INL/EXT-07-12388

Project Description

Advanced Fuel Cycle Initiative

AFC-2A and AFC-2B Experiments

Steven L. Hayes
Debra J. Utterbeck

March 2007

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

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Idaho National Laboratory
Idaho Falls, Idaho 83415

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Advanced Fuel Cycle Initiative AFC-2A and AFC-2B Experiments

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March 2007

Approved by

W. Jon Carmack — Date: 14 March 2007

Steven L. Hayes — Date: 19 Mar. 2007

Debra J. Utterbeck — Date: 13 March 2007

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1. Introduction

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 proposed AFC-2A and AFC-2B irradiation experiments are a continuation of the AFC-1 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, to be irradiated to burnup levels of ≥ 10 and ≥25 at.-% burnup. The AFC-2A & 2B experiments will be irradiated in two of the seven ATR East Flux Trap (EFT) guide tubes using the same hardware design as for the AFC-1B, D, F & H tests.

The AFC-2A & 2B irradiation experiments are expected to provide important irradiation performance data on metallic transmutation fuel forms, including irradiation growth and swelling, helium production, helium and fission gas release fractions, fission product and fuel constituent migration, fuel phase equilibria, and fuel-cladding chemical interaction. Of particular interest in these tests will be assessment of the effect that small additions of rare earth elements, expected to be carried over as a result of pyro-metallurgical reprocessing, might have on irradiation performance parameters.

Experiments AFC-2A & 2B will have design and test conditions analogous to the AFC-1F & H metallic fuel tests. The fuel test matrix in AFC-2A & 2B will be identical; only the target discharge burnups will differ for the two tests. An overview of these two experiments is shown in Table 1. The simultaneous insertion of these two irradiation test assemblies is proposed for August 2007 (ATR Cycle 140A).

Table 1. Overview of the AFC-2A & AFC-2B Experiments.

ATR Experiment Designation	Fuel Form	ATR Insertion	Target Discharge Burnup*
AFC-2A	Metallic	July 2007	≥ 10%
AFC-2B	Metallic	July 2007	≥ 25%

*Burnup in percent of initial (Pu-239 + U-235).

2. Scope of Work

The Idaho National Laboratory, through the Department of Energy, Idaho Operations Office has been assigned the responsibility of irradiating transmutation fuel forms in the Advanced Test Reactor (ATR) to evaluate certain transmutation effects for specific metallic fuel forms. Irradiation of these fuel forms will be done in the EFT of the ATR at the INL.

In order to accomplish this, INL will be responsible for:

- Fabricating cadmium shrouded flux trap baskets to house the AFC capsules in the flux trap housing during irradiation,
- performing neutronic analysis of the aggregate capsules,
- performing thermal hydraulic analysis of the experiment assembly,
- performing structural analysis of the ASME pressure vessel and AFC components,
- fabricating sodium-bonded TRU metallic fuel rodlets containing lanthanides,
- fabricating an ASME Section III, Class I pressure vessel capsule,
- encapsulating fuel rodlets into secondary ASME pressure vessel capsule,
- preparing the Experiment Safety Assurance Package (ESAP) and obtaining approval of the package, allowing reactor insertion of the experiment,
- shipping the experiment capsules from MFC to RTC,
- receiving the capsules and placement into cadmium shrouded baskets,
- inserting the assemblies in the ATR and irradiation of the capsules to the specified burnup,
- experiment handling and basket changeouts during reactor outages,
- storing as necessary in the ATR canal for cool down,
- shipping the irradiated capsules to HFEF located at MFC, and
- performing Post Irradiation Examination (PIE).

INL will provide project management and project engineering of all activities from the beginning of fuel fabrication through PIE. All activities will be documented and provided in reports as required by milestones identified in the approved workpackages.

The experiment fabrication and irradiation will be a coordinated effort between INL personnel located at the Science and Technology Complex (STC), Materials and Fuels Complex (MFC), and the Reactor Technology Complex (RTC). Fabrication of the fuel, rodlets, capsules and cadmium baskets will be performed at MFC.

INL will fabricate two capsules, each containing six sodium-bonded TRU metallic fuel rodlets containing lanthanides suitable for ATR irradiation. The capsules will be fabricated in the form of a drop-in containment vessel and will be fabricated and assembled in accordance with reference design specifications under ASME Section III, Class 1.

INL will fabricate the cadmium shrouded baskets to house the AFC-2 capsules in the East flux trap during irradiation. These baskets will be designed such that adequate fluence to meet test conditions is ensured, that there is adequate coolant circulation to prevent temperature distortions or mechanical effects, and that there is adequate mechanical support to secure the test capsule throughout the processes of reactor insertion, irradiation, and removal from the reactor. These baskets will be fabricated to mate precisely with all exterior dimensions of the test capsules and with all interior dimensions of the ATR east flux trap housing as currently configured.

INL will perform all neutronic, structural, and thermal analyses; and will prepare the Experiment Safety Assurance Package required for ATR experiment insertion. This package will be reviewed by Experiment Engineering, Nuclear Safety, and will be approved by the Safety Operations Review Board (SORC).

All arrangements will be made to package, load and transport the capsules from MFC in a 6M drum for delivery to the ATR for irradiation. Upon receipt, the capsules will be placed in cadmium shrouded baskets and placed in their perspective position in the EFT housing in preparation for irradiation.

The capsules will be removed from the ATR core during regularly scheduled ATR outages as needed to replace the cadmium baskets. Upon achieving the specified burnup, the capsules will be removed from the ATR and stored in the ATR canal for a minimum of 30 days for cool down.

The capsule assembly and aluminum sheathed cadmium segment of the basket assembly will be shipped to the Hot Fuels Examination Facility (HFEF) at MFC for post irradiation examinations (PIE). Shipment from the RTC to HFEF will be made using the GE Model 2000 shipping cask.

PIE activities will be performed at HFEF and will include hardness testing on fuel and cladding material; investigate techniques for measurement of curium in irradiated fuel; investigation of techniques for separations necessary to perform accurate analysis of curium isotopes in irradiated fuel specimens; TEM examination of irradiated metal alloy specimens; and performing transmission electron microscopy on metal alloy specimens. PIE will be performed in late FY-08 / early FY-09. The specific activities and schedule for PIE will be finalized at a later date.

3. Test Description

3.1 Fuel Rodlet

The rodlet assembly is designed as a miniature length, fast reactor fuel rod. The rodlet assembly consists of the metallic fuel column, bond sodium, stainless steel Type 421 (HT-9) cladding and an inert gas plenum. A stainless steel capsule assembly will contain a vertical stack of six rodlet assemblies. The capsule and rodlet radial dimensions of the metallic fuel specimens are shown in Figure 1. The annular gap between the fuel column and rodlet inner diameter is initially filled by the sodium bond and is designed to accommodate fuel swelling during irradiation. The annular helium-filled gap between the rodlet outer diameter and capsule inner diameter is designed to provide the thermal resistance necessary to achieve the design irradiation temperature of the fuel specimen.

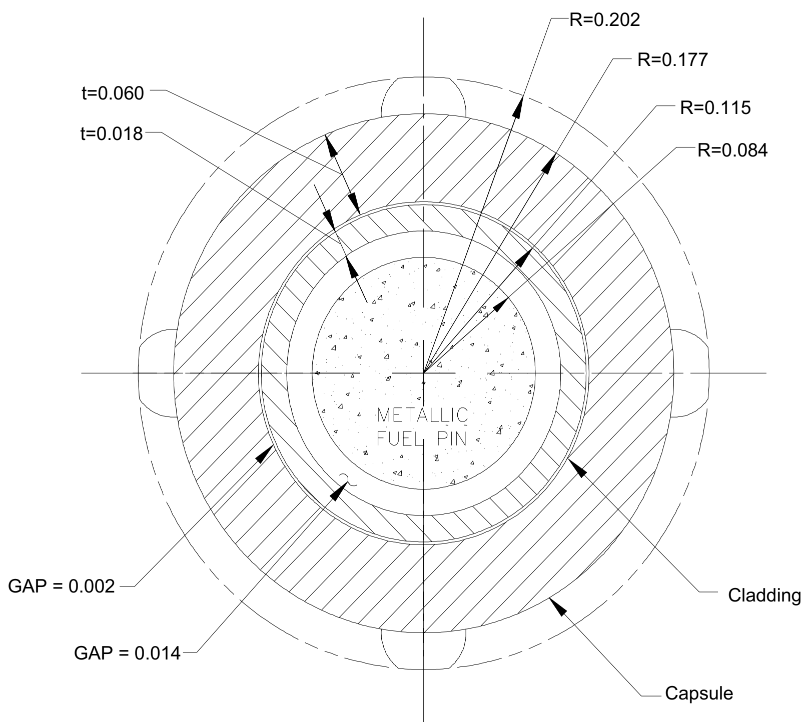


Figure 1. Radial dimensions of capsule and fuel rodlet assemblies for the AFC-2A & B metallic fuel tests.

Figure 2 shows the fuel rodlet assembly axial dimensions. Table 2 shows the materials used in constructing the rodlets along with their radial design dimensions. The design length of the metallic fuel column is 1.5-in.; the metallic fuel column may consist of a maximum of two pins, and the design diameter is 0.168-in. The bond sodium is designed to cover and exceed the fuel column height by between 0.25 and 0.50-in. The cladding for all rodlets is 6.0-in. in length (including welded endplugs) with 0.230-in. outer diameter and 0.194-in. inner diameter.

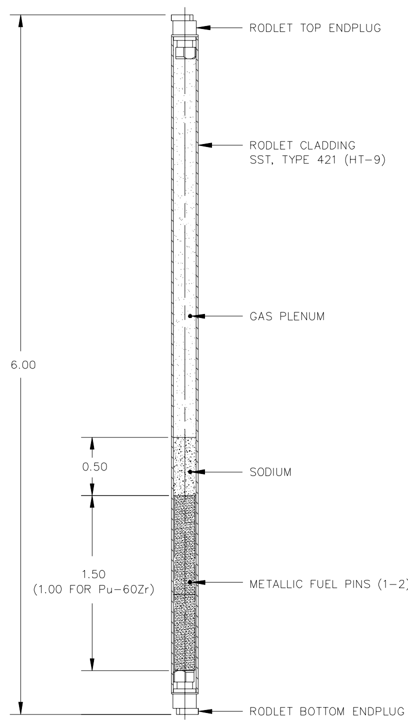


Figure 2. Rodlet assembly axial dimensions for the AFC-2A & B metallic fuel tests.

Table 2. Fuel Rodlet Design Data.

Design Parameter	**AFC-2A & B**
Cladding Material	421SS (HT9)
Cladding O.D.	0.230-in.
Cladding I.D.	0.194-in.
Bond Material	Sodium
Fuel Type	Metallic Alloy
Fuel Smear Density	75%
Fuel Porosity	0%
Fuel O.D.	0.168-in.
Fuel Height	1.50-in.

3.2 Test Matrix

The fuel compositions and positions of the metallic fuel rodlets in AFC-2A & 2B are shown in Table 3; note that the metallic alloy compositions are expressed as a weight percent for each constituent element.

Table 3. AFC-2A & AFC-2B Fuel Test Matrix.

Rodlet	**Metallic Fuel Alloy†**	**U-235 Enrichment**
1	U-20Pu-3Am-2Np-15Zr	93%
2	U-20Pu-3Am-2Np-1.0RE*-15Zr	55%
3	U-20Pu-3Am-2Np-1.5RE*-15Zr	45%
4	U-30Pu-5Am-3Np-1.5RE*-20Zr	55%
5	U-30Pu-5Am-3Np-1.0RE*-20Zr	65%
6	U-30Pu-5Am-3Np-20Zr	93%

†Alloy composition expressed in weight percent.
*RE designates rare earth alloy (6% La, 16% Pr, 25% Ce, 53% Nd).

The fuel compositions in these experiments were selected to build upon the irradiation performance data that have been obtained from the AFC-1B, D, F and H metallic fuel tests in the ATR. Compared to the fuel compositions in the previous tests, the AFC-2A, B uranium contents have been increased and the zirconium contents have been decreased, as the AFCI/GNEP program objectives have evolved to a position where a somewhat higher conversion ratio is deemed as acceptable in future sodium-cooled fast reactors used for actinide transmutation; the lower Zr content results in a denser fuel, though still considerably less dense than the U-20Pu-10Zr fuels irradiated routinely in EBR-II. The transuranic contents in the AFC-2A, 2B fuels is bounded by the previous ATR tests. The new parameter introduced in the AFC-2A, 2B fuel test matrix is a minor addition of rare earth elements (La, Pr, Nd, Ce) in some of the fuels; this is done to simulate rare earth carryover that may result from pyro-metallurgical reprocessing of metallic fuels.

Uranium enrichment will be varied to achieve target linear heat generation rates for the different fuel compositions. The calculated fuel constituent masses for each rodlet, as well as sum for each irradiation test assembly, are given in Table 4; note that in Table 4 the uranium content has been calculated assuming 'depleted uranium', but this will change when the final enrichment is determined for each rodlet.

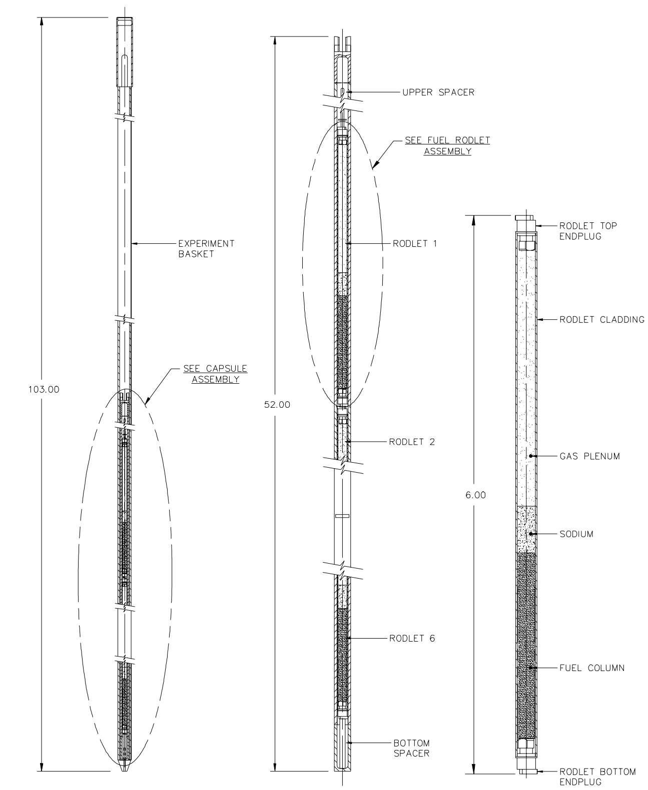
Table 4. AFC-2A and AFC-2B Rodlet Constituent Masses.

	Fuel Density (g/cm3)	Fuel Column Constituent Masses (g)													
		Np-237	Total U	U-235	U-238	Total Pu	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242	Am-241	RE	Zr	Bond Na
Rodlet 1	13.98	0.152	4.570	4.251	0.320	1.523	0.001	1.257	0.251	0.009	0.005	0.229	0.000	1.143	0.426
Rodlet 2	13.98	0.152	4.510	2.480	2.029	1.523	0.001	1.257	0.251	0.009	0.005	0.229	0.076	1.143	0.426
Rodlet 3	13.98	0.152	4.456	2.005	2.451	1.523	0.001	1.257	0.251	0.009	0.005	0.229	0.114	1.143	0.426
Rodlet 4	12.87	0.210	2.840	1.562	1.278	2.104	0.001	1.736	0.347	0.012	0.007	0.351	0.105	1.403	0.426
Rodlet 5	12.87	0.210	2.889	1.878	1.011	2.104	0.001	1.736	0.347	0.012	0.007	0.351	0.070	1.403	0.426
Rodlet 6	12.87	0.210	2.945	2.739	0.206	2.104	0.001	1.736	0.347	0.012	0.007	0.351	0.000	1.403	0.426
Total		**1.088**	**22.211**	**14.915**	**7.296**	**10.882**	**0.005**	**8.982**	**1.795**	**0.062**	**0.037**	**1.737**	**0.366**	**7.635**	**2.558**

Note: RE designates rare earth alloy (6% La, 16% Pr, 25% Ce, 53% Nd).

3.3 Irradiation Test Assembly Description

The irradiation test assembly, capsule assembly and rodlet assembly are shown in Figure 3. The irradiation test assembly consists of the experiment basket and capsule assembly, which contains six vertically-stacked rodlet assemblies. The experiment basket of the test assembly is designed to interface the capsule assembly with the ATR and to act as a thermal neutron flux filter. The current basket design is an aluminum-sheathed cadmium tube. The aluminum sheath accommodates a cadmium tube thickness between 0.021 and 0.045-in. For the AFC-2A & 2B experiments, it is proposed that the cadmium thickness be the same as in the AFC-1B, D, F & H experiments design, which is 0.045-in. The decrease in the thermal neutron flux will result in a reduction in the linear power in the fuel rodlets, which is necessary to meet the experiment design conditions.



IRRADIATION TEST ASSEMBLY CAPSULE ASSEMBLY FUEL RODLET ASSEMBLY

Figure 3. AFC-2 Series Irradiation Test Assembly for ATR East Flux Trap Positions.

The capsule assembly functions are the following: 1) provide a second, robust barrier between the water coolant and the fuel, sodium and fission products, and 2) provide additional free volume for expansion of helium and fission gases should the cladding of any number of rodlets be breached during irradiation (this free volume is sufficient to reduce the gas pressure on the capsule to below the design pressure limit of 500 psi assuming all six rodlets are breached). The relevant design data for the capsule assembly are summarized in Table 5. The capsule assembly will be fabricated to meet the intent of the ASME, Section III, Class 1 pressure vessel code requirements. The capsule assembly design will be identical in both experiments.

3.4 Irradiation Experiment Conditions

The experiments AFC-2A and 2B are designed for irradiation in the east flux trap. The two tests will be inserted in the ATR east flux trap drop-in positions that, together with the cadmium neutron filter baskets, will achieve the design linear powers.

The design objective is for each rodlet in these experiments to have a peak linear heat generation rate (LHGR) of 35.0 kW/m. The LHGR for each rodlet will be calculated using the MCNP Coupling With ORIGEN2 (MCWO) analysis methodology. The final uranium enrichment value for each rodlet will be determined based on these results.

The peak cladding temperature should not exceed 550°C during normal operation and 650˚C during off-normal conditions. The expected peak thermal conditions during irradiation for these experiments will be estimated based on the linear powers calculated by MCWO. In addition, the plenum pressures expected in each rodlet at a maximum burnup of 30 at.-% (i.e., depletion of initial Pu-239 + U-235) will be conservatively estimated to confirm that the total pressure on the capsule assembly (the safety class boundary) will not exceed 500 psi (established as the pressure limit from mechanical analysis) during irradiation.

The AFC-2A experiment should be discharged from the reactor upon reaching a target peak burnup of ≥ 10 at. %, and the AFC-2B experiment should be discharged from the reactor upon reaching a target peak burnup of ≥ 25 at. %

Table 5 - AFC-2 A & AFC-2B Fuel Test Matrix

Rodlet	**Metallic Fuel Alloy†**	**U-235 Enrichment**
1	U-20Pu-3Am-2Np-15Zr	93%
2	U-20Pu-3Am-2Np-1.0RE*-15Zr	55%
3	U-20Pu-3Am-2Np-1.5RE*-15Zr	45%
4	U-30Pu-5Am-3Np-1.5RE*-20Zr	55%
5	U-30Pu-5Am-3Np-1.0RE*-20Zr	65%
6	U-30Pu-5Am-3Np-20Zr	93%

4. Organization

This project is organized in accordance with the tasks that must be performed and the need for coordination among responsible performing departments.

4.1 Interfaces

There are two primary inter-organizational interfaces on this project; the INL Fuels & Materials Performance department and the Irradiation Test Programs department. BEA (M&O for the INL) is performing work that is funded by DOE. Thus, DOE functions in its role of regulatory oversight and INL is beholden to compliance with all applicable orders and guidelines.

INL will fabricate the experiments at the MFC and deliver the test assemblies to RTC for irradiation in the ATR. Steven Hayes is responsible for experiment design and post irradiation examinations. Debbie Utterbeck is responsible for irradiation planning and transportation. Tim Hyde is responsible for fuel and experiment fabrication. Steven Hayes has overall responsibility for these irradiation experiments.

4.2 Work Breakdown

The primary tasks necessary to complete this project can be roughly grouped into project management, analysis, test assembly fabrication, basket fabrication, shipping, irradiation and PIE. These tasks are managed by integrating them with quality assurance, quality control, safety, configuration management, and regulatory compliance. The Work Breakdown Structure (WBS) for this project is as follows:

1. **PROJECT MANAGEMENT**
    - 1.1. PEP AND SUPPORT DOCUMENTATION
    - 1.2. WORK PACKAGES AND APPROVALS
    - 1.3. PROJECT COORDINATION
        - 1.3.1.TECHNICAL ACTIVITY ASSIGNMENT
        - 1.3.2.STAFFING
        - 1.3.3.COST
        - 1.3.4.SCHEDULING
        - 1.3.5.RESOURCE ACQUISITION AND ALLOCATION
    - 1.4. PROCUREMENT
    - 1.5. CONFIGURATION MANAGEMENT
    - 1.6. SAFETY
    - 1.7. COMPLIANCE AND QUALITY
    - 1.8. REPORTING AND FINAL DOCUMENTATION
2. **ANALYSIS**
    - 2.1. NEUTRONIC AND PHYSICS ANALYSIS
    - 2.2. STRUCTURAL ANALYSIS
    - 2.3. THERMAL HYDRAULIC ANALYSIS
    - 2.4. EXPERIMENT SAFETY ASSURANCE PACKAGE

3. **TEST ASSEMBLY FABRICATION**
   - 3.1. FUEL FABRICATION
   - 3.2. RODLET FABRICATION AND FUEL ENCAPSULATION
   - 3.3. CAPSULE FABRICATION AND RODLET ENCAPSULATION
4. **BASKET FABRICATION**
5. **SHIPPING/IRRADIATION**
   - 5.1. PACKAGING AND SHIPMENT OF CAPSULE FROM MFC
   - 5.2. CAPSULE RECEIPT AT RTC
   - 5.3. CAPSULE BASKET INSERTION
6. **ATR IRRADIATION**
   - 6.1. REACTOR INSERTION
   - 6.2. CYCLE IRRADIATION
   - 6.3. REACTOR REMOVALS
   - 6.4. CANAL HANDLING AND STORAGE
   - 6.5. SHIPMENT TO MFC
7. **POST IRRADIATION EXAMINATION**

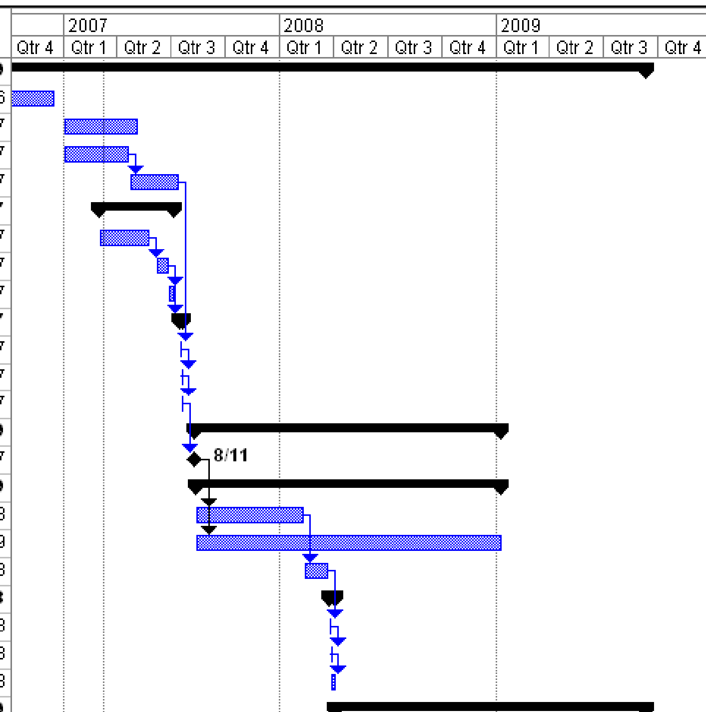
5. Schedule

5.1 AFC-2A and AFC-2B Task Schedule

The schedule shown in Figure 4 is proposed to meet identified milestones leading up to the insertion of the AFC-2A and 2B experiments into the ATR for irradiation beginning with ATR Cycle 140A. Figure 4 also identifies tentatively scheduled tasks after irradiation.

Figure 4. AFC-2A and AFC-2B GANTT Chart

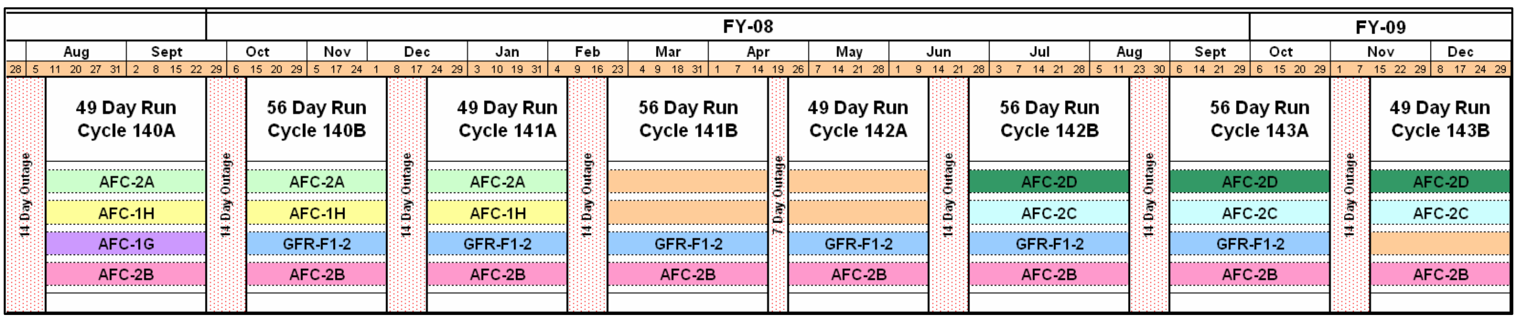
ID	Task Name	Start	Finish
1	**AFC-2A and AFC-2B**	**Mon 10/2/06**	**Thu 9/10/09**
2	Experiment Description for AFC-2A and AFC-	Mon 10/2/06	Fri 12/15/06
3	**Fabrication of Cadmium Baskets**	Mon 1/1/07	Fri 5/4/07
4	**Neutronic, Thermal, Structural Analsyis**	Mon 1/1/07	Fri 4/20/07
5	**Experiment Safety Assurance Package**	Mon 4/23/07	Fri 7/13/07
6	**Expeirment Assembly Fabrication**	**Thu 3/1/07**	**Thu 7/5/07**
7	Fuel Fabrication	Thu 3/1/07	Wed 5/23/07
8	Rodlet Encapsulation	Thu 6/7/07	Tue 6/26/07
9	Fabrication As-Built Data Package	Wed 6/27/07	Thu 7/5/07
10	**Shipping**	**Mon 7/16/07**	**Fri 7/20/07**
11	MFC Packaging and Shipment	Mon 7/16/07	Tue 7/17/07
12	RTC Receipt	Wed 7/18/07	Wed 7/18/07
13	Basket and EFT Loading	Thu 7/19/07	Fri 7/20/07
14	**Irradiation**	**Sat 8/11/07**	**Fri 1/9/09**
15	**Cycle 140A Startup**	Sat 8/11/07	Sat 8/11/07
16	**Experiment Irradiation**	**Mon 8/13/07**	**Fri 1/9/09**
17	AFC-2A	Mon 8/13/07	Fri 2/8/08
18	AFC-2B	Mon 8/13/07	Fri 1/9/09
19	ATR Canal Storage for Cooldown	Mon 2/11/08	Fri 3/21/08
20	**GE-2000 Cask Shipment to HFEF**	**Mon 3/24/08**	**Thu 4/3/08**
21	Load Capsules and Ship to HFEF	Mon 3/24/08	Wed 3/26/08
22	Receive GE-2000 at MFC	Thu 3/27/08	Thu 3/27/08
23	Unload GE-2000	Fri 3/28/08	Thu 4/3/08
24	**Perform PIE - SCHEDULE TBD**	**Fri 4/4/08**	**Thu 9/10/09**



5.2 ATR Irradiation Schedule

As reported above, the target burnup for the AFC-2A capsule is > 10 at.% and for the AFC-2B capsule is > 25 at.%. Based on previous AFC irradiated capsules, to reach programmatic target burnups, it is anticipated that the AFC-2A capsule will be irradiated in the ATR EFT for a total of three cycles and the AFC-2B for a total of eight cycles. The irradiation schedule [Figure 5] shows the AFC capsule irradiation schedule based on the current approved ATR Irradiation Plan dated November 30, 2006. All decisions for cycle irradiation will be validated by as-run analysis. Data comparisons of measured and calculated values will be performed to validate the basis for the irradiation.

Figure 5. Tentative ATR Irradiation Schedule for the AFC Capsules



6. Safety

Safety analysis and safety reviews will be performed in accordance with accepted INL and Reactor Program requirements. MFC and RTC Environmental Safety and Health will provide reviews for fabrication, work permits, shipments, and reactor insertion activities to assure adequate safety provisions are taken.

An Experiment Safety Assurance Package (ESAP) will be prepared to assure compliance with all applicable reactor standing directives, procedures, and requirements. The Safety Operation Review Committee (SORC) will review and approve the ESAP prior to shipment of the experiment or reactor insertion.

7. Quality Assurance, Fabrication and Assembly

Inspection will be provided by MFC and RTC Quality Divisions and in accordance with INL Quality Manual. Review will include inspections, material certification, drawings review and readiness review.

Quality assurance associated with AFC capsule design and fabrication shall meet the requirements specified in the SAR-153, Sections 10.1.7.3.5 Evaluation of Materials, and 10.1.8.1, Quality Review. Codes and standards of the latest published issue [noted below] shall apply to the intent specified for the AFC capsule design fabrication, welding inspection and examination unless otherwise exempted by drawings or other referenced documents.

8. Source Documents

- DOE N 441.1, Radiological Protection for DOE Activities
- DOE-5480.4, Environmental Protection, Safety, and Health Protection Standards
- 10 CFR Subpart A Requirements, Quality Assurance
- 29 CFR 1910, Occupational Health Safety Standards (OSHA)
- LWP-15021, “Radiation Protection Procedures
- MCP–2811, “Design Control”
- MCP–9217, “Design Verification”
- MCP–540, “Documenting the Safety Category of Structures, Systems and Components”
- MCP–2377, “Development, Assessment, and Maintenance of Drawings”
- MCP–2374, “Analyses and Calculations”
- MCP–9185, “Technical and Functional Requirements”
- LRD-15001, “Radiation Protection – INEL Radiological Control Manual”
- LRD-14001, “Occupational Safety Program”
- PRD-1002, “Safeguards and Security Requirements”
- PRD-5074, “Design Control”
- RCRA 40 CFR 261.2 & 261.34
- SAR-153, “Upgraded Final Safety Analysis Report for the Advanced Test Reactor”
- SP-10.2.2.8, “Facility Change Form Preparation and Use”
- SD-7006, “Marking Methods for Equipment, Components, and Materials”
- SD-7020, “Preservation and Protection Requirements for Nuclear and Reactor Components”
- SD-7022, “Cleanliness Acceptance Levels for Nuclear or Non-nuclear Service Components”
- TSR-186, “Technical Safety Requirements for the Advanced Test Reactor”

9. Acronyms

AFCI	Advanced Fuel Cycle Initiative
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance
CFR	Code of Federal Regulations
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
EFPDs	Effective Full Power Days
EFT	East Flux Trap
ESAP	Experiment Safety Assurance Package
GNEP	Global Nuclear Energy Partnership
HFEF	Hot Fuel Examination Facility
INL	Idaho National Engineering and Environmental Laboratory
LST	List (Document Type)
M&O	Management and Operations
MCP	Management Control Procedure (document type)
MFC	Materials and Fuels Complex
PIE	Post Irradiation Examination
RCRA	Resource Conservation and Recovery Act
RTC	Reactor Test Complex
SORC	Safety Operations Review Board
TSR	Technical Safety Requirement (document type)
WBS	Work Breakdown Structure