9700 S. Cass Avenue · Argonne, IL 60439 · neinfo@anl.gov

Nuclear Engineering Division

Major Programs

- **Advanced Fuel Cycle Initiative:** Development and assessment of technologies for improved management of spent nuclear fuel.
- **Generation IV Nuclear Energy Program:** Development of next generation nuclear systems featuring significant advances in sustainability, economics, safety, reliability, proliferation resistance and physical protection.
- **Global Nuclear Energy Partnership (GNEP):** International collaboration enabling the expanded worldwide use of economical, environmentally responsible nuclear energy to meet growing electricity demand, while addressing nuclear safeguards concerns.
- **Hydrogen Initiative:** Assessment and development of nuclear technologies for the generation of hydrogen as a replacement for fossil fuels.
- **Reduced Enrichment for Research and Test Reactors (RERTR):** Conversion of research reactors from high- to low-enriched uranium fuel to reduce risk of nuclear weapons proliferation.
- **International Nuclear Safety:** Fostering open exchange of safety information and improvements of nuclear plant safety worldwide.
- **Materials Disposition:** Safe disposition of excess weapons plutonium through reactor irradiation and conversion to spent fuel.
- **Decontamination and Decommissioning:** Development, demonstration and deployment of technologies for safe and economical D&D of nuclear facilities.
- **National Security and Nonproliferation:** Limiting risk of nuclear weapons proliferation through export control policy support, safeguarding of special nuclear materials in the Former Soviet Union, development of information management systems.
- **Nuclear Criticality Safety:** Enhancing capability for assuring safe storage and transport for nuclear materials.
- **Nuclear Data Program:** Processing and validation analysis, compilation, evaluation and measurements of nuclear data.
- **Nuclear Waste Form Modeling:** Assuring safe performance of waste forms from processed EBR-II spent fuel in the Yucca Mountain Geologic Repository.
- **Nuclear Regulatory Research:** Providing broad technical expertise in the relevant engineering technology areas and appropriate technical support to the NRC Office of Nuclear Regulatory Research.

Facilities

- **Aerosol Laboratory:** houses equipment to measure and record the physical parameters necessary to characterize the formation and transport of aerosols.
- **Computer Facilities:** state-of-the-art equipment provided to in-house staff and collaborating scientists. We have a Beowulf cluster (3 control nodes and 105 computer nodes) as an advanced computational platform for performing a variety of engineering analyses. We also use facilities outside the Division such as Jazz, a terascale (10E12 calculations per second) Linux computing cluster with 350 nodes, and the CAVE, one of the four sophisticated automatic virtual environment systems in existence.
- **Engineering Development Laboratory**: facilities used to obtain information on the behavior of molten nuclear fuel, both in-reactor pressure vessel and ex-vessel.
- **Environmentally Assisted Cracking (EAC) Laboratory:** four autoclave systems used to evaluate the resistance of nuclear reactor structural materials environmentally assisted cracking in simulated LWR coolant environments.
- **High Temperature Corrosion Test Facilities and High Pressure Test Facilities for Metal Dusting:** six corrosion test facilities and two thermogravimetric systems for conducting corrosion tests in complex mixed gas environments, in steam and in the presence of deposits, and five facilities for metal dusting degradation.
- **Irradiated Materials Laboratory:** Used to conduct research on the behavior of commercial nuclear reactor materials, including fuel cladding, pressure vessel steels, and other in-reactor components. The four beta-gamma hot cells and the glove boxes are used to determine mechanical properties of these materials and degradation due to long-time operation in corrosive and irradiation environments. Loss-of-coolant accident environment is also simulated to allow determination of post-quench ductility.
- **Laser Applications Laboratory:** houses two high-power laser systems, complete with diagnostics for materials-processing functions – a 6 kW CO2 laser and a 1.6 kW pulsed Nd:YAG laser.
- **Non-Destructive Evaluation (NDE) and Testing Facilities:** contains state-of-the-art NDE laboratories including microwave/millimeter wave, acoustic/ultrasonic, X-ray, thermal imaging, optics, and eddy current for health monitoring of materials and components used in aerospace, defense, and power generation (fossil and nuclear) industries as well as for medical and scientific research.
- **Prototype Cathode Processor:** high-temperature vacuum furnace capable of retorting volatile components of the charge material and producing a consolidated ingot (used primarily for research on spent nuclear fuel processing).
- **Robotics Laboratory:** houses various remote manipulator systems, including the Dual Arm Work Platform, to support enhancements to teleoperation of remote systems for nuclear applications.
- **Sodium Reaction Experimental Test Facility:** fully instrumented facility for conducting and observing reaction experiments between moist gases, steam and alkali metals.
- **Steam Generator Tube Integrity Facilities:** includes the High Temperature Blowdown Facility, the Room Temperature High Pressure Facility, the Tube/Tube-sheet Severe Accident Leakage Facility, and the Model Boiler Facility.

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For more information, please visit our website at www.ne.anl.gov or email us at NEinfo@anl.gov

Nuclear Engineering Division

Argonne National Laboratory
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Overview

Nuclear Engineering (NE) is one of the divisions within the Applied Science and Technology directorate of Argonne National Laboratory. The Division and its precursors have contributed to the development of civilian nuclear power systems for over 50 years, ever since the dawn of the nuclear age. Over the years, we have significantly expanded our competencies and applied them to problems outside of the civilian nuclear arena.

Our mission is to (1) advance the design and operation of nuclear energy systems, and (2) apply our nuclear energy–related expertise to current and emerging programs of national and international significance. We conduct analytical and experimental research with concentration in advanced nuclear energy systems, nonproliferation and national security, and environmental management. Our extensive capabilities in modeling and simulation are applied in the development of diverse engineering systems and the optimization of their performance.

The NE Division's programs are supported primarily by the U.S. Department of Energy (DOE) through a number of its offices. Other sponsors from a broad range of U.S. Government and industry organizations also support work in the Division. We actively seek opportunities to collaborate with university, national laboratory, industry, and international partners in pursuit of their interests and our mission goals.

Dr. Hussein S. Khalil
Director
Nuclear Engineering Division

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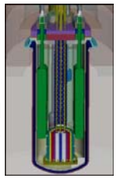
NE MAJOR CAPABILITIES

Nuclear Systems Modeling and Design Analysis

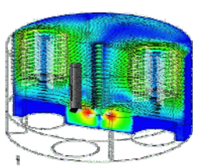
- **Reactor Physics and Fuel Cycle Analysis**
  We have played a major role in the design and analysis of most existing and past reactor types and of many advanced reactors, particularly those cooled by liquid metal. Our researchers have concentrated on developing computer codes for the assessment of reactor performance and safety characteristics, validating computer models by using experimental information obtained at critical facilities and power reactors, and applying these models in analyses that support core design and fuel cycle optimization.
- **Nuclear Data**
  We contribute to the development of comprehensive nuclear reactions and nuclear structure databases, including nuclear data measurement, modeling and evaluation methodologies, and processing and validation analysis that are implemented in basic science research and advanced nuclear technologies.
- **Nuclear Plant Dynamics and Safety**
  We perform analyses using large-scale, integrated computer codes which model the entire reactor plant. The product is a transient simulation of the behavior of all the major components in the plant, including fuel and coolant, coolant systems and associated components, and plant control and protection systems.



- **Advanced Reactor Development**
  We are the leading U.S. National Lab for the development of technologies for advanced nuclear power systems. This capability includes expertise in essentially all the major disciplines required in reactor design and development and the project management capability to integrate these disciplines efficiently and effectively.
- **Nuclear Waste Form and Repository Performance Modeling**
  We develop and apply computer software to address long-term performance of waste forms resulting from electrometallurgical processing of spent nuclear fuel. We are also proficient at developing and using models to assess and predict repository performance with a number of other waste forms and under other impact parameters.

Engineering Computation and Design

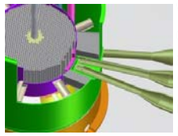
- **Engineering and Structural Mechanics**
  We develop computer codes and analytical methods for modeling the response of structures and continua to external loadings in two- and three-dimensions. Our codes are specialized for solving nonlinear static, transient dynamic and thermal problems for structures, solids, fluids, and fluid-structure interactions.
- **Heat Transfer and Fluid Mechanics**
  We specialize in the development and application of advanced computational methods for fluid and heat engineering. Simulation techniques are applied to provide fluid dynamics and heat transfer solutions supporting numerous nuclear and non-nuclear initiatives. Most of our activities are based on use of computational fluid dynamics (CFD) software.



- **Systems/Component Design, Engineering and Drafting**
  We provide a wide variety of equipment engineering, project engineering, design engineering and drafting services to Laboratory and external researchers. Our capabilities span a broad area, from project management to research and detailed design of systems and components, and have been applied in such diverse areas as vacuum and cryogenic systems, manufacturing engineering, hot cell equipment, and spent fuel processing systems.

National Security & Non-Proliferation Technologies

- **Nuclear Export Controls**
  We provide technical advisory services to DOE in the implementation of U.S. nonproliferation policy. This includes assessments of proliferation risks presented by emerging technologies and by proposed transfers of materials, equipment and technology, and participation in DOE programs designed to mitigate these risks.
- **National Security Information Systems**
  We design, develop, operate and maintain information technology systems for national security programs. These systems encompass security, nonproliferation and international treaty implementation systems for multiple agencies including the DOE, NNSA, DOD, DHS and others.
- **Research Reactor Conversions**
  We develop the technologies needed to use low-enriched uranium (LEU, <20%) instead of high-enriched uranium (HEU, ≥20%) in research and test reactors, and to do so without significant penalties in experiment performance, economic, or safety aspects of the reactors. Research and test reactors utilize nearly all the HEU used in civil nuclear programs, and worldwide attainment of the RERTR objectives will support important U.S. nonproliferation goals.
- **Russian Research Reactor Fuel Return (RRRFR)**

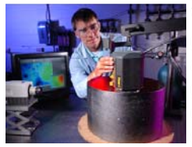


  We develop and convert research facilities including accelerator driven subcritical and critical assemblies to utilize low-enriched uranium fuel. State-of-the-art computer codes and design tools, which cover the different disciplines are maintained and used for this activity. The utilization of these facilities for research purposes and medical isotopes production is characterized. The existing facilities are used for performing reactor physics experiments.
- **International Nuclear Safety**
  We support DOE efforts to improve international nuclear safety. We work to build capabilities within countries, especially those with Soviet-designed reactors, to determine the safety status and assess the risks of their nuclear power stations. These capabilities and the results of comprehensive deterministic and probabilistic safety assessments have led to dramatic improvements in the safety of these operating reactors. Through our efforts on behalf of DOE, many projects have led to gainful employment for former Soviet weapons scientists, reducing nuclear proliferation risks.
- **Non-Destructive Evaluation (NDE) Technologies**
  We develop and provide technologies for interrogation and characterization of materials, components, and systems using state-of-the-art and emerging NDE techniques. Our capabilities have been applied to the aerospace, defense, and power generation (fossil and nuclear) industries to assess the integrity of critical components and thus help reduce system failures that can lead to costly shutdowns, cause damage to expensive equipment, and jeopardize the safety of end users. Our specialized NDE technologies have also been used in applications pertaining to scientific and medical research.
- **Vulnerability Assessments**

  We conduct R&D on physical devices, systems, and programs. We discover and demonstrate security flaws for a variety of sponsors, then devise practical countermeasures. This work also involves reverse engineering devices, developing microprocessor solutions, understanding the human factors that so strongly impact security effectiveness, and inventing new approaches and technologies for physical security and nuclear safeguards.

National Security & Non-Proliferation Technologies (continued)

- **Sensors & Instrumentation Technologies**



  We develop and evaluate sensor technologies for industrial process control, biomedical applications and remote detection of trace gases, toxic chemicals, explosives, and nuclear materials. Techniques applied to our sensor development include acoustic/ultrasonic, ion optics and electromagnetic waves ranging from millimeter waves (mmW) to gamma rays. We also pursue research on both passive and active techniques to detect and interrogate nuclear materials. All projects support DOE missions in energy and environmental research, NNSA missions in emergency response and nuclear non-proliferation, and DHS in safeguard and protection of our nation.

Risk and Safety Assessments

- **Facility Safety Assessments**
  Operations support for nuclear facilities within Argonne and throughout the DOE Laboratory system is provided in the form of detailed vulnerability assessments required under emerging national security-related regulations. We also undertake facility safety analysis report preparation and upgrade, and preparation for safety documentation to support facility modifications or special projects.
- **Risk Methodology and Evaluation**
  We conduct both deterministic and probabilistic safety analyses. This field covers a wide range of disciplines, usually requiring expertise in a number of areas as well as familiarity with formal hazards and risk evaluation methods. With many engineering disciplines represented on our staff, we are highly qualified to conduct the type of in-depth hazards and risk evaluations that are necessary for modern facilities to compete in today's highly regulated environment.

Nuclear Systems Technologies

- **Nuclear Criticality Safety**
  We perform criticality safety and shielding evaluations for nuclear facilities with complex configurations and operations involving wide ranges of geometries, materials, and neutron spectra. These capabilities are based on a staff with decades of cumulative experience (experimental and analytical) and the latest software and nuclear data libraries.
- **Research Reactor Analysis**
  We provide the analytical and design evaluations needed by the RERTR program. Our computational database, which is continuously updated and improved, consists of a number of computer codes to analyze the physics, thermal-hydraulics, and safety performance of research reactors. Using these analytical tools, the RERTR program performs studies of specific foreign and domestic reactors to assess their potential for conversion to LEU fuel and to provide analytical support for such conversions.
- **Systems/Process Monitoring, Diagnostics and Control**
  We develop, demonstrate and apply advanced software tools for optimizing the operation of nuclear power plants and other engineering systems. This software generates and substantiates information online about the condition of plant systems. This information can be used to maximize plant availability and power output, optimize plant maintenance functions and help operators cope with potential upsets.
- **Decontamination and Decommissioning (D&D)**
  Based upon our experience and expertise in decontamination and decommissioning of research reactors and surplus contaminated facilities, we provide technical support and guidance to D&D projects and share our expertise with the domestic and international community through technical oversight, training, and technical exchanges.

Engineering Experimentation

- **Reactor Safety Experimentation**
  We conduct a wide range of experimental research related to the safety of existing and future reactor technologies. This includes state-of-the-art experiments investigating high-temperature nuclear fuel melt behavior and materials interactions. We possess unique facilities that can accommodate the special needs of reactor materials testing.
- **Aerosol Experiments**
  We have extensive analytic and experimental capabilities to characterize the formation and transport of aerosols formed from the condensation of vapors. Computer codes have been developed to analyze various phenomena related to homogeneous and heterogeneous nucleation, aerosol agglomeration, and aerosol deposition.
- **Systems/Component Testing**
  We research, develop, design, procure, manufacture, install and test components and systems required for unique application. This includes the development of first-of-a-kind large-scale systems and components with complex requirements such as corrosive/hazardous materials, high-temperature structural integrity, and remote handling.
- **Laser and Robotics Applications**
  We carry out research and development on laser-based applications for materials processing, oil extraction technological enhancements, and aerosol or spray characterization. Computer simulation and robot task programming tools are employed to enhance the safety and efficiency of telerobotics in the decontamination and decommissioning of nuclear power plants, space nuclear power systems, and other remote applications.

Materials Testing

- **Environmentally Assisted Cracking (EAC) of Reactor Materials**
  We perform experimental testing and modeling to assess the crack growth rates for structural materials in simulated light-water reactor environments. Four test facilities are being used to develop experimental data on primary water stress corrosion cracking (PWSCC) and corrosion fatigue behavior of nickel-alloys and their welds. Our results provide valuable information to further the understanding of stress corrosion cracking and provide data needed for reactor safety evaluations and regulations.
- **Corrosion Performance/Metal Dusting**
  We test structural materials for their corrosion resistance in simulated metal dusting environments at elevated temperatures, typical of conditions in hydrogen-, ammonia-, and methanol-reformers and in syngas plants. We also use atmospheric test facilities to develop a fundamental understanding of metal dusting reactions and material performance over a wide range of simulated process conditions, temperatures, surface finish and coatings. These facilities are used to test developmental alloys and coatings with improved metal dusting resistance.
- **Irradiated Materials**
  Two hot-cell test facilities are used to develop experimental data on the irradiation-assisted stress-corrosion cracking susceptibility, fracture toughness, and corrosion fatigue, of wrought and cast austenitic stainless steels and their welds. These results provide valuable information needed for reactor safety evaluations and regulations. Other hot cells are used to fabricate guide-tube and fuel-cladding mechanical properties test specimens and to conduct high-temperature steam oxidation and water quench tests using high-burnup cladding samples for Loss-of-Coolant Accident (LOCA) research.
- **Steam Generator Tube Integrity**
  We conduct research and development and validate models for tube performance in pressurized water reactor steam generators.