Nuclear Reactor Laboratory

The MIT Nuclear Reactor Laboratory (NRL) is an interdepartmental center that operates a high-performance research reactor, known as the MITR-II, that supports MIT's educational and research initiatives and goals. After many years of planning, followed by the arduous process of relicensing, the MITR-II is now successfully operating at its approved licensing limit of 6 MW. To reach this long sought-after higher operating power, major improvements were made to several reactor operating systems. This achievement resulted in a 20% increase in neutron flux that will benefit researchers and students from MIT and across the country when they conduct research using the MITR-II.

"Photograph by Judith M. Daniels"

For the past 54 years, the NRL has provided both a safe and reliable neutron source and the infrastructure to facilitate use of that source. During its long and distinguished history, the NRL has supported educational training and cutting-edge research in the areas of nuclear fission engineering, material science, radiation effects in biology and medicine, neutron physics, geochemistry, and environmental studies. As a result, countless undergraduate and graduate students have benefited from their association with the NRL. It is the only major research university with a research reactor facility in the US where students can be directly involved in developing and implementing nuclear engineering experimental programs with neutron flux levels comparable to those of power reactors. As such, the MITR-II is indispensable to developing the workforce that will realize new visions for the future of nuclear power.

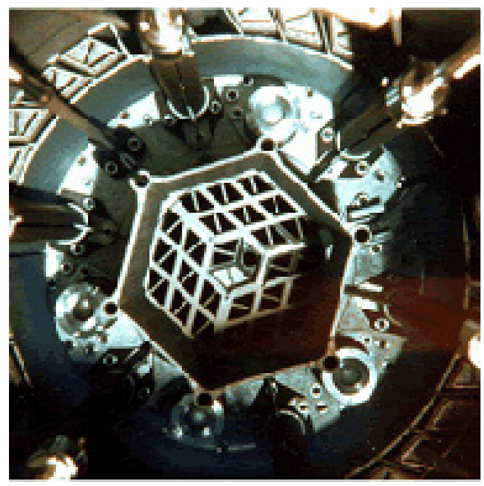
Facilities and Resources

The NRL's primary mission is to provide faculty and students from MIT, as well as the national scientific and engineering community, with both a state-of-the-art reactor facility and the infrastructure to enable and support its use for research and other societal objectives. The highest priority is placed on operating the research reactor in a highly professional manner that is safe for MIT, NRL staff and researchers, the public, and the environment. A secondary, but no less important, mission is to educate the general public about the benefits of maintaining a strong nuclear science program in the US. This is accomplished by providing tours and lectures that describe and clarify different nuclear science and technology programs.

The MITR-II is the second of two research reactors that have been operated by the NRL. The original reactor (MITR-I) achieved criticality in 1958. It was shut down in 1973 to allow conversion to the MITR-II, which offered a higher neutron-flux level. On July 8, 1999, a formal application was submitted to the US Nuclear Regulatory Commission

(NRC) to relicense the reactor for an additional 20 years and to upgrade the power level from 5 MW to 6 MW; the license and upgrade permission were granted in 2010. Now that that major endeavor has been effectively carried out, the next goal for the NRL is to convert the MITR-II's fuel from high-enriched uranium (HEU) to low-enriched uranium (LEU). Research funded under the Reduced Enrichment for Research and Test Reactors Program of the US Department of Energy (DOE) is now being conducted; this research will enable the MITR-II to meet this all-important, as well as highly anticipated, milestone.

The MITR-II, the major experimental facility of the NRL, is a heavy-water-reflected, light-water-cooled- and moderated nuclear reactor that utilizes flat, plate-type, finned, aluminum-clad fuel elements. The average core power density is about 70 kW per liter. The maximum fast and thermal neutron fluxes available to experimenters are 1.2×10^{14} and 6×10^{13} neutrons/cm^2, respectively. Experimental facilities available at the research reactor include two medical irradiation rooms, beam ports, automatic transfer facilities (pneumatic tubes), and graphite-reflector irradiation facilities. In addition, several in-core sample assemblies (ICSAs) are available. It generally operates 24 hours a day, seven days a week, except for planned outages for maintenance. The MITR-II encompasses a number of inherent (i.e., passive) safety features, including negative reactivity temperature coefficients of both fuel and moderator, a negative void coefficient of reactivity, the location of the core within two concentric tanks, the use of anti-siphon valves to isolate the core from the effect of breaks in the coolant piping, a core-tank design that promotes natural circulation in the event of a loss-of-flow accident, and the presence of a full containment building. These features make it an exceptionally safe facility.



Reactor Administration

The NRL's organizational structure is composed of four groups that work as a team to meet the short-term operational demands and long-term strategic challenges involved in operating a nuclear research reactor in the current environment. These groups are reactor operations; research, development, and utilization; engineering; and administration. David Moncton is the director of the NRL. He and Thomas Newton (director of reactor operations and associate director of reactor engineering), Lin-Wen Hu (associate director of research, development, and utilization), Edward Lau (assistant director of reactor operations), John Foster (reactor superintendent), John Bernard (senior advisor), and Mary Young (administrative officer) make up the NRL's senior management team. The team works to sustain the NRL's long-standing record of safe operation, to maintain and improve upon the MITR-II and its experimental facilities, and to provide an environment of support and excellence for researchers and students.

The NRL currently employs 45 individuals. The staff consists of six groups, including the previously mentioned seven senior staff. There are also six research staff, four technical staff, 12 technical support staff, two academic staff, three administrative support staff, two technicians, eight part-time student operators, and three student trainees. In general, NRL support staff, student employees, and technicians have specific responsibilities to a particular group.

Reactor Operations

Leadership of the reactor operations group is provided by director of reactor operations Thomas Newton, assistant director of reactor operations Edward Lau, and reactor superintendent John Foster. The reactor operations group, the largest at the NRL, is responsible for supporting all laboratory activities, with priority given to operation and maintenance of the 6 MW research reactor. The group consists of full-time employees and part-time undergraduate students. Almost all of the 26 members of the group are licensed by the NRC, and most hold a senior reactor operator (SRO) license. These licensed individuals perform reactor shift duties to support the 24/7 operating schedule. In addition, there is one full-time project mechanic to support reactor mechanical maintenance. Reactor operations supported the following NRL research projects: advanced cladding irradiation (ACI-2); hydride-fueled irradiation; heated ICSA; 4DH4 diffractometer; and 4DH1 student spectrometer.

The MITR-II reactor completed its 54th year of operation (its 37th since the 1974–1975 upgrade and overhaul). Beginning in 1994, the reactor was put on a schedule of continuous operation to support major experiments and utilization. The reactor was nominally maintained at a full power of 5.5 MW or higher. Total energy output for FY2012 was 24,200 megawatt-hours. This translates roughly to 4,200 hours of operation at full power.

Major NRL maintenance and upgrade projects accomplished in FY2012 include:

- Reactor staff coordinated with MIT's Department of Facilities to perform major maintenance on the main circuit breakers for Building NW12 and the reactor. This included cleaning, testing, and adjusting the eight relays from the two 13,800-volt substation breakers. All of the other 21 circuit breakers in the utility room, plus 10 circuit breakers and a transformer in the adjacent electrical cage, were cleaned and tested. Two 208-volt circuit breakers were refurbished. One full 208-volt circuit breaker was procured as a spare.
- Reactor staff coordinated with MIT Facilities and subcontractors for a complete replacement of the main fire alarm panel in building NW12,modernization and increased capacity, and the addition of an auxiliary fire alarm indicator panel in the NW12 front entry. Upgrades also included new smoke detectors in the NW12-100D utility room, various emergency-exit door fire alarm pull-boxes (as required by current building code, an outdoor strobe light on the building's front, and a smoke detector in the NW12-139AD server room. Successful testing of the new system by an independent fire alarm system consultant was completed in March 2012.

- Reactor staff also coordinated with MIT Facilities' engineering division to perform an engineering study of the upgrading of the fire alarm system in the reactor containment building and installation of a mist-based fire suppression system for the control room's instrument panel.
- Reactor staff modified the pressure relief system for the reactor containment building such that its pair of charcoal filter banks can be activated without reactor shutdown by causing air to flow into one filter bank and out the other.
- Reactor staff updated several sets of procedures, including the abnormal operating procedures, the standard operating plans, the test and calibration procedures, and the emergency plan. The security plan was also revised to include features of the reactor security system enhancements that had been installed in phase I and phase II in FY2010 and FY2011.
- Reactor staff worked with MIT Information Services and Technology (IS&T) to develop new job notification and occurrence reporting software. A prototype was developed and tested by selected reactor and NRL staff members to provide system testing and feedback. This system will take the place of the existing paper-based reactor maintenance history records and is scheduled to be in use by the entire staff by early FY2013. The new system aims to improve communication regarding repair requests, to enhance access for management oversight, and to provide a platform for documenting observations, occurrence analysis, and follow-up actions.

Many other routine maintenance and preventive maintenance items were also scheduled and completed throughout the fiscal year for experiments and for reactor operations.

Student Reactor Operator Training Program

To fulfill one of the stated missions of the NRL, the reactor operations group trains up to six MIT undergraduates each year (typically starting in their freshman year), to obtain an NRC license to operate the MIT reactor. The training program is rigorous and covers reactor dynamics, radiation detection, radiation safety, and reactor systems. The level of instruction is comparable to that offered in undergraduate courses covering the same topics. Students are also taught how to operate the MITR-II. On completion of the training program, students take a two-day examination administered by the NRC (one day written, one day oral). Successful candidates receive a reactor operator (RO) license and are employed part time. After the students gain experience, most are offered the opportunity to participate in a second training program that leads to a senior reactor operator license. This training program is an excellent educational opportunity for undergraduate students because it combines theoretical study with hands-on experience—squarely in the MIT tradition of graduating students who know how to design and build systems. In addition, students who receive the SRO license obtain management experience by serving as shift supervisors. Students who have completed this training program have regularly reported that it was one of the high points of their MIT experience.

From July 2011 through June 2012, two sets of NRC examinations were administered at MIT: in October 2011 there were two student candidates for the RO license and one student candidate for an upgrade to an SRO license; in January 2012 there was one student candidate for an upgrade to an SRO license. All candidates passed. Three MIT students, two ex-Navy nuclear operators, and five candidates for upgrades to SRO licenses are in training for the next NRC examination, scheduled for September 2012.

Reactor Research Facilities and Services

Partnership with Idaho National Laboratory

The NRL is in a partnership with the Idaho National Laboratory's (INL's) Advanced Test Reactor National Scientific User Facility (ATR NSUF) to perform advanced nuclear fuel, materials, and instrumentation irradiation experiments that are crucial to future-generation reactors. High-temperature and radiation-resistant materials are needed for advanced high-temperature reactor designs that would exhibit high thermal efficiency, as well as for hydrogen-production reactors. A related and equally important goal is to identify advanced fuels and materials that will enable both the extension of service and improved economic performance in the existing light-water reactor (LWR) fleet. This collaboration is designed to increase user access to national reactor irradiations and testing capabilities. NSUF test spaces at ATR, MITR, and other facilities are made available at no cost to external users, whose projects are selected through a peer review process. The MITR will offer a portion of its test capability to NSUF experimenters. Lin-Wen Hu and Gordon E. Kohse jointly manage the NRL and ATR NSUF partnership.

In-core Loops and Capsule Irradiation Facilities

The NRL has a strong in-core experimental program that supports research in advanced materials and fuels that are necessary for both existing and advanced power reactors. The MITR offers a unique technical capability that involves the design and use of in-core loops that replicate pressurized-water reactor and boiling-water reactor conditions to study the behavior of advanced materials and to perform scoping studies of advanced nuclear fuel. With rekindled national interest on the part of DOE and the nuclear industry in next-generation nuclear power systems, many intended to use novel materials and advanced forms of fuel, facilities are needed to test material and fuel behavior in a variety of radiation environments. The MITR is the university reactor best suited for carrying out such basic studies because of its relatively high power density (similar to that of a LWR), its capability to control chemistry and thermal conditions to reflect prototypic conditions, its easy-access geometric configuration, and its in-core space for up to three independent irradiation tests.

Post-irradiation Examination Facility

The MITR-II is equipped with post-irradiation examination facilities that include two top-entry hot cells with manipulators (1,000 Ci capacity each), a lead-shielded hot box (20 Ci capacity) with manipulators, an overhead crane with 3- and 20-ton capacities, and several transfer casks. One of the hot cells is currently equipped to disassemble and reassemble in-core water loop sample trains; the hot box is set up to perform similar tasks for ICSA capsules. In addition to these reactor-containment facilities, an exclusion-area laboratory is equipped for irradiated sample mechanical tests (tube specimens and miniature four-point bend test bars) and for irradiated sample sectioning and polishing.

Nanofluids Laboratory

The Nanofluids Laboratory experimental facilities and associated instrumentation are part of the Thermal Hydraulics Laboratory, supported jointly by MIT's Department of Nuclear Science and Engineering (NSE) and the NRL. These facilities can be used for research projects in general, for heat transfer and two-phase flow research, and for teaching at both the undergraduate and graduate levels. Experimental facilities and advanced instrumentation were constructed or acquired with funding support from industry sponsors AREVA, the Electric Power Research Institute, ABB, Idaho National Laboratory, the DOE Nuclear Education and Engineering Research Program, the DOE Innovations in Nuclear Infrastructure and Education Program (INIE), and Saudi Arabia's King Abdulaziz City of Science and Technology. The facilities can be described briefly as follows:

- Single-phase heat transfer loops: These are forced convection loops designed and constructed by MIT students and staff to investigate nanofluid heat transfer and pressure drop characteristics in laminar and turbulent flow regimes.
- Critical heat flux (CHF) loop: The CHF facility obtains flow CHF data for different types of nanofluids.
- Pool boiling facility: This apparatus is designed to understand the fundamental CHF mechanism. The facility is equipped with a thin indium-tin-oxide heater deposited over a sapphire substrate to provide a direct bottom-up view of the boiling phenomena on the heater surface and with an optical probe for measuring bubble size distribution.

Neutron Capture Therapy User Center

The Neutron Capture Therapy User Center comprises the following facilities and capabilities:

- High-intensity, high-purity beams of thermal and epithermal neutrons that approach the theoretical optimum for boron neutron capture therapy (BNCT).
- Physical and computational dosimetry associated with experimental (and clinical) studies.

- Bulk analysis of boron distributions in tissue specimens using prompt gamma neutron activation analysis (PGNAA) or inductively coupled plasma atomic emission spectroscopy (ICP-AES).
- Assistance with designing and performing animal or cell culture experiments to test new boron tumor-targeting agents or translational research to initiate new clinical trials in BNCT.

The thermal and epithermal neutron medical irradiation facilities are the only beams licensed by NRC for clinical trials. The fission converter-based epithermal neutron beam line has been augmented to include an optional lithium filter that improves beam penetration and increases the therapeutic ratio for deep-seated tumors by as much as 15%.

The center maintains and operates the reactor's fission converter, PGNAA, and the thermal neutron beam facilities used primarily for boron drug testing and characterization.

Neutron Spectrometer Experimental Facility

The web-enabled time-of-flight experimental facility can be operated locally or remotely over the Internet using MIT's iLabs server architecture. Hardware and software upgrades made during previous years improved reliability and supported a heavy schedule of student experiments in both the fall and spring terms. The longer data collection times that are feasible with remote operation have both markedly improved the data quality available to students and greatly enhanced the educational value of the experiments conducted. Continued incremental improvements to the hardware and software are planned, together with outreach efforts to broaden the user base of the facility outside MIT. The US Military Academy at West Point ran experiments on the facility using iLabs as part of its physics and nuclear engineering instrumentation laboratory course during the fall semester of 2011 and plan to use the facility in fall 2012. In addition to the educational use, the time-of-flight beam is in use as part of a research program to measure neutron capture cross-sections for copper isotopes; this program has funding from Oak Ridge National Laboratory and the participation of a graduate and undergraduate student and Professor Benoit Forget of NSE. Researchers from INL used the facility for testing neutron detectors that are under development.

Neutron-scattering Facility

The revitalization of the NRL's neutron-scattering capability is complete. This program, funded by the National Science Foundation, began several years ago under the direction of Professor Moncton with the assistance of research scientist Boris Khaykovich. As a result of their efforts, the NRL's neutron-scattering capability, , includes new neutron-scattering instruments, a neutron diffractometer with polarizing capabilities, and a neutron optics test station. Both instruments are operational. Professor Moncton and Dr. Khaykovich use the neutron optics test station in a DOE-funded neutron optics research program whose goal is to develop specialized neutron-focusing optics for scattering and imaging applications. In addition, professor Peter Fisher and several outside groups have used the test station to develop novel neutron detectors.

Neutron scattering and spectroscopy are among the preeminent tools for studying the structure and dynamics of matter at the atomic and molecular scales. A powerful new neutron facility, the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory (ORNL), is expected to revolutionize this field and enable the United States to regain the leadership in this field that was lost to Europe decades ago. SNS will inspire a new generation of instrument development, a new generation of neutron scientists, and, as a result, new scientific research with neutrons.

The NRL envisions the following programs resulting from this initiative:

- Education and training for students in basic concepts of neutron scattering
- Enhanced production of new materials at MIT and elsewhere by allowing rapid evaluation via neutron scattering
- Development of novel neutron optics components
- Conceptual development of new instruments for future installation at SNS
- Establishment of a facility designed to allow users from outside MIT to conduct early phases of some experiments more quickly than at large facilities, and to test and develop new neutron optics components.

Environmental Research and Radiochemistry

The NRL's environmental research and radiochemistry laboratories are equipped for both prompt and delayed gamma neutron activation analysis (NAA). A prompt gamma spectrometer was built as part of the BNCT program to measure the boron content in the blood and tissue of patients and experimental animals; this and is now available to other users. With respect to delayed NAA, the MITR-II is equipped with two pneumatic tubes that are commonly used for NAA, primarily for analysis of trace metals. One offers a thermal flux of 5.7×10^{13}, and the other offers a thermal flux of 7.2×10^{12}. Several of the tubes are automated so that samples can either be ejected to a hot cell within the reactor containment or be transferred via a pneumatic tube to a laboratory in an adjacent building. In addition to the pneumatic tubes, there are four water-cooled facilities in which large numbers of samples can be simultaneously irradiated in a uniform flux. Samples in these facilities can be rotated. ICP-AES is also available at the NRL. The NRL's NAA laboratory is equipped with three high-purity germanium systems with Genie 2000 software.

The NRL makes its NAA facilities and expertise available to industry, other universities, private and governmental laboratories, and hospitals. Research- and service-oriented collaborations were continued with several MIT research laboratories as well as with other educational and research institutions.

Reactor Engineering

Thomas Newton is the NRL's associate director for engineering. This group's activities include support and development for experiments such as the ICSA, the high-temperature irradiation facility, and ACI-2s. This group also performs neutronic modeling of proposed experiments for evaluation of neutron fluxes, reactivity, and heat generation. Work with ex-core experiments, including upgrade and operation of a neutron diffractometer, has continued as well. Other activities of this group include engineering support of upgrades to reactor mechanical and instrumentation systems, supervising the management of fuel in the reactor and fission converter, and overseeing shipments of spent fuel. The group also offers other engineering services as needed.

Dr. Newton is also the principal investigator for the program to convert the reactor to LEU fuel. The Global Threat Reduction Initiative (GTRI) Program under DOE has committed to converting all research reactors using HEU to LEU. Although a number of lower-power reactors have been converted under this program, the remaining five US reactors with higher power densities (the MITR-II, the University of Missouri Research Reactor Center, the National Institute of Standards and Technology Reactor, the High Flux Isotope Reactor at ORNL, and the Advanced Test Reactor at INL) require the development of fuels with significantly higher densities. Such a fuel, a monolithic uranium-molybdenum fuel with a uranium density of about 16 g/cm^3, is under development and is undergoing qualification testing. The MITR-II is expected to be the first reactor in the world to use this fuel.

With continuing support from the GTRI program, neutronic and thermal-hydraulic modeling tools for the MITR-II conversion study have been developed and benchmarked for both steady-state and transient conditions. These models are being used to compare the current HEU fuel with proposed LEU fuels. Burn-up modeling tools using both Monte Carlo and diffusion theory methods have also been developed so that fuel life, reactivity, neutron fluxes, and power peaking can be evaluated over time. Such models are being used to determine core performance and to develop a fuel management strategy that will reduce power peaking in the LEU core while meeting experimental as well as fuel-supply needs.

Feasibility studies have shown that this LEU fuel can be used in the MIT reactor, although without an increase in reactor power it could come at a significant penalty in neutron flux to in-core and ex-core experimental facilities. These studies have also shown that the reactor could operate using LEU fuel at or near 7 MW without significant changes to the reactor infrastructure, which would allow all experiments to operate with the same or greater neutron fluxes present in the current HEU core at 6 MW.

Studies on mixed HEU–LEU cores show that it also appears feasible to introduce LEU into the current core to allow testing under nominal operating conditions during the transition.

Reactor Research, Development, and Utilization

Lin-Wen Hu is the associate director of the research, development, and utilization group. She and her staff have developed a robust program that assists MIT faculty, researchers, and students, as well as those outside the NRL, in their use of the reactor and its irradiation facilities. Tasks undertaken by this group include:

- Supporting research in the area of advanced materials and fuel research
- Providing researchers with a service-based infrastructure that utilizes the MITR-II for trace element analysis, isotope production, and irradiation services
- Supporting an outreach program to the educational community to encourage understanding of nuclear energy and its applications
- Supporting MIT's educational missions by providing Independent Activities Period lectures, hosting Undergraduate Research Opportunities Program students, and offering laboratory courses for professionals, undergraduates, and advanced secondary school students
- Expanding the user base for underutilized experimental facilities

Irradiations and experiments conducted during this reporting period include the following:

- Activation of gold-198 seeds for brachytherapy
- Irradiation of germanium wafers for material science studies
- Activation of uranium and plutonium foils for detector calibration at the Los Alamos National Laboratories
- Activation of ocean sediments for the Woods Hole Oceanographic Institute
- Activation of Teflon and NAA standards for the University of Alabama
- Activation and NAA of ultra-high-purity boron-11 for a trace element analysis conducted by Ceradyne Boron Inc.
- Activation and NAA of cerium oxide and barium sulfate nanoparticle samples for animal tracer studies at Harvard School of Public Health
- Activation and NAA of FLiNaK and FLiBe salt crystals in conjunction with the MIT portion of the Liquid Salt Reactor Project
- Experiments at the 4DH1 radial beam port facility by MIT undergraduate and graduate students, including measurements of leakage in the neutron energy spectrum to determine reactor temperature, measurements of neutron wavelength and time of flight, and measurements of attenuation coefficients for eight shielding materials
- Use of the reactor for training MIT student reactor operators and for NSE classes (22.06 Engineering of Nuclear Systems; 22.09 Principles of Nuclear Radiation Measurement and Protection; 22.921 Nuclear Power Plant Dynamics and Control; and the reactor technology course for nuclear power executives)

- Use of the thermal neutron beam for testing gadolinium-based solid-state neutron detectors for Lincoln Laboratories researchers
- Neutron transmutation doping of germanium wafers for both the Lawrence Berkeley National Laboratory (LBNL) and the National Institute for Nuclear Physics and subsequent use of the wafers for further neutrino detector research at LBNL

Research Programs

In-Core Loops

After the advanced cladding irradiation experiment was successfully completed in October 2007, a new set of internal features—including bend test bars, thermal conductivity specimens, and a set of tube specimens—were designed, manufactured, and installed to accommodate a second advanced cladding irradiation campaign. This second round of in-core irradiations of silicon-carbon cladding with a planned in-reactor exposure of two years started in February 2009, with funding from Toshiba/Westinghouse. The same experiment, with different SiC composite samples, was also selected for funding by INL's ATR NSUF. This project began in mid-June 2009 and continued throughout FY2011, with several intermediate sample examinations and change-outs. In addition to tube samples of composite cladding, specimens to evaluate the performance of candidate end-sealing methods were irradiated. Professor Mujid Kazimi is the principal investigator for this project.

Irradiation of hydride metallic fuel was completed in FY2012. This fuel matrix is being studied by University of California, Berkeley (UCB) researchers for use in advanced LWRs. This fuel irradiation project was selected by the ATR user facility to be performed at the MITR-II. Working closely with UCB and INL staff, the fuel capsules were designed and fabricated and the irradiation was completed in December 2011.

In March 2011, the NRL was able to operate three in-core experiments simultaneously for the first time since the MITR-II was built in the 1950s. This accomplishment reflects the successful planning and execution of reactor experiments by the utilization and research development group with the support of reactor operations and reactor radiation protection staff. The following in-core experiment projects are ongoing as a result of the partnership with ATR NSUF and other DOE initiatives:

- ACI loop for LWR SiC composite cladding irradiation
- Hydride fuel capsule irradiation
- High-temperature material titanium compounds (MaxPhases)
- High-temperature irradiation resistant thermocouples irradiation in ICSA

New Initiatives

The NRL and the Nuclear Science and Engineering Department, in collaboration with UCB and the University of Wisconsin, are pursuing research in the area of high-temperature fluoride salt-cooled reactors. DOE selected a proposal titled High-Temperature Fluoride Salt-cooled Reactor for Power and Process Heat under its Integrated Research Project. This effort aims to develop a path to a commercially viable salt-cooled, solid-fuel, high-temperature reactor with superior economic, safety, waste, nonproliferation, and physical security characteristics compared with LWRs for base-load electricity production and process heat applications. A $7.5 million research grant was awarded for three years to pursue this new reactor concept. Dr. Charles Forsberg and Dr. Lin-Wen Hu are the MIT principal investigators. Although the end product is a pre-conceptual reactor design and a development roadmap, the experimental and analytical work will:

- Conduct material tests in laboratory loops and the MIT reactor to test key materials required in-core and out-of-core.
- Develop the appropriate tools for the thermal hydraulic/neutronic/safety analysis, validated with experiments using salt stimulants to provide key data.
- Develop pre-conceptual point designs for a test reactor and commercial prototype reactor.
- Conduct a series of workshops and collaborative research and development (R&D) to support the development of the roadmap to commercialization that includes defining what is known and unknown, R&D needs, and a prioritized development strategy (technology, licensing, and so on).

Safety and Security

Operational Safety

The Nark's Office of Nuclear Reactor Regulation has oversight responsibility for program management, inspections, and operator licensing for all test and research reactors, including the MITR-II. Many years ago, MIT established its own means of ensuring safe operation of the nuclear reactor by appointing independent experts to a Reactor Safeguard Committee. The committee—whose members are from MIT as well as from industry—is ultimately responsible for overseeing all nuclear safety issues related to the reactor and ensuring that reactor operation is consistent with MIT policy as well as with NRC rules, operating procedures, and licensing requirements. All members of the NRL organization are keenly aware that safe operation of the nuclear reactor at MIT is their top priority. This level of awareness is achieved through the commitment and continuous training provided by the NRL's management team. An environment of cooperation and attention to detail among reactor employees and experimenters regarding all reactor safety matters is essential. Because of this approach to safety, each and every individual employed at the reactor can be proud of the NRL's outstanding safety and operating record, which is seen in the results of NRC inspections.

Reactor Radiation Protection

Radiation protection coverage is provided by the Reactor Radiation Protection Program of the Environment, Health, and Safety Office (EHS). Although this is a separate organization within MIT, it is very responsive to the NRL management team. Personnel include a deputy director for EHS who serves as the reactor radiation protection officer (William McCarthy) and two EHS officers, one technician, and a part-time administrative support staff member. Routine activities include, but are not limited to, radiation and contamination surveillance, experimental review and approval, training, effluent and environmental monitoring, internal and external dosimetry programs, radioactive waste management, emergency preparedness, and ensuring that all exposures at the NRL are as low as reasonably achievable in accordance with applicable regulations and Institute committees. An EHS officer (James Rowlings from the safety program) serves as EHS lead contact to the NRL under EHS management system organizational structure.
The NRL has a robust As-Low-as-Reasonably-Achievable (ALARA) program. ALARA-related policies, procedures, and metrics have resulted in improvements to the facility's day-to-day safety and efficiency.

As part of the NRL's Continuous Improvement Program, a custom-made SAP-based job notification and occurrence reporting was created by a team of individuals from IS&T. The system was successfully launched for routine use by all members of the NRL. Individuals can now log on and enter any unusual observations, which will be reviewed daily by NRL management for corrective actions, job assignments, and tracking of action status.

Security

System-wide tests continued quarterly, with the coordination of MIT Police, the MIT Security and Emergency Management Office (SEMO), and Siemens Building Technologies. Detailed reports were prepared and sent for review by DOE's National Nuclear Security Administration (NNSA). These reports were also reviewed by the NRC. In addition, NNSA conducted its annual site walk-through and assessment.

The reactor's security plan was overhauled to include features of the reactor security system enhancements that had been installed in Phase I and Phase II in FY2010 and FY2011. The federal requirement for submission of fingerprints to the NRC and FBI for criminal history background checks was also added to the plan. The revised security plan was reviewed and approved by the MIT Reactor Safeguards Committee, and then submitted to the NRC.

Assistant director Lau began to study possibilities for additional upgrades and improvements to the reactor security infrastructure with SEMO and the MIT Police. This is intended to become a Phase III contract with NNSA, expanding the enhancements to include the western perimeter of NW12 and the MIT Police headquarters dispatch console. The latter upgrade will allow intelligent handling of reactor security data and improve efficiency of communication and response. Throughout the fiscal year, NRL coordinated with NNSA to develop elements of the upgrade proposal.

Professional Activities in Support of NRL's Mission

The NRL maintains a very close working relationship with the National Organization of Test, Research, and Training Reactors (TRTR). TRTR's primary mission is education, fundamental and applied research, application of technology in areas of national concern, and improving US technological competitiveness around the world.

Appointments, Awards, and Events

The NRL is pleased to report that Lin-Wen Hu was awarded the MIT Excellence Award for 2012 in the category of "Innovative Solutions." This prestigious award, the highest for MIT staff, is in recognition of her energetic and persistent efforts to transform the research mission of the NRL to a focus on in-core experimentation.

Lin-Wen Hu

David E. Moncton
Director