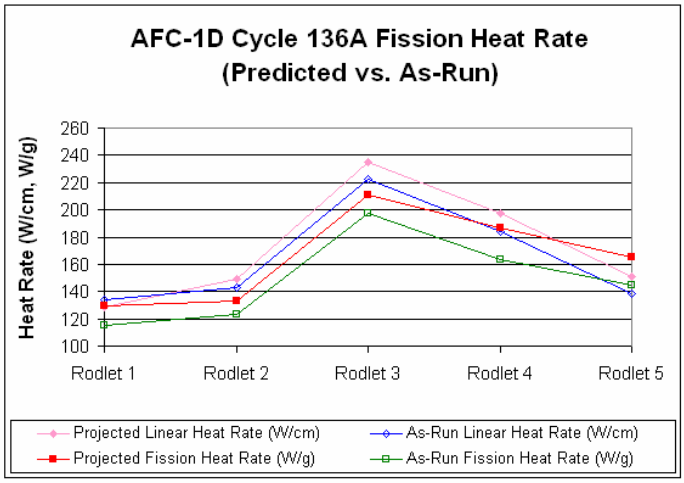
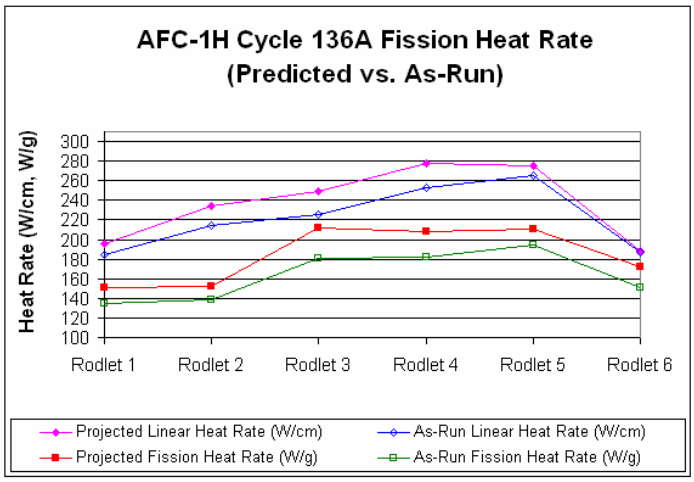


Figure 4. AFC-1D, AFC-G and AFC-1H End of Cycle 136A Fission Heat Rate Calculations

AFC-1D End of Cycle 136A Fission Heat Rate Calculations					
56 EFPDs - Projected Calculations				50.9 EFPDs - As-Run Calculations	
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1D (Metal)	Rodlet 1	128.76	133.64	129.65	114.77
	Rodlet 2	148.85	142.92	132.63	123.67
	Rodlet 3	235.41	222.33	210.71	197.32
	Rodlet 4	197.26	183.9	186.49	163.25
	Rodlet 5	151.11	138.06	165.69	144.69
	Dummy	--	--	--	--

AFC-1H End of Cycle 136A Fission Heat Rate Calculations					
56 EFPDs - Projected Calculations				50.9 EFPDs - As-Run Calculations	
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1H (Metal)	Rodlet 1	195.18	184.12	150.76	134.6
	Rodlet 2	233.59	214.82	152.38	138.04
	Rodlet 3	248.6	225.2	211.7	180.94
	Rodlet 4	277.37	252.37	208.59	182.29
	Rodlet 5	275.16	265.3	210.22	194.63
	Rodlet 6	187.85	187.21	172.04	150.35





AFC-1G End of Cycle 136A Fission Heat Rate Calculations					
56 EFPDs - Projected Calculations				50.9 EFPDs - As-Run Calculations	
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1G	Rodlet 1	129.57	119.58	111.62	103.97
	Rodlet 3	248.68	231.98	168.38	157.12
	Rodlet 4	196.1	165.69	169.14	145.57

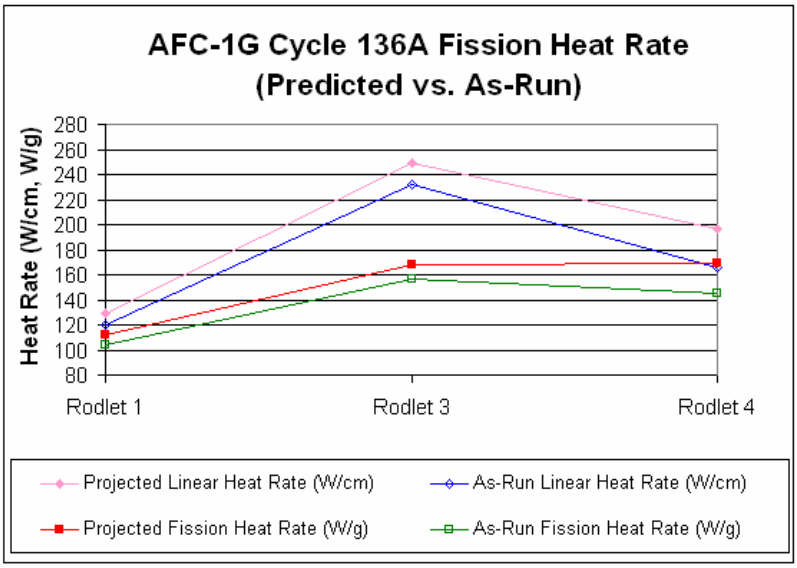
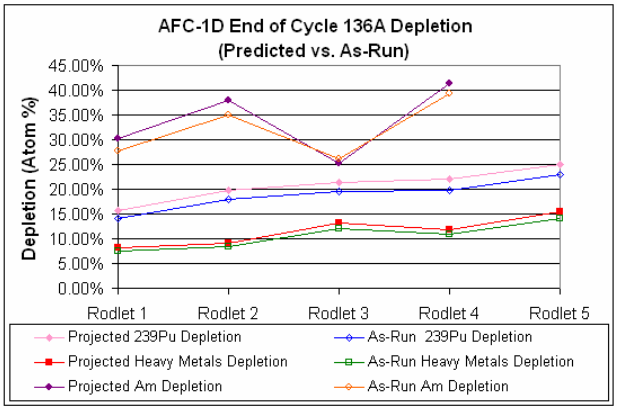
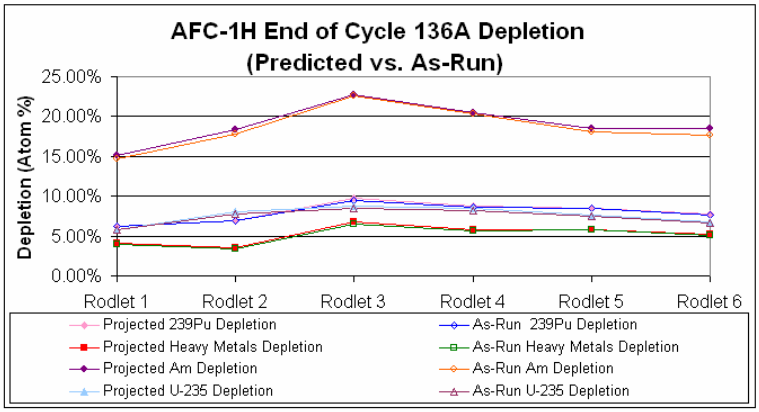


Figure 5. AFC-1D, AFC-G and AFC-1H End of Cycle 136A Depletion

AFC-1D End of Cycle 136A Depletion							
56 EFPDs - Projected Calculation			50.9 EFPDs - As-Run Calculations				
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion
AFC-1D (Metal)	Rodlet 1	15.58%	14.07%	8.12%	7.48%	30.15%	27.66%
	Rodlet 2	19.74%	17.99%	9.08%	8.34%	38.05%	34.93%
	Rodlet 3	21.47%	19.47%	13.23%	12.07%	25.16%	26.24%
	Rodlet 4	22.03%	19.86%	11.73%	10.96%	41.30%	39.23%
	Rodlet 5	25.11%	22.92%	15.49%	14.10%	--	--
	Dummy	--	--	--	--	--	--

AFC-1H End of Cycle 136A Depletion									
56 EFPDs - Projected Calculations			50.9 EFPDs - As-Run Calculations						
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion	Projected U-235 Depletion	As-Run U-235 Depletion
AFC-1H (Metal)	Rodlet 1	6.28%	6.15%	4.03%	3.98%	15.17%	14.69%	5.85%	5.73%
	Rodlet 2	6.96%	6.87%	3.52%	3.39%	18.39%	17.86%	8.02%	7.72%
	Rodlet 3	9.69%	9.51%	6.73%	6.49%	22.72%	22.58%	8.79%	8.42%
	Rodlet 4	8.76%	8.62%	5.74%	5.60%	20.52%	20.27%	8.41%	8.23%
	Rodlet 5	8.51%	8.45%	5.84%	5.75%	18.52%	18.14%	7.61%	7.45%
	Rodlet 6	7.71%	7.59%	5.22%	5.14%	18.56%	17.59%	6.78%	6.66%





AFC-1G End of Cycle 136A Depletion									
56 EFPDs - Projected Calculations			50.9 EFPDs - As-Run Calculations						
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion	Projected U-235 Depletion	As-Run U-235 Depletion
AFC-1G	Rodlet 1	5.88%	5.67%	3.03%	2.92%				
	Rodlet 3	6.67%	6.45%	3.74%	3.65%	17.12%	16.68%	8.29%	8.06%
	Rodlet 4	8.55%	8.23%	4.50%	4.33%				

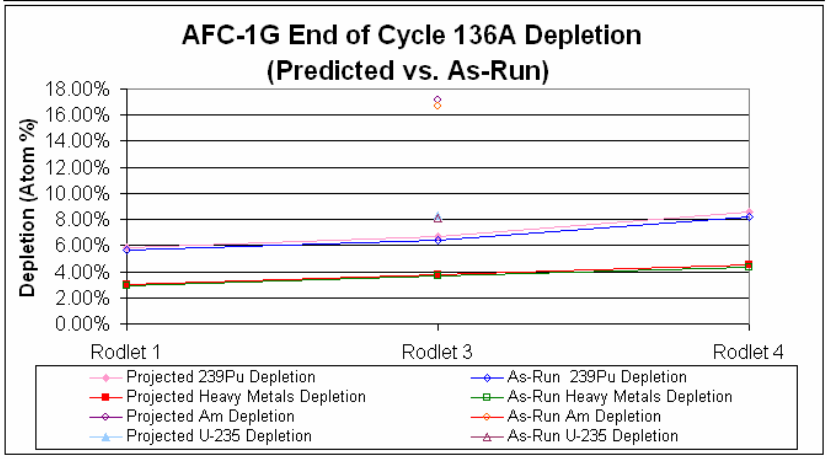
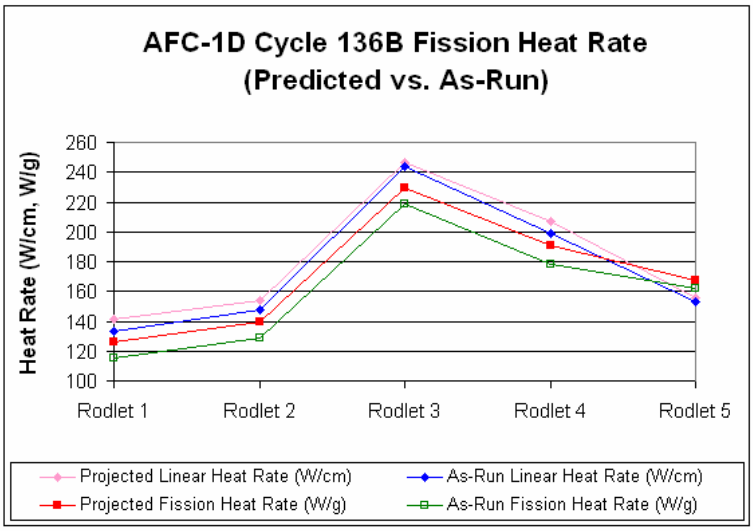
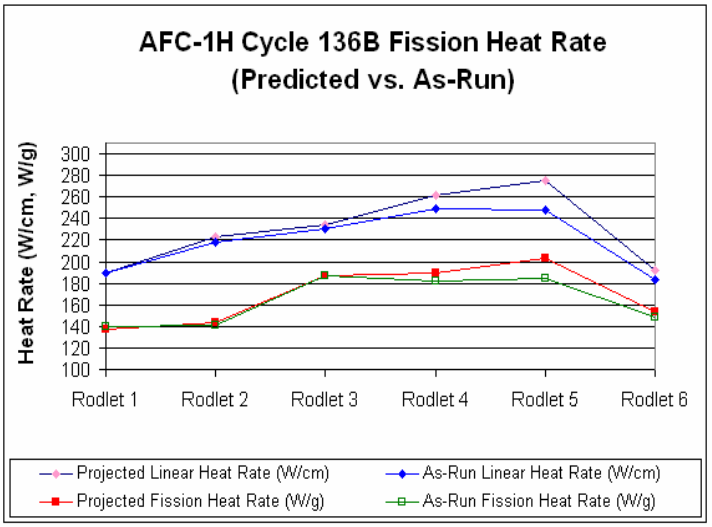


Figure 6. AFC-1D, AFC-G and AFC-1H End of Cycle 136B Fission Heat Rate Calculations

AFC-1D End of Cycle 136B Fission Heat Rate Calculations					
49 EFPDs - Projected Calculations			39 EFPDs - As-Run Calculations		
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1D (Metal)	Rodlet 1	141.37	133.64	125.94	115.43
	Rodlet 2	153.63	148	139.11	128.86
	Rodlet 3	246.45	243.98	229.31	218.62
	Rodlet 4	207.41	198.7	190.48	177.92
	Rodlet 5	155.71	153.19	167.54	161.71
	Dummy	--	--	--	--

AFC-1H End of Cycle 136B Fission Heat Rate Calculations					
49 EFPDs - Projected Calculations			39 EFPDs - As-Run Calculations		
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1H (Metal)	Rodlet 1	189.8	189.97	136.94	139.95
	Rodlet 2	223.44	217.91	143.91	141.1
	Rodlet 3	234.22	230.06	187.43	186.84
	Rodlet 4	261.15	249.28	189.94	181.97
	Rodlet 5	275.4	248.07	203.03	184
	Rodlet 6	191.6	183.67	153.27	148.79





AFC-1G End of Cycle 136B Fission Heat Rate Calculations					
49 EFPDs - Projected Calculations			39 EFPDs - As-Run Calculations		
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1H	Rodlet 1	130.93	125.13	113.41	109.33
	Rodlet 3	248.73	237.54	170.26	162.41
	Rodlet 4	192.41	180.53	167.38	159.75

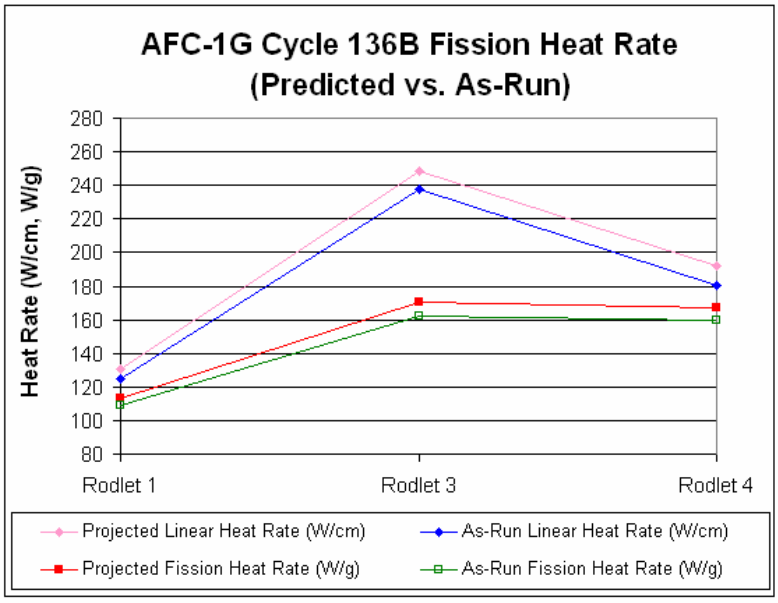
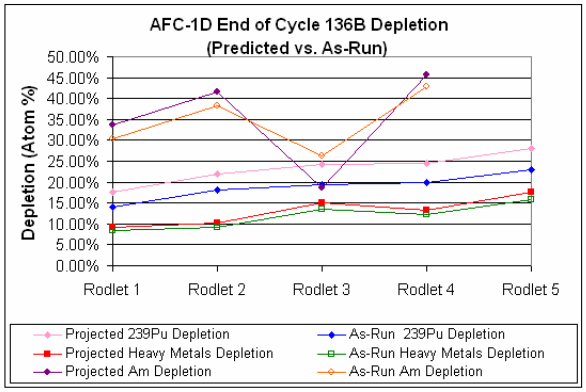
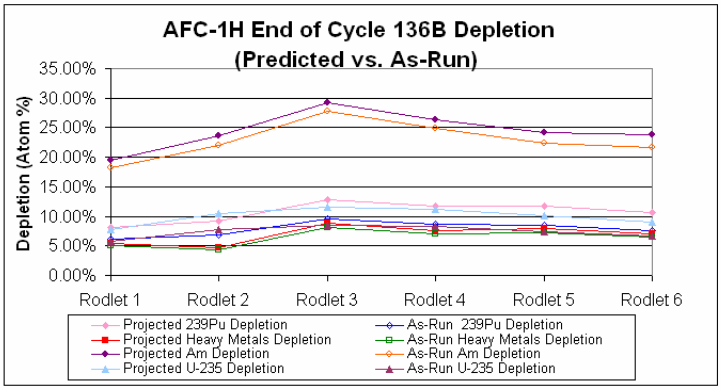


Figure 7. AFC-1D, AFC-G and AFC-1H End of Cycle 136B Depletion

AFC-1D End of Cycle 136B Depletion							
49 EFPDs - Projected Calculations				39 EFPDs - As-Run Calculations			
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion
AFC-1D (Metal)	Rodlet 1	17.63%	14.07%	9.31%	8.35%	33.79%	30.31%
	Rodlet 2	21.91%	17.99%	10.24%	9.28%	41.68%	38.17%
	Rodlet 3	24.19%	19.47%	15.11%	13.51%	18.56%*	26.38%
	Rodlet 4	24.60%	19.86%	13.35%	12.24%	45.71%	42.81%
	Rodlet 5	27.98%	22.92%	17.56%	15.72%	--	--
	Dummy	--	--	--	--	--	--

AFC-1H End of Cycle 136B Depletion									
49 EFPDs - Projected Calculations				39 EFPDs - As-Run Calculations					
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion	Projected U-235 Depletion	As-Run U-235 Depletion
AFC-1H (Metal)	Rodlet 1	8.09%	6.15%	5.34%	5.00%	19.55%	18.31%	7.79%	5.73%
	Rodlet 2	9.26%	6.87%	4.65%	4.29%	23.55%	21.94%	10.53%	7.72%
	Rodlet 3	12.78%	9.51%	8.84%	8.17%	29.19%	27.72%	11.51%	8.42%
	Rodlet 4	11.71%	8.62%	7.62%	7.02%	26.39%	24.85%	11.18%	8.23%
	Rodlet 5	11.73%	8.45%	7.88%	7.20%	24.24%	22.40%	10.15%	7.45%
	Rodlet 6	10.62%	7.59%	7.06%	6.48%	23.80%	21.68%	9.07%	6.66%





AFC-1G End of Cycle 136B Depletion									
49 EFPDs - Projected Calculations				39 EFPDs - As-Run Calculations					
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion	Projected U-235 Depletion	As-Run U-235 Depletion
AFC-1G	Rodlet 1	7.63%	7.09%	3.92%	3.66%				
	Rodlet 3	8.79%	8.25%	4.95%	4.61%	22.51%	20.10%	10.96%	10.16%
	Rodlet 4	11.34%	10.42%	6.03%	5.54%				

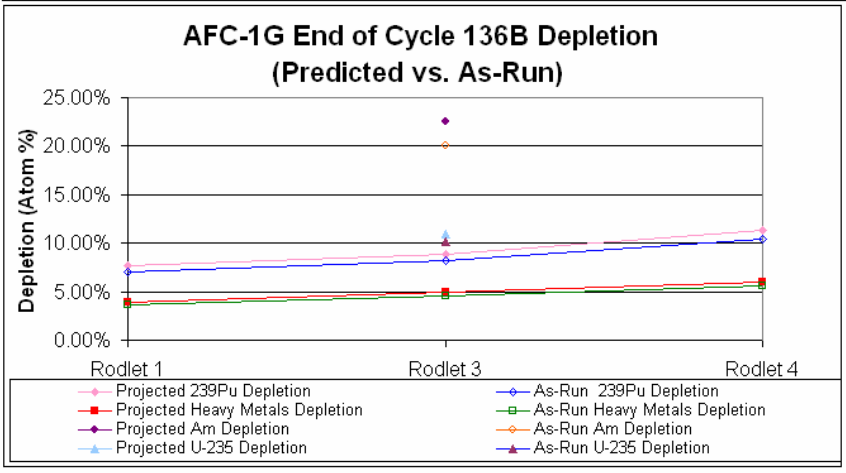
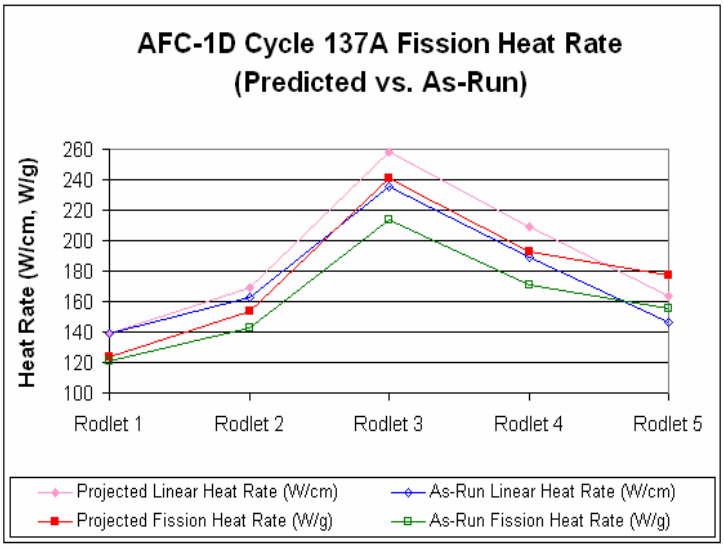
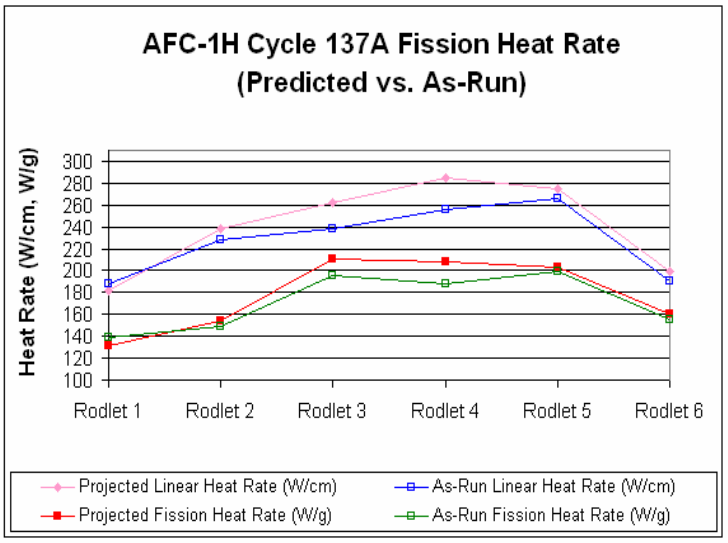


Figure 8. AFC-1D, AFC-G and AFC-1H End of Cycle 137A Fission Heat Rate Calculations

AFC-1D End of Cycle 137A Fission Heat Rate Calculations					
55 EFPDs - Projected Calculations				54.1 EFPDs - As-Run Calculations	
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1D (Metal)	Rodlet 1	138.95	139.16	124.05	120.93
	Rodlet 2	169.02	162.69	153.58	142.65
	Rodlet 3	258.31	235.7	241.32	213.35
	Rodlet 4	208.88	189.31	192.4	170.98
	Rodlet 5	163.95	146.45	176.88	155.74
	Dummy	--	--	--	--

AFC-1H End of Cycle 137A Fission Heat Rate Calculations					
55 EFPDs - Projected Calculations				54.1 EFPDs - As-Run Calculations	
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1H (Metal)	Rodlet 1	181.86	187.76	131.61	139.46
	Rodlet 2	237.76	227.85	153.63	148.7
	Rodlet 3	261.77	238.24	210.6	195.7
	Rodlet 4	285.18	255.58	208.38	188.65
	Rodlet 5	274.8	265.63	203.4	199.35
	Rodlet 6	199.11	190.08	159.8	155.38





AFC-1G End of Cycle 137A Fission Heat Rate Calculations					
55 EFPDs - Projected Calculations				54.1 EFPDs - As-Run Calculations	
ID		Projected Linear Heat Rate (W/cm)	As-Run Linear Heat Rate (W/cm)	Projected Fission Heat Rate (W/g)	As-Run Fission Heat Rate (W/g)
AFC-1H	Rodlet 1	125.49	129.27	108.9	113.51
	Rodlet 3	256.11	234.7	176	162.02
	Rodlet 4	195.87	178.41	170.9	159.06

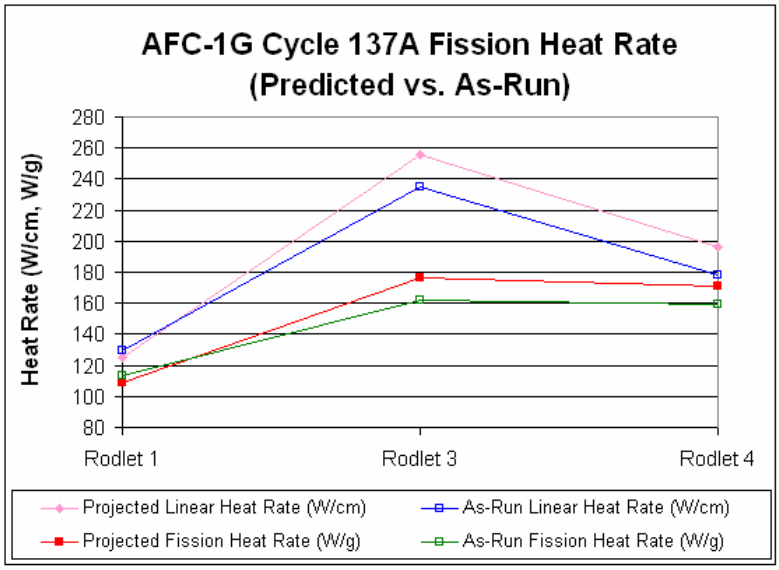
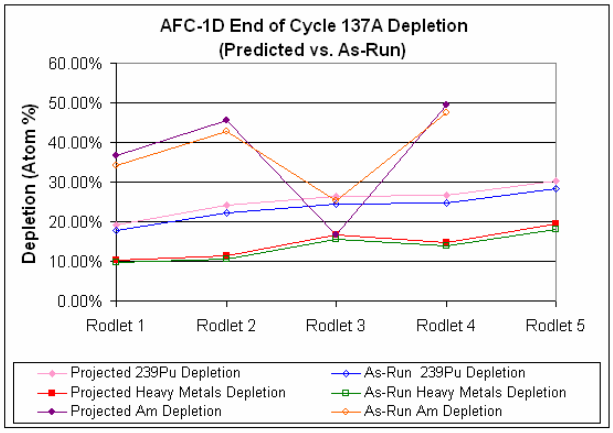
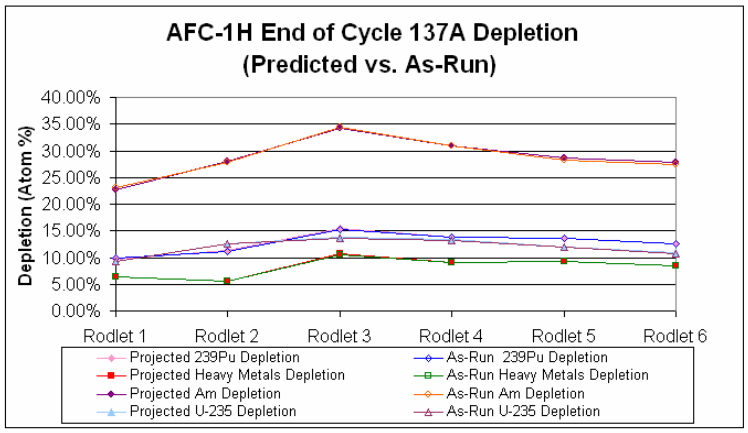


Figure 9. AFC-1D, AFC-G and AFC-1H End of Cycle 137A Depletion

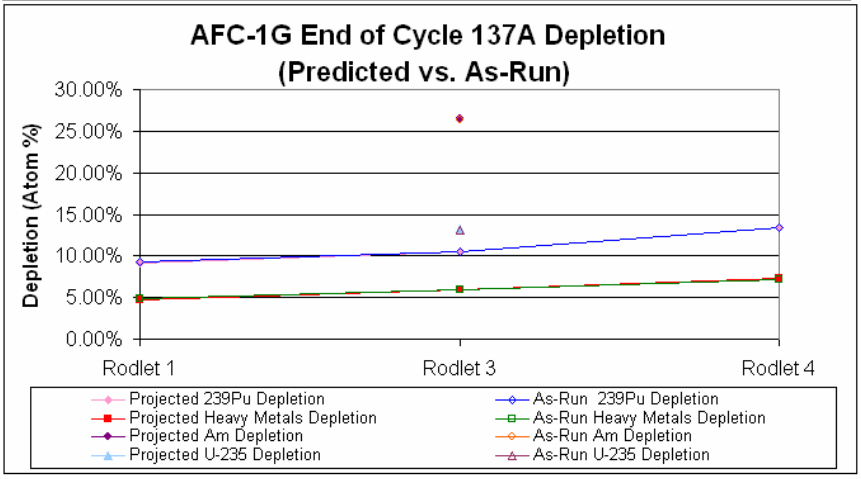
AFC-1D End of Cycle 137A Depletion							
55 EFPDs - Projected Calculations					54.1 EFPDs - As-Run Calculations		
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion
AFC-1D (Metal)	Rodlet 1	19.24%	17.69%	10.27%	9.59%	36.57%	34.14%
	Rodlet 2	24.15%	22.32%	11.48%	10.69%	45.67%	42.85%
	Rodlet 3	26.46%	24.45%	16.69%	15.48%	16.78%*	25.20%
	Rodlet 4	26.65%	24.66%	14.67%	13.95%	49.51%	47.52%
	Rodlet 5	30.40%	28.27%	19.33%	17.94%	--	--
	Dummy	--	--	--	--	--	--



AFC-1H End of Cycle 137A Depletion									
55 EFPDs - Projected Calculations						54.1 EFPDs - As-Run Calculations			
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion	Projected U-235 Depletion	As-Run U-235 Depletion
AFC-1H (Metal)	Rodlet 1	9.79%	9.82%	6.43%	6.49%	22.61%	23.16%	9.30%	9.35%
	Rodlet 2	11.29%	11.04%	5.64%	5.58%	28.05%	27.88%	12.63%	12.54%
	Rodlet 3	15.51%	15.34%	10.76%	10.58%	34.27%	34.33%	13.91%	13.64%
	Rodlet 4	13.82%	13.73%	9.14%	9.07%	30.90%	30.95%	13.36%	13.27%
	Rodlet 5	13.67%	13.63%	9.36%	9.33%	28.60%	28.25%	12.06%	12.04%
	Rodlet 6	12.48%	12.48%	8.48%	8.37%	27.91%	27.33%	10.95%	10.71%



AFC-1G End of Cycle 137A Depletion									
55 EFPDs - Projected Calculations						54.1 EFPDs - As-Run Calculations			
ID		Projected 239Pu Depletion	As-Run ^{239}Pu Depletion	Projected Heavy Metals Depletion	As-Run Heavy Metals Depletion	Projected Am Depletion	As-Run Am Depletion	Projected U-235 Depletion	As-Run U-235 Depletion
AFC-1G	Rodlet 1	9.16%	9.22%	4.78%	4.81%				
	Rodlet 3	10.57%	10.53%	5.97%	5.92%	26.52%	26.32%	13.18%	13.05%
	Rodlet 4	13.47%	13.33%	7.29%	7.21%				



10. 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.%, 25 at.%, and 25 at.%, respectively. Based on the as-run analysis reported in Section 8 of this report, it is expected that the AFC-1D test will require approximately 4 additional cycles of irradiation to reach the desired 40 at.% burnup, and the AFC-1G and AFC-1H experiments will require approximately 4 to 5 additional cycles of irradiation to reach the desired 25 at.% burnup. During FY-06, Post Irradiation Examination (PIE) was completed on sibling experiments. Based on the PIE examination of the sibling experiment AFC-1B, the programmatic design burnup limit on the AFC-1D metallic fuel experiment was revised. Prior to insertion of AFC-1D in the ATR, the thermal hydraulic and fuel performance behavior were analyzed and documented in the Final Experiment Description and Design & Data Package for AFC-1A, AFC-1B, AFC-1C and AFC-1D. Design limits for burnup, fuel and cladding temperature were also specified. The PIE data of AFC-1B with a peak burnup of 8 at.% showed that the fuel rodlets exhibited significantly less fission damage than projected (ranging from a factor 3-5 times lower for the different fuel compositions). There was also less swelling, porosity development, restructuring and fission gas release. These data indicate that AFC-1D could be safely irradiated to significantly higher burnup, possibly 75-80 at.%, and exhibit acceptable fuel performance. Because there is the possibility that the fuel performance trend may change at higher burnups, the programmatic limit was revised to 40 at.%. Similar evaluations are currently being performed for the AFC-1G test. Therefore, if the burnup limit on the AFC-1H test is increased to 40 at.% burnup, it is expected to require approximately 8 additional cycles of irradiation.

Burnups for the AFC-1 test assemblies at the end of Cycle 137A completed in June 2006, are summarized in Table 19.

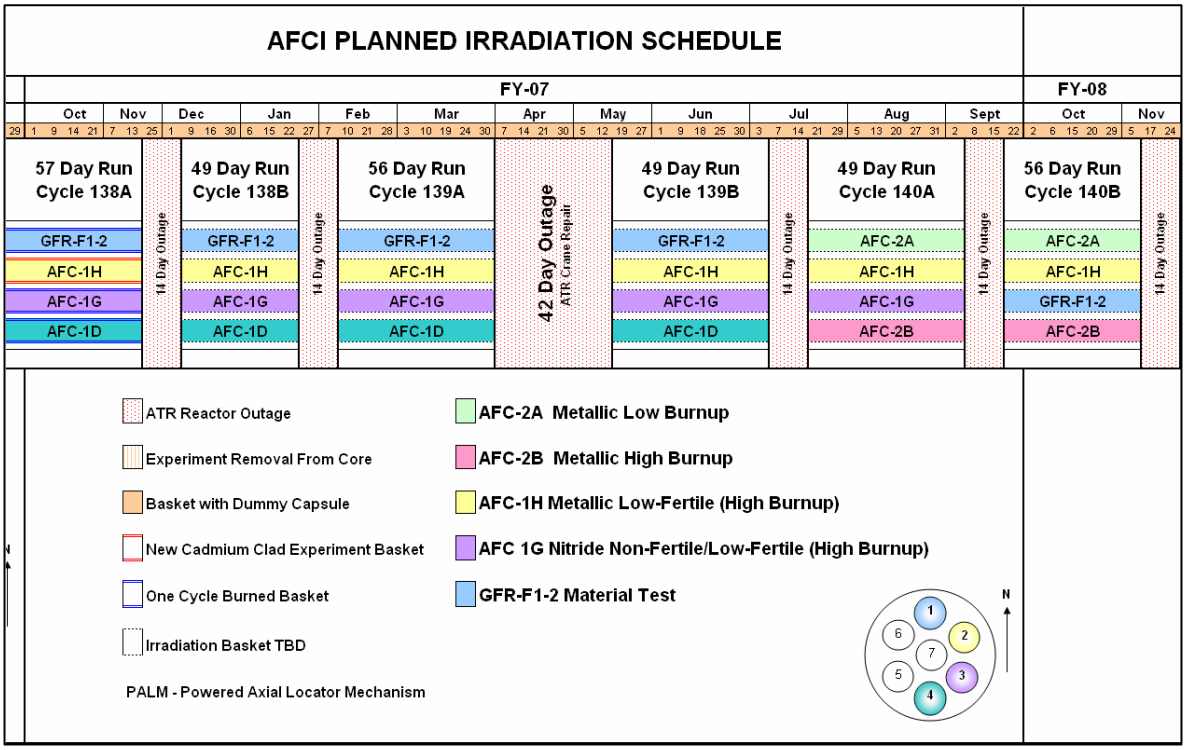
Table 19. Heat Rate and Burnup of the AFC-1D, AFC-1G, and AFC-1H Experiments at the EOC 137A.

Test Position and ID		Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)	^{235}U Depletion (atom%)	Fissions/cc
E-2 AFC-1H	Rodlet 1	187.76	139.46	9.82%	6.49%	23.16%	9.35%	1.04E+21
	Rodlet 2	227.85	148.70	11.04%	5.58%	27.88%	12.54%	1.23E+21
	Rodlet 3	238.24	195.70	15.34%	10.58%	34.33%	13.64%	1.34E+21
	Rodlet 4	255.58	188.65	13.73%	9.07%	30.95%	13.27%	1.48E+21
	Rodlet 5	265.63	199.35	13.63%	9.33%	28.25%	12.04%	1.48E+21
	Rodlet 6	190.08	155.38	12.48%	8.37%	27.33%	10.71%	1.06E+21
E-3 AFC-1G	Rodlet 1	129.27	113.51	9.22%	4.81%	--	--	7.22E+20
	Dummy	--	--	--	--	--	--	--
	Rodlet 3	234.70	162.02	10.53%	5.92%	38.50%	13.05%	1.31E+21
	Rodlet 4	178.41	159.06	13.33%	7.21%	--	--	1.07E+21
	Dummy	--	--	--	--	--	--	--
	Dummy	--	--	--	--	--	--	--
E-4 AFC-1D	Rodlet 1	139.16	120.93	17.69%	9.59%	34.14%	--	1.34E+21
	Rodlet 2	162.69	142.65	22.32%	10.69%	42.85%	--	1.53E+21
	Rodlet 3	235.70	213.35	24.45%	15.48%	25.20%	--	2.36E+21
	Rodlet 4	189.31	170.98	24.66%	13.95%	47.52%	--	1.93E+21
	Rodlet 5	146.45	155.74	28.27%	17.94%	--	--	1.52E+21
	Dummy	--	--	--	--	--	--	--

11. FUTURE AFC-1 IRRADIATIONS

The high burnup AFC-1D and AFC-1H test assemblies are expected to complete irradiation in the fourth quarter of FY-07 and the high burnup AFC-1H test in the third quarter of FY-08, if the burnup is increased from 25 at.% to 40 at.%. Plans are also underway to fabricate and insert two new AFCI experiments identified as AFC-2A and AFC-2B. The proposed 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 ≥ 10 at.% and ≥25 at.% burnup, respectively. Table 20 shows the tentative irradiation schedule through FY 2007.

Table 20. AFCI FY-07 Planned Irradiation Schedule



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