

AN OVERVIEW OF CURRENT PROJECTS / REACTOR UTILIZATION FOR THE ADVANCED TEST REACTOR

Robert C. Howard and Debbie J. Utterbeck
ATR Experiment Engineering and Irradiation Test Programs
Idaho National Laboratory
P.O. Box 1625
Idaho Falls, ID 83415-7101
robert.howard@inl.gov

In addition to performing testing for the U.S. Navy, the Advanced Test Reactor (ATR), located at the Idaho National Laboratory, is currently embracing the most customers, with the most diverse requirements ever experienced in the operating history of ATR.

Three experiments that give a fair representation of the variety and complexity of tests currently utilizing ATR are the Advanced Graphite Capsule (AGC), the Advanced Fuel Cycle Initiative / Light Water Reactor (AFCI/LWR) project, and the production of cobalt-60 for the medical industry.

The primary objective of the irradiation of the AGC is to provide irradiation creep design data, as well as data for the effects of irradiation creep on key physical properties for several candidate graphites for the Next Generation Nuclear Plant (NGNP) program. The primary driver for this test is that strains of graphite previously produced for high temperature applications, such as for the Fort St. Vrain gas reactor are no longer in production. In addition, the new varieties of graphite that are produced under various fabrication methods, have no corresponding high flux-high temperature data. The key data to be obtained from this experiment include:

- Irradiation creep design data and data on the effects of irradiation creep on key physical properties [strength, elastic modulus, coefficient of thermal expansion (CTE)]
- The effects of neutron irradiation on the properties of a wide range of next generation nuclear plant (NGNP) relevant graphites, including dimensional changes, strength, elastic modulus, thermal conductivity, and CTE
- Data on the single crystal irradiation behavior of graphites to be derived from highly oriented pyrolytic graphite (HOPG)

These data are critical to the design of the NGNP and support ongoing work in the area of model development; e.g., irradiation effects model such as dimensional change and creep strain, structural modeling, and fracture modeling. Moreover, the data will be used to underpin the American Society of Mechanical Engineers (ASME) design code currently being prepared for graphite core components.

Due to the customer's requirements, this will be one of the most complex tests ever built and installed in ATR.

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 radiotoxicity and heat load of high-level waste sent to a geologic repository (DOE, 2003). One important component of the technology development is actinide-bearing transmutation fuel forms containing plutonium, neptunium, americium (and possibly curium) isotopes. There are little irradiation performance data available on non-fertile fuel forms, which would maximize the destruction rate of plutonium, and low-fertile (i.e., uranium-bearing) fuel forms, which would support a sustainable nuclear energy option. Initial scoping level irradiation tests on a variety of candidate fuel forms are needed to establish a transmutation fuel form design and evaluate deployment of transmutation fuels.

The AFCI program currently plans two parallel deployments of transmutation fuels. Series One deployment consists of mixed-oxide fuel forms with minor actinide elements to be irradiated in commercial light water reactors. Series Two implementation entails non-fertile and low-fertile metallic or nitride fuel forms with minor actinide elements irradiated in fast neutron spectrum reactors or accelerator driven systems. The AFC-1Æ and AFC-1F Irradiation Experiments are part of the Series Two fuel development effort. The AFC-1F Experiment consists of low-fertile metallic fuel compositions and is a follow on test to the AFC-1B and AFC-1D Irradiation Experiments which consist of metallic non-fertile fuel compositions. Experiment AFC-1Æ is a consolidation of the AFC-1A and AFC-1E experiments. The AFC-1Æ and AFC-1F experiments will be performed in the Advanced Test Reactor (ATR) at the Idaho National Engineering and Environmental Laboratory (INEEL) similar to the other tests. The programmatic and technical rationale for performing these scoping tests in a thermal reactor have been presented (Hayes, 2003). In summary, there are many fuel performance issues that depend primarily on temperature and power, which parameters can be varied by the experiment design, and the transmutation fuel performance data can be acquired at an accelerated schedule and for significantly lower costs.

The Series Two 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. Experiments AFC-1B and AFC-1D will provide irradiation performance data on non-fertile, actinide-bearing metallic fuel forms and Experiments AFC-1F will provide these data on low-fertile, actinide-bearing metallic fuel forms. Experiment AFC-1Æ will provide corresponding data on both non-fertile and low-fertile, actinide-bearing nitride fuel forms.

The results from these tests will be used in planning an irradiation experiment in a fast spectrum reactor, which is called FUTURIX (formerly designated AFC-3). FUTURIX is

a collaborative irradiation test with the Commissariat à l'Énergie Atomique of France (CEA) that is planned in the PHENIX reactor at Marcoule, France starting in April 2006. The irradiation performance data of AFC-1(B, D) and AFC-1(Æ, F) will provide assurance that the test fuels behave in accordance with design predictions and in conformance to the approved safety envelope and are part of the required safety data for the FUTURIX irradiation test. This test campaign is currently ongoing in ATR and is approximately 50% complete.

The least complex variety of experiment, but no less important is the “drop-in” represented by the production of cobalt-60. This style of “drop-in” is relatively effortless and requires no cycle-by-cycle analysis to satisfy safety or technical specifications. The design of the drop in capsules has been in use by ATR for approximately fifteen years and has proven very effective. The target utilizes cobalt in the form of a 1-mm diameter x 1-mm thick disc and is configured in the target such that self shielding is not an issue. ATR currently produces approximately 200k curies of cobalt-60 per year and is anticipating doubling this in the next few years. The entire lot of this isotope is produced for the medical isotope community, and is shipped in the GE 2000 cask.

These three projects offer a general overview of the current utilization of ATR while demonstrating ATR's ability to accommodate a wide array of requirements.