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Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

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Monitoring Improved, but More Planning Needed for DOE Test and Research Reactors

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The Honorable Mike Synar
Chairman, Environment, Energy, and
Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

On February 28, 1991, you requested that we examine a number of issues regarding the Department of Energy's (DOE) nondefense-related nuclear facilities. You were particularly concerned that test and research reactors, which represent a valuable national resource for technical and scientific research, are aging and may eventually become unsafe to operate. As agreed with your office, this report focuses on (1) the adequacy of DOE's management of and long-range planning for use of the agency's test and research reactors, particularly with regard to plans for replacing aging reactors whose continued operation may eventually affect safety and operational efficiency, and (2) the operating condition in terms of safety of DOE's test and research reactor facilities.

Results in Brief

In 1989, DOE consolidated the management of its nondefense test and research reactors into a single office within the Office of Nuclear Energy. This consolidation has helped improve the management of these reactors. DOE, however, has not fully addressed the need to plan for the timely retirement or replacement of these aging reactors. All of the Department's 10 operating test and research reactors are over 25 years old and are showing signs of deterioration caused by age. The Department has developed plans to replace its two largest research reactors, but replacement may take 10 or more years and thus gaps in needed reactor services could result. DOE has not planned for the retirement or replacement of its other reactors. Without timely planning for the retirement or replacement of the reactors, safety may be compromised, operating expenses may be increased, reactor performance may decrease, and gaps may occur in needed reactor services.

During the past few years, DOE has emphasized increased safety awareness in the operation of its nondefense test and research reactors. This increased emphasis on safety awareness has resulted mainly from DOE's reactions to safety problems discovered by the Department and others at defense reactor facilities in the mid- to late-1980s. DOE has hired new personnel with rigorous safety experience gained in the commercial nuclear power sector; added new, more stringent safety requirements; performed additional safety analyses (at some reactor facilities); and increased monitoring. However, nuclear facility appraisers (including DOE's Tiger Teams, which perform technical safety appraisals) continue to identify problems indicating that some of the nondefense reactor facilities are only slowly accepting safety as their highest priority. According to the appraisers, the identified problems were not serious enough to curtail reactor operations. DOE is working to correct these problems, but it will take a number of years before the corrections are completed.

Background

Test and research reactors, although much smaller than commercial power reactors and reactors used to produce nuclear materials, are a versatile source of radiation for experimental purposes. For example, experimenters can use these reactors to (1) study the effects of radiation on materials and components to be used in advanced power reactors, (2) determine the molecular structure of materials and identify trace impurities in these materials, (3) treat certain brain cancers, and (4) produce isotopes for medical and industrial use.

DOE was operating 10 test and research reactors as of April 1992. At the beginning of the 1980s, DOE had a more active nondefense nuclear test and research program, with over 25 test and research reactors. However, both the program and the need for a large number of reactors to support it have diminished, mainly because of a decrease in demand for reactor services. The decrease in demand has been compounded by an increase in operating costs resulting largely from expanded safety requirements and standards. With demand for the services of some reactors dropping, DOE has decided that it is not cost-effective to continue to operate them.

DOE identifies its reactors by size as category "A" (20 megawatts or more) or "B" (less than 20 megawatts).[1] DOE's 10 operating test and research reactors include 4 category "A" reactors and 6 category "B" reactors.[2] These reactors are primarily used for materials and components testing, basic research, and biological tests and research. Two reactors serve as diagnostic tools for other reactors. (See app. I for a list of the reactors,

[1]A megawatt equals 1 million watts. The power level expressed (i.e., 20 megawatts) represents the thermal power generated, not electric power.

[2]DOE also has reactors on a nonoperating standby or shutdown status, mainly because of insufficient demand for their services. See app. IV for a description of these reactors.

their categories, and their functions. See apps. II and III for profiles of the category "A" and "B" reactors.)

DOE ensures the safe operation of its test and research reactors through continual inspections performed by staff from DOE headquarters and field offices as well as by the contractor responsible for the operation of the reactor facility. DOE orders stipulate the requirements for safe operation, and DOE requires that up-to-date safety analysis reports (SAR) document the conditions required for safe operation for each of its nuclear facilities. DOE has required SARs for all of its nuclear facilities since 1976.

DOE has two other safety analysis tools for its reactors, but neither is required. DOE makes case-by-case decisions on the need for these assessments. The first, a probabilistic risk assessment (PRA), helps determine the probability that certain internally or externally caused accidents will happen and the potential effect of such accidents on the safe operation of a reactor facility. The second analysis tool, a plant life extension study, is a thorough examination of a facility's components and systems to identify those that may limit the life of the reactor. The results help DOE assess whether a reactor can be safely operated beyond its normal life span. DOE rarely performs a PRA or a plant life extension study for its smaller (category "B") reactors, mainly because the safety risk is considered much lower in this size reactor.

DOE Has No Plan for the Eventual Retirement or Replacement of Most of Its Aging Reactors

DOE has not developed a long-range plan for utilization of its nondefense test and research reactors. According to DOE officials, the diminishing number of these reactors and their individual uniqueness make a formal plan unnecessary to manage most aspects of their utilization. The Department does concede, however, that it will eventually need to make decisions and plans concerning the retirement or replacement of its aging test and research reactors. DOE has not developed a plan for the timely retirement or replacement of most of these reactors. Without such a plan, problems resulting from aging may adversely affect the safe operation of these reactors, increase operating costs, diminish reactor performance, and cause gaps in needed reactor services.

A strategic plan for the utilization of valuable, costly resources generally helps ensure that logical, defendable decisions are made concerning the future of those resources. For example, in the case of the test and research reactors, such a plan and its supporting analysis could help DOE make and defend decisions on which reactors to keep operating, which to shut down, and which, given a reactor's age and condition and the prospects for continuing or new missions, should be replaced.

DOE did begin to develop a long-range utilization plan for its test and research reactors in 1987,[3] but the plan has remained in draft form and has not been worked on since 1987. DOE officials told us that the number and need for some of these reactors had changed or diminished so rapidly that it was difficult and perhaps unrealistic to develop a strategic plan for managing this group of reactors. For example, DOE recently stopped operating the Fast Flux Test Facility (FFTF)—DOE's most modern (12 years old) and largest test reactor facility. The FFTF has many capabilities similar to (or in some cases exceeding) those of DOE's two operating category "A" test reactors, which are much older than the FFTF. However, DOE put the FFTF on nonoperating standby status in April 1992 because the Department had been unable to find a suitable mission to pay the FFTF's nearly $90 million annual operating cost.[4]

In addition, DOE officials now question the need for a formal, long-range utilization plan to manage most aspects of what they consider a small group of reactors. For example, DOE officials contend that they can easily compare capabilities and other characteristics among the four operating category "A" reactors (two test reactors and two research reactors) and among the six operating category "B" reactors because of their small number and unique qualities. (Apps. I, II, and III describe the capabilities of DOE's currently operating category "A" and "B" reactors.)

More Planning Needed for Timely Retirement or Replacement of Reactors

DOE concedes that its aging reactors, all over 25 years old, will eventually need to be retired or replaced. However, for the most part, the Department has not planned for the timely retirement or replacement of these reactors. DOE has plans to replace two reactors, but this planning may not be timely enough to preclude potential problems caused by continuing deterioration from age. Experts in reactor safety have recommended that DOE plan in a more timely way to retire or replace all of its aging reactors to avoid potential safety problems, increased operating costs, degradation of performance, and decreased reactor availability.

[3]Nuclear Energy Long-Range Facility Utilization Plan (Draft), Department of Energy (Nov. 1987).

[4]DOE may restart the FFTF if it can find such a mission. See our report entitled Nuclear Science: Fast Flux Test Facility on Standby, Awaiting DOE Decision on Future Missions (GAO/RCED-92-121FS, Apr. 9, 1992).

DOE's four category "A" reactors are showing signs of age deterioration. DOE plans to replace its two category "A" research reactors—the High Flux Beam Reactor at Brookhaven National Laboratory and the High Flux Isotope Reactor at Oak Ridge National Laboratory—in the early 2000s with a single, larger research reactor, the Advanced Neutron Source (see app. V). Both of the high flux reactors are over 26 years old, and some of their component materials are becoming brittle from constant irradiation. Both of these reactors had been shut down for several years because of safety and other problems and were recently restarted.

DOE's two category "A" test reactors—the Experimental Breeder Reactor II (EBR-II) and the Advanced Test Reactor (ATR)—have also shown signs of deterioration from age. DOE has not developed plans for their replacement or retirement but has performed plant life extension studies on the reactors to identify and attempt to mitigate potential problems that may prevent the reactors from operating safely beyond their original design life. Both of these category "A" reactors have continuing missions into the next decade, and DOE believes that they can operate safely for another 12 to 22 years, respectively.

DOE has no plan for the eventual replacement of its six category "B" reactors and has not performed plant life extension studies for these reactors.[5] The category "B" reactors are considered simpler in design than the category "A" reactors and less subject to some effects of aging.

Nuclear reactor safety experts from the National Research Council and the Advisory Committee on Nuclear Facility Safety have suggested that DOE do more planning for the long-range use of its nondefense test and research facilities.[6] These two groups are especially concerned that DOE plan for the eventual retirement or replacement of aging reactors. They note that DOE will likely operate its four category "A" reactors well beyond their original design lifetimes even though these reactors are experiencing the effects of age deterioration. The Council and the Committee point out that, in time, maintenance costs and the costs of facility upgrades will increase and performance will be reduced because of this deterioration. Both groups believe that, as a result, DOE's continued operation of these reactors will be quite unattractive when compared with the use of modern reactor facilities

[5]Some of these "B" reactors may eventually be shut down if there is not sufficient demand for their services.

[6]Safety Issues at the DOE Test and Research Reactors, National Research Council (Washington, D.C.: 1988) and Final Report on DOE Nuclear Facilities, Advisory Committee on Nuclear Facility Safety (Washington, D.C.: Nov. 1991).

that can be designed with greater safety features and a higher level of performance. The groups contend that if DOE sees that long-term reactor missions will need to be supported, it should move ahead expeditiously to plan for the replacement of aging reactors. The Council and the Committee believe that timely planning and execution of reactor retirement and replacement projects can alleviate potential safety concerns about the operation of aging reactors and preclude gaps in reactor availability such as those that occurred recently with DOE's production reactors.

In addition, the Committee has suggested that DOE should accelerate its planning for the replacement of its two basic research high flux reactors. The Committee points out that problems resulting from aging have prompted special surveillance of irradiation damage to materials at these reactors and that, as a result of this continuing damage, these reactors may be available only for a limited additional time. The Council and the Committee also believe that DOE should plan now for the eventual replacement of its two aging category "A" test reactors if DOE identifies long-term missions that require the capabilities of these reactors. The Council and the Committee are aware of DOE's plant life extension studies, but believe that it is not premature to make replacement decisions and plans. For example, the Council said in 1988 that although a plant life extension study of the EBR-II did not reveal any problems of immediate concern, over time more and more of the costs of supporting DOE's older reactors, such as the EBR-II, would be devoted to mitigating problems resulting from aging simply to maintain existing safety margins.

Safety Oversight Is Improving, but Some Problems Continue

DOE's nondefense nuclear reactor facilities have benefited from the increased safety awareness brought about in large part by publication of and reaction to the discovery of safety problems at DOE's defense nuclear facilities. However, while there is an identifiable trend toward increased safety awareness at the test and research reactor facilities, safety appraisers still find problems indicating that some of these facilities are adapting more slowly. (Apps. II and III cite recent safety problems of each of DOE's nondefense test and research reactors.)

DOE Has Taken Positive Safety Actions

DOE has reacted to identified safety problems by hiring additional personnel, developing new safety requirements, and increasing monitoring and inspections of all of its nuclear facilities. DOE has also implemented most of the National Research Council's 1988 recommendations for improvements in the management and safety of DOE's four category "A" test and research reactors.[7] One of the recommendations that DOE implemented was the consolidation of responsibility for management of its test and research reactors under a single headquarters office—the Office of Nuclear Energy.

DOE has improved the monitoring of its reactors by hiring personnel with experience in the commercial nuclear sector, where safety attitudes and procedures are more rigorous. In addition, DOE has now established on-site offices within the nuclear reactor facilities operated by contractors. The DOE site personnel directly monitor daily facility operations. Previously, DOE was less involved in monitoring the contractors' activities, partly because the field offices were located miles away from the facilities.

DOE has also introduced new orders addressing safety at its nuclear facilities. Many of the orders have been adopted from the safety requirements imposed on the commercial sector by the Nuclear Regulatory Commission and others. For example, a DOE order for the conduct of operations at its facilities contains the same requirements imposed on the commercial sector by the Institute of Nuclear Power Operations, which sets standards for operations in the commercial nuclear sector. DOE's order, implemented in 1990, stresses the need for excellence in the conduct of operations at all DOE facilities.

With new and more experienced personnel and more stringent DOE orders stressing safety awareness, DOE inspection groups have increased their appraisals of DOE's nuclear facilities, including nondefense facilities. Some of the facilities that we visited had been appraised more than 12 times in the preceding year. In addition, more groups are now performing safety-related appraisals of these facilities. For example, appraisals are performed by (1) environment, safety, and health inspectors, nuclear engineering technical inspectors, and quality assurance inspectors from DOE field offices; (2) environment, safety, and health Tiger Teams from DOE headquarters;[8] (3) Office of Nuclear Safety, Office of Nuclear Energy Self-Assessment, and functional technical groups from DOE headquarters; and (4) equivalent groups from the facilities' operating contractors. Most of these appraisals are performed annually. Through these appraisals and daily facility monitoring by field office site personnel, DOE has become well

[7]The Research Council's 1988 study, commissioned by DOE, appraised DOE's category "A" test and research reactors but did not appraise the category "B" reactors.

[8]Tiger Teams are nonpermanent, DOE-led teams composed of experts from within and outside of DOE that conduct environment, safety, and health appraisals at DOE facilities.

informed on the safety problems that exist at its nondefense nuclear facilities. In addition, the four large nondefense nuclear reactors that DOE currently operates have implemented the National Research Council's 1988 recommendations, including the recommendation that probabilistic risk assessments be performed.

Appraisers Are Still Finding Deficiencies at Facilities

Despite the apparent trend toward increased safety awareness at DOE's nondefense nuclear facilities, the results of some safety appraisals, especially those performed by DOE's Tiger Teams, indicate that some facilities are only slowly accepting increased safety awareness as their highest priority.

For example, recent Tiger Team audits revealed that many of the 10 operating reactor facilities need to improve their SARs, in part by updating and reformatting old reports. Most facilities were correcting this situation, but some were moving slowly. At least one facility had planned a SAR update for the past several years but had not accomplished it. Officials at some of the facilities said that higher-priority work and a lack of resources and funding delayed their completion and updating of SARs. They said that DOE's initiatives to increase safety awareness, accompanied by many new DOE orders, have increased operating costs and made it increasingly difficult for some facilities to perform their primary mission because of the time spent on safety initiatives.

Other findings also led the Tiger Teams to conclude that some facilities are slow to make environment, safety, and health issues their highest priority. For example, the Tiger Teams reported as follows on some of the laboratories where DOE has nondefense reactors:

- Argonne National Laboratory-West, Idaho (the location of DOE's Experimental Breeder Reactor—EBR-II—and several small category "B" reactors). The Tiger Team's 1991 appraisal strongly criticized the laboratory's management and the DOE site office for one category I finding (a hazardous, clear, and present danger to personnel, requiring immediate attention) on an unsafe operating procedure within the reactor complex and seven category II findings (serious, but not a clear and present danger to workers and the public). One of the category II findings, which concerned an old weld, brought the safe operation of the EBR-II into question. The team concluded that DOE's Chicago field office and the contractor for Argonne West "have not responded effectively to the

Secretary's ES&H (environment, safety, and health) initiatives, and a cultural change is needed."

- Argonne National Laboratory-East, Illinois. The Tiger Team's 1990 report contained few specific and no serious findings on the safe operation of the laboratory's small research reactor (JANUS). However, the team found many "significant" deficiencies in other parts of the laboratory that reflect on the acceptance of safety priorities by the laboratory and the DOE Chicago field office. For example, operations were curtailed at the Argonne Tandem Linac Accelerator System when the team found that the accelerator was being operated without adequate radiation protection shielding. The team concluded that "a significant change in culture is required before ANL-E [Argonne National Laboratory-East] can attain consistent and verifiable compliance with statutes, regulations, and DOE Orders."
- Oak Ridge National Laboratory, Tennessee. The Tiger Team's 1990 appraisal noted that despite substantial improvement in the reactor program, deficiencies still existed "throughout reactor sites," including a lack of compliance with DOE's safety orders and requirements for quality assurance, operations, maintenance, emergency preparedness, personnel protection, and worker safety. The Tiger Team stated that the causes for these deficiencies were "management's lack of attention to implementation detail and insufficient resources."
- Idaho National Engineering Laboratory, Idaho. The Tiger Team's 1991 audit found numerous health, safety, and environment problems affecting the laboratory, but few serious findings (that is, no category I or II findings, but a number of lesser deficiencies) at the laboratory's Advanced Test Reactor and smaller support reactors. The team recognized that while the laboratory was experiencing numerous deficiencies, it was making progress toward giving the highest priority to safe operation. However, the team faulted management at the laboratory and DOE for lack of direction and oversight, allowing environment, safety, and health problems to continue.

DOE has improved its timely identification of problems at its test and research reactor facilities. The facilities have corrected some of these identified problems and are working to correct the others, none of which are considered serious enough to curtail operations. However, according to DOE field office and laboratory officials, it will take a number of years and additional funding to correct these problems. DOE headquarters officials said that a long and continuous effort may be needed to get some of its facilities to fully accept and implement a culture that emphasizes the environment, safety, and health, but that progress is being made.

Conclusions

As the number of DOE's nondefense test and research reactors dwindles with diminishing demand and increasing operating costs, DOE must decide which reactors to shut down and which to maintain or replace. The small number of reactors currently in operation—10, with more expected to close—includes many with unique capabilities and functions. In DOE's view, this restricted number and the reactors' specialized functions have now made formal long-range planning that compares the capabilities, age, and condition of the reactors unnecessary.

However, given the age of the test and research reactors and the deterioration that is taking place, it is not premature to plan for the timely retirement or replacement of these reactors. Without such planning, safety problems, diminished reactor performance, increased operating costs to maintain existing safety levels, and gaps in service to experimenters who use the reactors could occur. DOE already plans to replace its two category "A" research reactors, but service to some experimenters could be interrupted in the 10 years this process will take. DOE's two category "A" test reactors are also deteriorating because of age and will eventually have to be closed down or replaced. The FFTF, which DOE now has on standby, is a newer category "A" test reactor that could be used to replace some of the capabilities of these older reactors if these capabilities are needed for future missions.

Safety, or at least the identification of safety problems, has improved at DOE's nondefense test and research facilities. DOE currently has an inventory of identified problems at these facilities that will take a number of years to correct. Ensuring safer operations will, however, entail continued identification and correction of problems.

Recommendation

To avoid possible degradation in safe operation, increased operating costs, degradation in performance, and gaps in needed reactor service, we recommend that the Secretary of Energy require that the manager of DOE's test and research reactor facilities develop a long-range plan for the timely retirement or replacement of aging reactors. In their analysis of the possible need to eventually replace the Department's two older operating category "A" test reactors, DOE planners should consider the cost and benefits of using the Fast Flux Test Facility, now on standby, as a possible replacement rather than constructing a newer, more expensive reactor.

Scope and Methodology

We conducted our review from April 1991 through April 1992 in accordance with generally accepted government auditing standards. We interviewed officials at DOE headquarters and field offices and at the national laboratories where the Department's nondefense test and research reactors are located. We visited and reviewed each reactor. Dr. George W. Hinman, a consultant in nuclear physics, helped us review some of these reactors. We also reviewed pertinent documents, including the results of previous audits and evaluations, safety analyses, probabilistic risk assessments, plant life extension studies, and DOE orders.

We discussed the results of our work with officials from DOE's Office of the Assistant Secretary of Nuclear Energy, who generally agreed with the facts as presented. We incorporated their comments where appropriate. As requested, we did not obtain written agency comments on this report.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will provide copies to the appropriate congressional committees; the Secretary of Energy; the Director, Office of Management and Budget; and those involved in our review. We will also make copies available to others upon request.

This work was performed under the direction of Victor S. Rezendes, Director, Energy Issues, who may be reached at (202) 275-1441 if you or your staff have any questions. Other major contributors to this report are listed in appendix VI.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

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Abbreviations

ANL-E	Argonne National Laboratory-East
ANL-W	Argonne National Laboratory-West
AELEX	Aging Evaluation and Life Extension
AFSR	Argonne Fast Source Reactor
ANS	Advanced Neutron Source Reactor
ARMF/CFRMF	Advanced Reactivity Measurement Facility/Coupled Fast Reactivity Measurement Facility
ATR	Advanced Test Reactor
ATRCF	Advanced Test Reactor Critical Facility
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
BSF	Bulk Shielding Facility
DOE	Department of Energy
EBR-II	Experimental Breeder Reactor II
ES&H	environment, safety, and health
FFTF	Fast Flux Test Facility
FY	fiscal year
GAO	General Accounting Office
HFBR	High Flux Beam Reactor
HFIR	High Flux Isotope Reactor
HPRR	Health Physics Research Reactor
IFR	Integral Fast Reactor
INEL	Idaho National Engineering Laboratory
JANUS	Argonne biological research reactor
MW	megawatt
NRAD	Neutron Radiography Reactor Facility
ORNL	Oak Ridge National Laboratory
PBF	Power Burst Facility
PCA	Pool Critical Assembly
PRA	probabilistic risk assessment
SAR	safety analysis report
TSF	Tower Shielding Facility
TSR-I	Tower Shielding Reactor I
TSR-II	Tower Shielding Reactor II
TREAT	Transient Reactor Test Facility

DOE's Nondefense Test and Research Reactors Operating as of April 1992

Dollars in millions

Reactor	Location	Age (years)	Category size (power level)[a]	Use	FY 1992 budget
Advanced Test Reactor (ATR)	Idaho National Engineering Laboratory, Ida.	25	A (250 MW)	Test	$60.6
Experimental Breeder Reactor II (EBR-II)	Argonne National Laboratory-West, Ida.	28	A (62.5 MW)	Test	43.0
High Flux Beam Reactor (HFBR)	Brookhaven National Laboratory, N.Y.	27	A (35.4 MW)	Research	23.9
High Flux Isotope Reactor (HFIR)	Oak Ridge National Laboratory, Tenn.	27	A (85 MW)	Research	28.5
JANUS	Argonne National Laboratory-East, Ill.	27	B (0.2 MW)	Medical/ biological research	0.6
Brookhaven Medical Research Reactor (BMRR)	Brookhaven National Laboratory, N.Y.	33	B (3 MW)	Medical/ biological research	1.1
Tower Shielding Facility (TSF)	Oak Ridge National Laboratory, Tenn.	32	B (1 MW)	Test	2.2
Neutron Radiography Reactor Facility (NRAD)	Argonne National Laboratory-West, Ida.	14[b]	B (0.25 MW)	Diagnostic tool	1.1
Transient Reactor Test Facility (TREAT)	Argonne National Laboratory-West, Ida.	33	B (bursts)	Test	4.8
Advanced Test Reactor Critical Facility (ATRCF)	Idaho National Engineering Laboratory, Ida.	28	B (0.003 MW)	Diagnostic tool to support ATR	0.4

[a]A megawatt (MW) is one million watts.

[b]This reactor was used in Puerto Rico before 1978. This period of service before 1978 is not included in the 14-year total of service at Argonne.

Source: Developed by GAO from DOE data.

Profiles of Category "A" Reactors Operating as of April 1992

The Department of Energy's (DOE) category "A" reactors have a power level of greater than 20 megawatts (MW) thermal. Category "A" reactors are DOE's larger test and research reactors.

The safety problems discussed for these reactors have been identified and are being corrected. These corrections may take a number of years in some cases. Appraisers did not consider the problems identified serious enough to warrant closing the facility.

Experimental Breeder Reactor II (EBR-II)

- Location: Idaho National Engineering Laboratory (INEL), Argonne National Laboratory West Site (ANL-W), Idaho Falls, Idaho
- Operating contractor: University of Chicago
- Current status: Operating as of April 1992
- Approximate age: 28 years in 1992
- FY 1992 budget: $43 million (includes $11.2 million for fuel supply)

Facility Description

The EBR-II is a reactor with a thermal power rating of 62.5 MW, fueled by metal and cooled by liquid metal sodium. It was constructed in 1963 to support the U.S. breeder reactor program. The reactor is cooled by the pool of liquid metal sodium in which it is located as well as by additional sodium that circulates in the system. The EBR-II is the only test and research reactor that also generates electricity, supplying about 15 MW of electric power to the complex.

Mission and Utilization

By 1969, the EBR-II had demonstrated the feasibility of using a metal-fueled, liquid-metal-cooled breeder reactor to produce commercial power and the feasibility of using certain techniques for on-site reprocessing of spent nuclear fuel. In the 1970s, the EBR-II became a major facility for irradiation testing of fuels and materials. Currently and through the 1990s, the EBR-II will be devoted primarily to supporting DOE's advanced liquid-metal reactor development program (including DOE's Integral Fast Reactor Project to recycle metal fuel). The EBR-II is also being used to support DOE's fusion, naval reactor, and space and defense programs as well as the joint U.S.-Japan power reactor and fuel development programs. Thus, the EBR-II will be fully utilized for at least the next 5 years.

Safety and Age Issues

While the EBR-II has had a record of safe operations, and the reactor itself has demonstrated the passively safe operating capabilities of a liquid-metal-cooled reactor, appraisals indicate that the EBR-II's management needs to make improvements in safety practices. For example, the August 1991 Tiger Team audit documented poor safety practices for personnel protection (one posing immediate danger to personnel) and quality verification involving questions of the safe operation of certain EBR-II systems. In addition, the Tiger Team's audit and other previous audits dating back to 1987 criticized the EBR-II's management for not having safety analysis documentation for the reactor that was up-to-date and in compliance with DOE orders. The current documentation for the EBR-II does not constitute a complete safety analysis. The EBR-II's personnel are updating and reformatting the documentation to bring it into compliance with DOE requirements.

The National Research Council had suggested that the EBR-II's management perform a probabilistic risk assessment (PRA). In 1991, management completed the first phase of the PRA. According to EBR-II officials, their 1991 PRA analysis shows no high risk events affecting the reactor's safe operation. However, further studies will be required before the EPR-II's management can include all of the Council's suggestions for the PRA.

With regard to aging, DOE had planned to close the EBR-II in the 1990s after 30 years of service. The Department performed a plant life extension study in 1984 to identify problems that might preclude the EBR-II from operating safely for up to 30 years. A number of problems were identified, but none was considered insurmountable. In 1988, DOE changed its mind about the closure of the EBR-II because it needed the EBR-II to support its metal-fueled, liquid-metal-cooled reactor program and related fuel recycling demonstration program (collectively called the Integral Fast Reactor Project). Thus, in 1991, DOE performed another plant life extension study to identify any problems that could prevent the EBR-II from operating safely for 40 years (or until about 2004, calculated from its date of initial operation in 1964). Again, some problems were identified, but DOE considered that they could be resolved. The EBR-II, however, is showing signs of deterioration. For example, unplanned shutdowns have occurred because of aging components, loss of ductility in stainless steel, potential swelling of nonreplaceable graphite located around the core, and thermal fatigue or creep limitations. A specific change that has been noticed and measured is an upward bowing of the top grid plate that holds reactor core subassemblies. Continued bowing of this core component could result in binding of the subassemblies. The EBR-II's personnel are monitoring this change.

Advanced Test Reactor (ATR)

- Location: Idaho National Engineering Laboratory, Idaho Falls, Idaho
- Operating contractor: EG&G Idaho, Inc.
- Current status: Operating as of April 1992
- Approximate age: 25 years as of 1992
- FY 1992 budget: $60.6 million

Facility Description

The ATR is cooled by water and has a thermal power of 250 MW. The ATR is unusual in that the fuel is not in a compact core but resembles a curved ribbon closing on itself in the shape of a four-leaf clover. The largest dimension, diagonally across the opposite lobes of the "clover," is 3 feet. The power level of each of the four lobes can be varied independently for specific experiments performed in nine test loops (closed systems of pipe through which a coolant circulates). The ATR's core also includes other positions (called capsules) where other experiments can be performed.

Mission and Utilization

The ATR's basic mission is the irradiation of fuels and materials, almost exclusively for DOE's Naval Reactors Program. However, the ATR is also used to perform tests in support of the Modular High Temperature Gas Production Reactor Program, and about one-third of the ATR's space is available for other work. Currently, EG&G uses some of this space to produce a number of isotopes for medical and industrial use.

Safety and Age Issues

The ATR began operating in 1967 and has operated safely during its first 25 years. The August 1991 Tiger Team audit found no serious (category I or II) safety problems in its inspection of the ATR. The team did identify a number of items that indicate that management needs to formulate ancillary plans, policies, and procedures in order to improve the conduct of operations for the ATR. According to the team, more rigor in service plans and a clearly defined policy for in-service inspections are needed for the ATR. Furthermore, the team found that the facility's log-keeping and shift turnover process did not comply with DOE's requirements. Previous audits (non-Tiger Team) of the ATR and occurrence reports of unusual events in the ATR's operations indicate a need for management to ensure compliance with established operating procedures and requirements, and a need to complete or establish program requirements. In addition, the ATR's safety analysis report (SAR) is not currently in compliance with DOE's latest guidance.

The ATR's management has been active in performing several levels of PRAS for the ATR. EG&G has designed these PRAS, in part, to address the concerns that the National Research Council expressed in its 1988 report, including reactivity and loss of coolant accidents, severe accident behavior, threats to the reactor confinement, needed improvements in experimental loop operations, uncertainties in core neutronics during accident conditions, and the need for full use of PRAS to identify and establish safety priorities. DOE has made and is expected to make significant upgrades to the ATR facility as a result of the PRAS.

With regard to aging, the ATR began operations in the late 1960s with an expected minimum design life of 20 years. The ATR has now operated in excess of this 20-year minimum life span. DOE's current goal is to have the ATR operate through the year 2014 (a 45-year life span, calculated from its initial date of full operations in 1969) in support of the Naval Reactors Program.[1] Operation through 2014 requires careful consideration of age-related degradation. Experience with other DOE reactors indicates that age degradation effects must be mitigated or safety will be at risk. For example, the National Research Council noted severe aging in DOE's production reactors. The ATR shares some design features with these production reactors and is thus subject to similar aging phenomena.

EG&G established a formal Aging Evaluation and Life Extension (AELEX) Program for the ATR in 1987 to identify the measures that must be taken to prevent or counterbalance aging effects in the ATR's system, structures, and components. The AELEX Program is identifying components that are life-limiting and have to be changed. Most of the internal structures subject to radiation damage are changed at periodic intervals to avoid significant age-related deterioration. The next set of changes and upgrades is scheduled for 1992. Some components, including the reactor vessel and primary piping, probably cannot be replaced and are life-limiting. The limiting conditions are loss of tensile strength and ductility. The AELEX Program is monitoring these properties by irradiating samples of the same kind of materials used in the ATR and then subjecting these materials to tests of tensile and fracture toughness. However, according to DOE and EG&G, the AELEX Program has thus far identified no problems in the system, components, or structure that will prevent the ATR from operating through 2014.

[1]This goal may change because of planned cutbacks in defense programs, including the Navy's reactor program.

High Flux Beam Reactor (HFBR)

- Location: Brookhaven National Laboratory (BNL), Upton, New York
- Operating contractor: Associated Universities, Inc.
- Current status: Operating as of April 1992
- Approximate age: 27 years in 1992
- FY 1992 budget: $23.9 million

Facility Description

The HFBR became operational in 1965, at a power level of 40 MW. In 1982, the reactor's operating power was upgraded to 60 MW to enhance research capabilities. (The power has since been reduced to 35 MW; see the section on safety and age issues below.) The HFBR uses highly enriched uranium fuel, a heavy water moderator, and heavy water as a coolant. The core is approximately 19 inches high and 21 inches in diameter. In contrast to power reactors, which are designed to minimize the escape of neutrons from the core, the HFBR has been expressly designed to maximize the number of neutrons available in external beam tubes to be used by researchers in their experiments.

Mission and Utilization

The HFBR supplies intense beams of neutrons for experiments in a wide variety of basic research applications in physics, chemistry, and biology. The reactor also provides irradiation facilities for neutron activation analysis, radiation damage studies, and isotope production for experimental purposes.

The HFBR primarily supports research programs for the Office of Basic Energy Sciences in DOE's Office of Energy Research. Before its shutdown in March 1989 for more than 2 years for safety reasons, the HFBR had more than 200 users annually. Fifty percent of the reactor's users were from U.S. universities, 17 percent each from U.S. industry and foreign laboratories, and 16 percent from U.S. government laboratories. During the 2-year shutdown, some users took their experiments to other reactors, such as the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory or the Chalk River Reactor in Canada. But Brookhaven officials believe that many experimenters postponed their experiments and have restarted or will be restarting their experiments at the HFBR now that it is operational again.

Safety and Age Issues

During HFBR's 2-year shutdown, the safety problems that caused the shutdown were addressed, as were many of the deficiencies noted by a 1988 National Research Council study. A PRA was performed. The HFBR was restarted in 1991 at about half its operating power before the shutdown; BNL could not show that the reactor would be safe to operate at its pre-shutdown power level of 60 MW. The reactor must meet additional safety requirements before it can increase its operating power. Most of the HFBR's experiments can be performed at the lower operating power—30 MW—but they will take longer to complete. BNL hopes to increase the reactor power to 60 MW following additional safety analyses, thermal hydraulic testing, and reactor safety modifications that may be required to support operation at higher power levels. No plant life extension study has been performed for this reactor, although BNL's officials indicated they would like to hire an engineer in fiscal year 1992 to perform such a study. DOE plans to replace the aging HFBR in about 10 years with the Advanced Neutron Source (ANS), to be built at Oak Ridge National Laboratory (see app. V). The National Research Council's study pointed out that the HFBR is suffering from the effects of aging. For example, the Council cited the fact that the HFBR's beam tubes are becoming embrittled and should be monitored very carefully.

High Flux Isotope Reactor (HFIR)

- Location: Oak Ridge National Laboratory, Oak Ridge, Tennessee
- Operating contractor: Martin Marietta Energy Systems, Inc.
- Current status: Operating as of April 1992
- Approximate age: 27 years in 1992
- FY 1992 budget: $28.5 million

Facility Description

The HFIR is a multipurpose facility operated to support research programs for the Office of Basic Energy Sciences in DOE's Office of Energy Research. HFIR's initial startup was in 1965 and it began operation in 1966 at its designed full-power level of 100 MW. (In 1986, the full-power operating level was reduced to 85 MW as the result of a safety analysis.) The HFIR uses highly enriched uranium fuel and is cooled with light water.

Mission and Utilization

The HFIR was originally designed for the production of isotopes. However, the HFIR is also a source of neutrons for experiments performed in its four experimental beam-tube facilities to irradiate materials. Since restarting the HFIR in May 1990 after a long shutdown because of safety, management, and procedural problems, the HFIR's personnel have tried to increase the reactor's operational time but have experienced unplanned downtimes. The goal is for the HFIR to be operational 81 percent of the time, with a 19-percent scheduled outage. The HFIR's management has also been trying to rebuild utilization lost during the long period of shutdown. In addition to being used by DOE, the HFIR has been used by scientists from industry, universities, other government laboratories, and foreign groups for neutron-scattering research and materials irradiation experiments.

Safety and Age Issues

Internal reviews of the laboratory's research reactors found that the HFIR was operating in an unsafe condition because the laboratory failed to properly monitor the radiation-induced embrittlement of the HFIR's pressure vessel. Consequently, the reactor was shut down in November 1986. Full power was reduced from 100 MW to 85 MW following an updated safety analysis. During 1987 and 1988, many additional internal and external reviews were performed of the HFIR's safety and management. These reviews identified other deficiencies and made recommendations on restarting the reactor. The reactor was not restarted until April 1989 after extensive plant modifications and safety and management improvements were accomplished. The reactor was again shut down in May 1989 because of two operational incidents. Additional reviews were conducted and the HFIR was again restarted in May 1990 at a power level of 85 MW.

While the technical safety appraisal conducted by the Tiger Team in November 1990 found that reactor operations had improved substantially since the HFIR was shut down in late 1986, the team found deficiencies in each of the technical areas examined. The team also noted that the HFIR does not have a final SAR that meets current requirements. Oak Ridge is working to correct this and estimates that the report may cost about $7 million to complete. Other deficiencies cited by the team include lack of compliance with some DOE orders and safety standards. The team found that these deficiencies were caused by (1) management's lack of attention to implementation detail and (2) insufficient resources. Oak Ridge is working to correct the identified deficiencies.

DOE expects to replace the aging HFIR (and also the HFBR at Brookhaven) with the Advanced Neutron Source, to be built at Oak Ridge National Laboratory early in the next decade. In the meantime, HFIR will continue to support DOE's Office of Energy Research and DOE's isotope program.

Profiles of Category "B" Reactors Operating as of April 1992

DOE's category "B" reactors have a power level of less than 20 megawatts thermal. Category "B" reactors are DOE's smaller test and research reactors.

Tower Shielding Facility (TSF)

- Location: Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee
- Operating contractor: Martin Marietta Energy Systems, Inc.
- Current status: Operating as of April 1992
- Approximate age: 32 years as of 1992
- FY 1992 budget: $2.2 million (excluding Japan's contribution to the cooperative shielding program)

Facility and Mission Description

The TSF includes four 315-foot towers erected on the corners of a 100-foot by 200-foot concrete pad. The original Tower Shielding Reactor (TSR-I) was a 0.5-megawatt (MW) materials-testing reactor built in 1954 to study radiation protection for pilots and passengers of a proposed nuclear airplane. The radiation source (the reactor) had to be located far enough away from the ground and building structures to avoid neutron scattering and was therefore suspended in midair from the high towers.

The original reactor was replaced in 1960 with the Tower Shielding Reactor II (TSR-II), which has a maximum power output of 1 MW. From 1960 until 1973, the TSR-II operated in both ground level and elevated positions at a variety of power levels. In 1973, the TSR-II was moved to the Beam Shield Facility, which surrounds the reactor on three sides with concrete and stainless steel shielding. The fourth side consists of a shutter that allows the neutron beam to exit the reactor and irradiate shielding experiments set up outside it. Underground buildings near the towers contain the control equipment and operating crew, and a reinforced concrete handling pool provides shielding during reactor maintenance.

The current mission of this facility is to provide a versatile test environment for radiation shielding experiments in support of international agreements and advanced reactor designs. It is currently being used to complete studies for the Japanese-American Shielding Program of Experimental Research for the U.S. Advanced Liquid Metal Reactor Program.

DOE plans to operate the TSR-II through fiscal year 1992, when the Japanese-American shielding program is to be completed, probably in September 1992. DOE will probably shut the TSR down if a new mission is not found to fund the reactor's operation. ORNL, however, believes that there will be a future need for shielding experiments and utilization of the Tower Shielding Facility.

Condition

As a result of internal and external reviews of ORNL's research reactors that raised technical and management concerns, the TSR-II was shut down in 1987. The operating contractor made equipment upgrades, organizational changes, and documentation updates before the TSR was restarted in 1990.

The November 1990 Tiger Team audit disclosed a category II finding at the TSF involving an industrial safety hazard, which has since been corrected. In addition, the Tiger Team stated that the content and format of TSR's safety analysis report (SAR) did not comply with DOE guidance. ORNL stated that it will update this analysis if the TSR remains open after completion of its current mission and if ORNL receives funding to update the SAR.

Advanced Test Reactor Critical Facility (ATRCF)

- Location: Idaho National Engineering Laboratory (INEL), Test Reactor Area, Idaho Falls, Idaho
- Operating contractor: EG&G Idaho, Inc.
- Current status: Operating as of April 1992
- Approximate age: 28 years in 1992
- FY 1992 budget: $0.4 million

Facility and Mission Description

The ATRCF is a water-cooled, low-power (3.4-kilowatt) category "B" reactor whose core region is nearly identical to that of the Advanced Test Reactor (ATR). The ATRCF is designed to test prototypical experiments before irradiation of the actual experiments in the ATR. The ATRCF provides valuable reactor physics data that the ATR uses to set up its experiments.

Condition

The ATRCF was recently restarted after being shut down for failure to follow proper safety operating procedures. In addition, audits have noted deficiencies in ATRCF's SAR and technical specifications but concluded the ATRCF could resume operations with its existing documentation. EG&G plans to correct deficiencies in this documentation in 1992. The ATRCF will likely continue to operate as long as the ATR operates, since it is an important element of the ATR's program.

Transient Reactor Test Facility (TREAT)

- Location: Idaho National Engineering Laboratory, Argonne National Laboratory West Site (ANL-W), Idaho Falls, Idaho
- Operating contractor: University of Chicago
- Current status: Operating as of April 1992
- Approximate age: 33 years as of 1992
- FY 1992 budget: $4.8 million

Facility and Mission Description

The TREAT is an air-cooled, category "B" reactor designed to produce short, controlled bursts of nuclear energy. The purpose is to simulate accident conditions in other reactors leading to fuel damage, including melting or even vaporization of test specimens, while leaving the TREAT's "driver" fuel undamaged. These tests provide data that help (1) determine the consequences of accident conditions, (2) refine computer simulations of reactor accidents, and (3) ultimately design reactors with greater inherent safety.

The TREAT is located in a separate building at ANL-W and is separated from its control room by some distance. The TREAT conducts 50 to 100 pulsed experiments per year (currently about 50). Customers include DOE's New Production Reactor development program, Light Water Reactor development program, Integral Fast Reactor (IFR) development project, and Space and Defense Power Systems programs. In the next several years, the TREAT will be heavily involved with the EBR-II's support of DOE's IFR project. For example, fuel proposed for the IFR was exposed to different levels of radiation in the EBR-II and then tested for fuel response in accidents simulated in the TREAT.

Condition

In 1987, the TREAT was shut down for an extended period to complete upgrade modifications. The upgrades included new reactor instrumentation, reactor control computers, reactor filtration/cooling systems, and advanced control rod drive systems. The reactor building was enlarged to provide assembly storage and overhead handling space for experiments. The TREAT passed safety inspections and a readiness review before being restarted in 1989. According to the 1991 Tiger Team audit, TREAT's final safety analysis documentation, completed in November 1988, does not comply with DOE's guidance for format and content. A PRA has not been performed, but this assessment is not a DOE requirement. A plant life extension study has not been performed (this study is also not a DOE requirement), but, as discussed above, there have been major recent upgrades to the TREAT's control and safety systems.

Neutron Radiography Reactor Facility (NRAD)

- Location: Idaho National Engineering Laboratory, Argonne National Laboratory West Site (ANL-W), Idaho Falls, Idaho
- Operating contractor: University of Chicago
- Current status: Operating as of April 1992
- Approximate age: 14 years as of 1992 at the Argonne National Laboratory facility, but the reactor was used before 1978 in Puerto Rico.
- FY 1992 budget: $1.1 million

Facility and Mission Description

The NRAD is a small 0.25-MW reactor located below the main hot-cell examination facility at ANL-W. The core is cooled by the natural circulation of tank water. The NRAD is used to provide fast, high-quality neutron radiographs of fuels, materials, and components under examination at the hot-cell facility. For example, it has been or is being used to radiograph advanced metal fuel from the EBR-II; fuels from the Shippingport reactor, the Power Burst Facility, and the Space and Defense Power Systems programs; and experiments from the Fast Flux Test Facility. The NRAD will play an important role in the development work for DOE's Integral Fast Reactor Project and will also find important applications as long as ANL-W is involved in fuel development and evaluation.

Condition

The NRAD's safety documentation was updated in 1987 but does not comply with DOE's latest format and content requirements, according to the 1991 Tiger Team report. DOE's Chicago Field Office gave the NRAD an outstanding rating in its 1989 safety appraisal. One of the more severe challenges to the NRAD would occur if the water tank ruptured and the water leaked out, exposing the core. The presence of two large penetrations in the tank of the neutron radiography beam means that the laboratory should consider the probability of this kind of accident. The NRAD is unlikely to be affected by aging in the near term since the fuel elements are not subject to high temperatures, and the reactor operates essentially at atmospheric pressure.

Biological Research Reactor (JANUS)

- Location: Argonne National Laboratory, Argonne, Illinois
- Operation contractor: University of Chicago
- Current status: Operating as of April 1992
- Approximate age: 27 years in 1992
- FY 1992 budget: $0.6 million

Facility and Mission Description

The JANUS, which became operational in 1965, is a low-power, low-temperature research reactor cooled and moderated with water and operated at power levels up to 200 kilowatts. It is fueled with highly enriched uranium and housed in a cement block confinement building. Its reactor core is located in an aluminum tank 4 feet in diameter and 7 feet high that is surrounded by graphite, a common reflector material.

The reactor has been specifically designed as a facility for DOE's biological and medical research programs to perform cell and animal irradiations. Two irradiation rooms, a low-flux room and a high-flux room, located on opposite sides of the reactor, provide space for the irradiations. Exposure of specimens in the high-flux room is accomplished by lifting the room's shutters and exposing the specimen to a neutron stream from the operating reactor. Exposure of specimens has never been performed in the low-flux room because dosage measurements showed excessive gamma radiation and neutron-induced radioactivity in the room's walls, floor, and ceiling.

The JANUS conducts programs primarily for the Office of Health and Environmental Research in DOE's Office of Energy Research. Users have included research scientists from DOE, other government agencies, academia, private industry, and international groups.

During calendar year 1990, the reactor was in operation for 71 days, with seven major experiments conducted by Argonne scientists and other experiments conducted by scientists not associated with Argonne. During 1989, the reactor was in operation for 117 days. Biological experiments take several days to set up, conduct, and analyze—thus somewhat explaining the apparently low actual operating time for the reactor. Future plans call for continued reactor operation in support of DOE's Office of Energy Research programs.

Condition

Since 1985, the JANUS has undergone $155,000 worth of equipment upgrades. The cooling tower and secondary pipes were replaced in 1988 at a cost of $53,000. Air conditioning and fire protection upgrades and safety reevaluations were accomplished in 1990 and 1991 at a total cost of $160,000.

The JANUS reactor has undergone an increasing number of safety reviews over the past several years. For example, the responsible DOE field office performs safety appraisals and quality assurance reviews annually and the laboratory conducts numerous self-assessments. Many of the same deficiencies were found in these appraisals and assessments, but none was considered detrimental to the safe operation of the reactor. (The Tiger Team's 1990 audit of Argonne contained no specific recommendations for the JANUS.) These reviews noted that the JANUS should operate more formally by documenting all of its activities to ensure adherence to newly promulgated safety and quality assurance regulations. The laboratory budgeted $80,000 and $51,000 in its fiscal year 1991 and 1992 budgets, respectively, for correction of the deficiencies. In addition, the laboratory budgeted $190,000 in fiscal year 1992 for a plant life extension study to identify any upgrades necessary for continued operation.

Brookhaven Medical Research Reactor (BMRR)

- Location: Brookhaven National Laboratory (BNL), Upton, New York
- Operating contractor: Associated Universities, Inc.
- Current status: Operating as of April 1992
- Approximate age: 33 years in 1992
- FY 1992 budget: $1.1 million (expected to increase to $1.6 million in FY 93)

Facility and Mission Description

The BMRR, a 3-MW, light-water-cooled reactor, began operation in 1959. The reactor is housed in a 60-foot-diameter confinement building with three levels each for equipment, experiments, and operations.

Two cooling systems supply approximately 1,200 gallons per minute of water each to the core. The primary system uses high-purity treated water. The secondary water system routes water from dedicated wells in a "once through" configuration that returns the water to the ground.

The BMRR research reactor was designed and constructed for medical and biological research. The BMRR is operated to support research programs for the Office of Health and Environmental Research in DOE's Office of Energy Research. Its primary mission is to provide intense neutron beams for animal irradiation in developing the Boron Neutron Capture Therapy procedure for clinical trials in the treatment of certain brain tumors. The reactor normally operates up to 6 hours a day, 4 days a week. After the BMRR completes its work with animals in connection with developing this procedure, DOE may have to reassess the need for the BMRR and find new missions for it because, for the most part, the reactor is not suitable for treating most human brain cancers with the new procedure, according to Boron Neutron Capture Therapy researchers.

Condition

The reactor was shut down from March to August 1990 because of contamination surveys that were conducted at BNL as the result of a contamination incident at the HFBR. The contamination surveys found no areas of concern at the BMRR. After the reactor was restarted in August 1990, it operated at a reduced power (1.25 MW) because the 1990 Tiger Team found that the secondary cooling system was discharging contaminated water into the ground. It returned to its full 3-MW power in July 1991 when the cooling problem was corrected.

Because of the increasing number of safety oversight requirements, the BMRR plans to increase its full-time-equivalent personnel from about 4 in 1991 to 9 in 1992 and 10 in 1993, tripling its operating budget.

Test and Research Reactors Recently Assigned to Standby or Shutdown Status

The following category "A" reactor and category "B" reactors have recently been put on standby (may be restarted) or shutdown (no intention of restarting) status:

- Fast Flux Test Facility (FFTF), Hanford Site, Washington. The FFTF is DOE's newest (12 years old in 1992) and largest test reactor. It is a fast-spectrum category "A" nuclear reactor cooled by liquid metal sodium. It was constructed for the irradiation testing of reactor fuels and materials and for long-term testing of plant components and systems. It has a power rating of 400 megawatts (MW) and uses a fuel which is a mixture of uranium oxide and plutonium oxide. DOE planned to close the FFTF on April 1, 1992, because DOE had not been able to find a mission or missions to pay the FFTF's nearly $90 million annual operating costs. However, on March 13, 1992, the Secretary of Energy stated that the FFTF would be put on nonoperating standby status, effective April 1, 1992. He stated that this will give DOE more time to consider the FFTF for possible future DOE missions that may occur in the next several years. The cost to keep the FFTF on standby may be $60 million per year.
- Bulk Shielding Facility (BSF), Oak Ridge National Laboratory (ORNL). The BSF includes two reactors—the Bulk Shielding Reactor (BSR) and the Pool Critical Assembly (PCA). Both have been maintained in standby condition since 1987 at a cost of about $.5 million per year. The BSR was originally built in 1951 for studies of radiation shielding and low-temperature material damage studies. The PCA, built in 1956, was used to train reactor operators and nuclear engineering students. DOE, after unsuccessfully considering other potential uses for the BSF, is expected to shut it down in 1992.
- Zero Power Physics Reactor (ZPPR), Argonne National Laboratory West Site, Idaho. Since 1969, the ZPPR has been used to conduct experiments to obtain data on the criticality of different fuel systems and core configurations being considered for advanced reactor programs. It was placed on nonoperational standby in 1992 at an annual cost of about $1.5 million. The ZPPR may be restarted on an "as needed" basis to support such DOE programs as the Liquid Metal Reactor Program and the companion fuel recycling demonstration program—the Integral Fast Reactor Project.
- Advanced Reactivity Measurement Facility/Coupled Fast Reactivity Measurement Facility (ARMF/CFRMF), Idaho National Engineering Laboratory (INEL). The ARMF/CFRMF is actually two small (up to 100 kilowatts) reactors, similar in design, that share the same (water) cooling pool. The ARMF became operational in 1960 and the CFRMF in 1962. The ARMF is used for irradiations and reactivity measurements. The CFRMF is

used for irradiations, neutron radiography, determining hydrogen content, and other testing of materials. Both of these reactors were shut down in 1991 because of safety problems. DOE has been unable to find a sponsor to pay restart costs of about $1 million, including hardware modifications for the reactors. Other facilities can perform the type of services offered by the ARMF and the CFRMF. Thus, DOE is likely to permanently shut the reactors down if a sponsor cannot be found.

- Argonne Fast Source Reactor (AFSR), Argonne National Laboratory West Site, Idaho. The AFSR, a very small category "B" reactor, is in the process of being shut down; its fuel has been removed and it is being dismantled. When the reactor was operating, it was used on an infrequent basis to support the experiments of the ZPPR, generally for the development of measurement techniques and for instrument calibration.
- Health Physics Research Reactor (HPRR), Oak Ridge National Laboratory. The HPRR, a small category "B" reactor, was shut down in 1990 after about 27 years of operation. The HPRR provided a versatile facility for radiobiological research (the study of principles, mechanisms, and effects of radiation on living matter), radiation dosimetry (the measurement of the amount of radiation delivered to a specific place or the absorption of radiation), and nuclear reactor training.
- Power Burst Facility (PBF), Idaho National Engineering Laboratory. The PBF started operation in 1972. It was originally constructed to provide experimental data on nuclear fuel rods for the Atomic Energy Commission's light water reactor program. The reactor was shut down and placed on standby status in fiscal year 1985 after the Nuclear Regulatory Commission completed its testing mission. The PBF is funded by DOE's Office of Energy Research. In 1992, the PBF budget was $3.8 million. DOE had considered using the PBF to conduct treatment of brain cancer using the Boron Neutron Capture Therapy. However, committees examining this possibility have recently recommended that the PBF not be converted to a clinical facility. Such a conversion would cost about $80 million (including conversion and standby costs) and take about 7 years to complete (including time for compilation of the data necessary to make the conversion decision). Following the committees' recommendations, DOE has decided to close the PBF and possibly pursue the Boron Neutron Capture Therapy through a new clinical reactor and/or accelerator facility. This decision will be made after more data are gathered on the procedure and the possible technologies (reactor and accelerator) that may be used to support it.

Advanced Neutron Source Is Expected to Replace Two Older Reactors

DOE plans to replace two of its older category "A" research reactors—the High Flux Beam Reactor (HFBR) and the High Flux Isotope Reactor (HFIR)—with the Advanced Neutron Source (ANS) reactor. The ANS' conceptual design is expected to be completed before 1993 and the reactor is expected to begin operation early in the next decade.

Advanced Neutron Source

- Location: Proposed for Oak Ridge National Laboratory (ORNL), but the National Environmental Policy Act site selection has not been completed.
- Operating contractor: Martin Marietta Energy Systems, Inc.
- FY 1992 budget: $24.1 million

Facility Description

The ANS will be a heavy-water-cooled and -moderated reactor using highly enriched uranium silicide fuel clad in aluminum and positioned in a core pressure-boundary tube that can be replaced. An unpressurized tank of heavy water that serves as a neutron reflector and moderator will surround the core pressure-boundary tube. Targets for materials irradiation and transplutonium production will be located near the core, inside the core pressure-boundary tube, while beam tubes and other irradiation facilities will be located in the reflector tank. Four major buildings are planned: a reactor containment building, a reactor support building, a guide hall building, and an office building.

Mission

The ANS is a new, experimental facility planned to meet the nation's need for an intense, steady-state source of neutrons. It will be equipped with an initial complement of advanced instruments for neutron scattering and nuclear physics research as well as facilities for isotope production and the study of materials in high radiation fields. The ANS will replace the HFBR (located at Brookhaven National Laboratory) and the HFIR (located at Oak Ridge National Laboratory).

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