RESEARCH REACTOR USAGE AT THE IDAHO NATIONAL ENGINEERING LABORATORY IN SUPPORT OF UNIVERSITY RESEARCH AND EDUCATION

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ABSTRACT

The Idaho National Engineering Laboratory is a US Department of Energy laboratory which has a substantial history of research and development in nuclear reactor technologies. There are a number of available nuclear reactor facilities which have been incorporated into the research and training needs of university nuclear engineering programs. This paper addresses the utilization of the Advanced Reactivity Measurement Facility (ARMF) and the Coupled Fast Reactivity Measurement Facility (CFRMF) for thesis and dissertation research in the PhD program in Nuclear Science and Engineering by the University of Idaho and Idaho State University. Other reactors at the INEL are also being used by various members of the academic community for thesis and dissertation research, as well as for research to advance the state of knowledge in innovative nuclear technologies, with the EBR-II facility playing an essential role in liquid metal breeder reactor research.

HISTORY

The Idaho National Engineering Laboratory (INEL) is a US Department of Energy laboratory with a long history of activity in nuclear technology development. Roughly sixty nuclear reactors have been designed, built and operated at the INEL in the past forty years. The variety of reactors operated at the INEL includes reactors for materials research, nuclear fuels testing, reactor concept validation and severe accident research. A series of light water reactors were developed and operated for nuclear materials research, among them the Materials Test Reactor (MTR), the Experimental Test Reactor (ETR) and the Advanced Test Reactor (ATR). The concept of a liquid metal-cooled breeder reactor is presently being validated with the Experimental Breeder Reactor (EBR-II) program. Fundamental studies of severe accident phenomenology of light water reactors have been conducted with the Power Burst Facility (PBF) and the Loss of Fluid Test (LOFT) reactors. These are just a few of the major reactor facilities which have been implemented at the INEL over the past decades.

With a total work force of over 11,000, the INEL has a large contingent of degreed nuclear engineers at all levels. Nuclear engineers are involved in the operation of nuclear reactor facilities and in research, development, design and testing of various nuclear technologies. The Laboratory mission has broadened from the early days as the National Reactor Testing Station, but it continues to include a substantial amount of work in advanced technology development related to nuclear power and nuclear safety. Programmatic work at the INEL includes work on Modular High Temperature Gas-cooled Reactor (MHTGR) design, advanced Light Water Reactors design (ALWR) and safety, nuclear reactors for space and non-terrestrial environments, safety of commercial nuclear reactors and severe accident research for existing and planned nuclear reactors. Such work is typically done in support of the missions of the US Department of Energy (DOE) and the US Nuclear Regulatory Commission (NRC).

PhD PROGRAM IN NUCLEAR SCIENCE AND ENGINEERING AT INEL

The availability of graduate nuclear engineers to meet the programmatic requirements at the Laboratory has been viewed with some concern in recent years. The combination of growing programs in nuclear technologies at our Laboratory with decreasing enrollments in nuclear engineering at our nation's universities[1,2] is likely to lead to a substantial personnel shortfall. In 1989, in response to this concern, the Idaho Operations Office of the US Department of Energy (DOE) contracted with the University of Idaho (UI) and Idaho State University (ISU) to establish a resident PhD program in Nuclear Science and Engineering for the Idaho Falls area[3]. That program was approved by the Idaho State Board of Education in the summer of 1989 and was begun in the fall of that year.

A resident Director has been appointed for the new PhD program. Dr. Alan Stephens, formerly Associate Dean of Engineering at ISU, has taken on this new responsibility as of January, 1990. He will be joined within the

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next six months by two additional full-time faculty members who will develop and implement this program at the Idaho Falls Center for Higher Education.

The program is open to all applicants, but was specifically developed for the resident staff members at the Laboratory. The enrollment in the program in the first year is twelve students, and it is anticipated that the program will grow to a steady state of twenty to twenty five active participants within a few years. An important facet of this program is ready access to facilities at the INEL for conducting thesis and dissertation research. This includes nuclear reactors, and the subject of this paper is research activities underway which are available to PhD students in this program.

UTILIZATION OF EXISTING REACTOR FACILITIES FOR THESIS AND DISSERTATION RESEARCH

The Advanced Reactivity Measurement Facility (ARMF) and the Coupled Fast Reactivity Measurement Facility (CFRMF) are 100 kW swimming-pool reactors located in the same pool at the Test Reactor Area (TRA) of the INEL. TRA is about fifty-five miles west of Idaho Falls, in the center of the 890 square mile isolated desert site that is an important research asset of the Laboratory. Because of the distance from Idaho Falls, experiments in those facilities are best accomplished by individuals with assignments at the site or those who regularly visit there for their work activities. The reactors at TRA are used for a wide variety of research and training activities which support the missions of the Laboratory.

The ARMF and CFRMF reactors are generally available to laboratory researchers in need of neutron or gamma irradiation for experimental tests. This will include staff members pursuing the PhD in Nuclear Science and Engineering in the UI/ISU program, as well as external academic visitors conducting their research at the INEL. While dissertation research activities are just being planned by this new group of PhD students, the past and present programmatic use of these facilities suggests the breadth of research which they can undertake here. Research activities supported at the facility include: neutron activation analysis for trace element identification, neutron radiography to image hydrogen concentration in specimens, radiation damage effects studies, radioisotope production, reactivity measurements, reactor physics studies and reactor training.

The operational character of these reactors is similar to a number of university facilities, with some differences. The unique capabilities of the ARMF reactor include a square cross section vertical access tube which provides an access of large cross-section (13 cm x 13 cm) to a peak fast ... flux region of 10 (12) n/cms /sec. I... ations in that port can be performed over a wide temperature range, from hundreds of degrees Celsius to 77 Kelvin. A future cryogenic facility may permit the irradiation of samples down to 4 Kelvin. Complete hardware packages, such as electronic components and optical components can be irradiated, with measured response made in-situ. For experiments requiring large beam volume and easy access, a beam tube provides a large area irradiation of 10 (7) n/cms /sec at the top of the reactor bridge.

The CFRMF is similar to the ARMF, but has a pneumatic rabbit tube passing through the reactor core for irradiation of samples and the rapid transfer of such samples in and out of the core. Irradiated samples are counted with high resolution gamma spectrometers as well as with beta and alpha detectors, as appropriate to the particular experiment. The reactor also has a burst mode of operation available for experiments requiring a short pulse of high intensity radiation.

Research which has been done or is underway using these reactor facilities includes a number of areas of nuclear engineering science. Radiation damage experiments have been conducted on nuclear fuels and nuclear system components, including pressure vessel materials. The effects of irradiation temperature and fluence on the optical transmission of laser components have been determined. Hydrogen accumulation in irradiated metals and ceramics has been studied. There have been dosimetry and health physics studies, as well as the study of the chemistry of fission products and the breeding and burnup of fissile fuels.

Research opportunities for academic use of these reactors also include science and engineering outside of traditional nuclear engineering fields. Areas in which research can be supported at these facilities include materials science, life sciences, environmental sciences, geology and geophysics, history and forensic science, archaeology, space science, nuclear physics and chemistry.

UTILIZATION OF EXISTING REACTOR FACILITIES FOR STUDENT REACTOR OPERATOR TRAINING

Training of MS level students in reactor operation has also been conducted using these facilities in the past. It is anticipated that a laboratory course in advanced nuclear reactor operation will be of value to many PhD students in experimental programs. Typical approved experiments include: void coefficient of reactivity; differential and integral control rod worth; reactivity of various sample materials as a function of location; and distribution of neutron flux in and near the core. The students can also participate in typical reactor operating procedures, including approach to critical, startup and shutdown, as well as learn of operational requirements for compliance with technical specifications.

SUMMARY AND CONCLUSIONS

In summary, this paper has addressed the use of Laboratory reactors at the INEL to support the PhD program of the University of Idaho and Idaho State University in Nuclear Science and Engineering. The Advanced Reactivity Measurement Facility (ARMF) and the Coupled Fast Reactivity Measurement Facility (CFRMF) are the particular reactors discussed. Research which can be supported by these facilities includes neutron activation analysis, neutron radiography, radiation damage effects studies, radioisotope production, reactivity measurements and reactor physics studies. In addition to research, a substantial amount of training in reactor experiments can be conducted as a component of a PhD program. Other reactors at the INEL are also being used by various members of the academic community for thesis and dissertation research, as well as for research to advance the state of knowledge in innovative nuclear technologies. In particular, the EBR-II facility is playing an essential role in liquid metal breeder reactor research.

REFERENCES

[1] An annual survey of the status of nuclear engineering is conducted under the auspices of the US Department of Energy and the US Nuclear Regulatory Commission, the most recent version is published as "Nuclear Engineering Enrollments and Degrees, 1987," DOE/ER-0370, US Government Printing Office (1988).

[2] There is further discussion of the enrollment and education of nuclear engineers in "Nuclear Engineering Case Study," by D. M. Woodall, presented to the National Academy of Engineering workshop, "National Priorities and Technological Change: Fostering Flexibility in the Engineering Workforce," September 29, 1989.

[3] Program initially discussed in a paper by Charyulu, Jacobsen, and Stephens at the June, 1989, Annual meeting of the ASEE in Lincoln, Nebraska.

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