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The Advanced Test Reactor's Role in Nuclear Power for the 21st Century

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ABSTRACT

The Test Reactor Area located at the US Department of Energy's Idaho National Engineering and Environmental Laboratory (INEEL) was a cornerstone in the development of nuclear technologies during the last half of the 20th century. The INEEL's Advanced Test Reactor (ATR) has base programs planned for the first half of the 21st century. As the role of nuclear technologies unfolds in the coming decades, past and future testing at the ATR will continue to contribute to technical, operational, and public issues facing the industry. Optimal use of the past and future experience base will provide opportunities for continual improvement in reactor operation and performance.

IDAHO'S HISTORY IN NUCLEAR ENERGY

Since 1951, when electricity was first generated using nuclear power, the Idaho National Engineering and Environmental Laboratory (formerly the National Reactor Testing Station) has played a leadership role in nuclear technologies. Over fifty reactors of different types and often first of a kind have been built at the INEEL. Nearly all of these have completed their mission and are now shutdown or dismantled. The experience gained in Idaho is a substantial part of today's knowledge base for reactor control and coolant systems, materials expertise, fuel performance, waste treatment, and operator training programs.

The Test Reactor Area is the site of three major test reactors. The original Materials Test Reactor operated from 1952 to 1970. The Engineering Test Reactor operated from 1957 to 1981. The Advanced Test Reactor began operations in 1967 and will be operated for many more decades. The experience base at INEEL and the ATR can be a significant asset to the nuclear industry as the new millenium begins. The ATR may well see a longer future than any other reactor currently in operation.

The primary role of ATR programs has been and will continue to be irradiation testing of advanced fuels and structural materials. In the last several years, about thirty percent of the reactor test space has become available for commercial and international programs and many new programs have recently been initiated for a variety of sponsors. Traditional testing methods at ATR have been and will continually be improved as instrumentation and measurement methods evolve. Beyond the traditional testing role, however, ATR offers a unique opportunity to share a large experience base with others in the nuclear industry. ATR has planned outages seven to eight times each year, and much has been learned about planning outage work, performing routine maintenance, and resolving unforeseen difficulties. Each operating cycle includes both refueling and experiment changes. The entire core structure has been replaced many times and will be replaced many more times in the next century. Many plant systems have been upgraded or replaced including the control systems, training simulator, liquid waste facility, emergency coolant pumps, secondary coolant system piping, and the cooling tower. Authorization basis documents have recently been upgraded to new standards. Writing these and implementing them gave the ATR staff a comprehensive understanding of issues nuclear plants face as authorization basis requirements change. ATR has continued to maintain good public relations in a political atmosphere that sometimes is not supportive of nuclear operations.

SYSTEM UPGRADES TO THE ADVANCED TEST REACTOR

There have been many capital improvements made to the ATR and its support systems. The reactor and process control rooms were remodeled in 1989 and 1993, respectively. The experiment loop operating control system was replaced with a state of the art digital system in 1994. This upgrade has virtually eliminated reactor scrams from spurious instrument signals. Spurious scams occurred a few times each year before the control change, but has only occurred once in the last five years.

Reactor internals were replaced for the fourth time in the fall of 1994, and the new components are approaching their halfway point. A new set of beryllium reflector blocks, a new aluminum neck shim housing, and new control cylinders are available for the next internals replacement in the next decade.

In 1997 and 1998 a new test rig for temperature controlled experiments was designed and built. Known as the Irradiation Test Vehicle (ITV), the test rig will accommodate fifteen separate experiments with individual temperature control to a maximum design temperature of 600° C. The ITV was originally funded to support testing of materials for fusion research, but it is equally well suited for a wide variety of other materials. The ITV will be installed in ATR's center flux trap in the spring of 1999. Having the ITV available in this location provides experimenters a most economical method to utilize ATR's highest flux fields in a temperature controlled environment.

In late 1998, the ATR cooling tower and underground secondary piping were replaced. The old cooling tower was demolished, underground piping replaced, and a new fiberglass cooling tower erected in sixty days. The improvements will last many more decades.

NEW SIMULATOR FOR OPERATOR TRAINING

About ten years ago, a new reactor simulator and operator training facility was constructed. Prior to this, training personnel, classrooms, and the simulator were located in several different buildings. Several of the classrooms were very old and the noise levels from ventilation and other systems made conditions less than optimum for learning. Individual training records were kept in several different locations within the building and there was very little space available for training and reference materials making them difficult to control properly. The intent of the new training center was to consolidate all reactor and auxiliary operator training instructors, classrooms, the simulator, records, and related materials in one location.

The new facility houses the simulator, three classrooms, the reactor and auxiliary operator instructors, and a library which includes adequate space for all the individual training records, training and reference materials. The instructors are located in the same building as the simulator, classrooms, records, training materials and references. The training records, materials and references are located in one office area where access and control can be maintained. Building and testing the new control system for the simulator prior to installation in the ATR not only assured that they performed as designed, but also demonstrated the fidelity of the simulator. Reactor operating procedures are also tested in the simulator prior to using them in the ATR.

IMPROVEMENTS IN OPERATING PERFORMANCE

Equipment upgrades alone are not sufficient to assure improvement in reactor operating performance. Work planning and operating procedures may have an even larger impact on reactor availability. Improvement in these areas has been significant at ATR over the last decade. Even though ATR has seven or eight outages each year, reactor availability has been as high as 80%. This is primarily due to the level of detail that is planned during an outage.

The management for routine ATR outages is structured around matrixing individuals with specific functional skills to the outage management team. The team members report to the Outage Manager and are responsible for executing outage planning, scheduling, coordinating and reporting requirements. The team is established just prior to each reactor outage and continues to function in the areas of Outage

Planning, Outage Scheduling, Work Control, Tagout Control, Equipment Status Control, Status Tracking, Radiological and Safety Control and Lessons Learned through the duration of the outage.

An outage typically begins with reactor shutdown on a Sunday Morning. This permits the reactor to cool down before the full work force arrives on Monday. A master work plan, which identifies all work on a running three-day schedule, is prepared including approved procedures for each of the many tasks to be performed during the outage. Typical tasks include defueling and refueling the reactor, removal and insertion of many experiments, and a wide variety of maintenance work on experiment loops, reactor cooling systems, and instrument calibrations. Each of these tasks requires support from operations, crafts, engineering, and safety personnel. Constant communications and dedicated personnel are essential to complete each outage successfully. Planning for the next outage begins immediately after each outage is completed. Engineering and experimenters are required to submit work plans four weeks ahead of the outage. Each experiment must complete an Experiment Safety Analysis and submit it for approval one week before each reactor outage. A Core Safety Assurance package reflecting all experiment, facility, and fuel changes is prepared and approved prior to each reactor startup.

INCREASING THE SAFETY MARGIN

The safety margin at ATR has increased due to two general reasons. First, continuous efforts are made to better understand risks and consequences of potential accidents. And second, improvements in procedures and work practices are implemented wherever possible. The safety documentation has been updated and reflects a state of knowledge that was less complete when ATR originally started operation. As this documentation was completed, every assumption was questioned and a more current knowledge base was used to analyze potential accidents. Many risks were reduced by invoking limitations on fairly simple operations, such as heavy crane lifts in key areas.

The Technical Safety Requirements and ATR's Safety Analysis Report (TSR/SAR) have been updated. A complete review of safety issues was completed as the basis for these new documents. A number of requirements were added to prevent accidents that could lead to loss of core coolability from either metal water reactions or fuel damage. ATR has a positive void coefficient in the flux traps. Requirements have been placed on experiments such that limited changes in void can occur if an experiment fails. Experimenters must confirm that maximum void reactivity change due to experiment failure is no more than $1.00. Previously, large breaks were part of the design basis, but large breaks leading to fuel damage were shown to be not credible due to the frequency of pipe breaks and the amount of time the plant operates at powers that would damage fuel.

ATR's FUTURE CONTRIBUTIONS TO NUCLEAR ENERGY

ATR will continue to make significant contributions to the safe and efficient development of nuclear energy. As in the past, testing programs on a wide variety of technologies will continue. In addition, the experience that continues to be gained at ATR can be shared with the wider community as they face challenges in the future. ATR's role will continue to be fuels and materials testing, primarily for the US Department of Energy, but also for industrial and international sponsors. ATR is being utilized to test new fuels with more proliferation resistance. Tests using weapons grade plutonium in mixed oxide fuels are in progress. Tests of fuels with longer lifetimes are proposed. Several tests in ATR are studying material aging problems. Some of these are focused on the development of new materials while others are aimed at qualifying or repairing materials in current reactors.

Sharing ATR's operating experience can also contribute to others in the nuclear industry. The experience base at ATR may provide valuable lessons learned for other reactors as they plan upgrades to current systems or consider new safety reviews.