National Criticality Experiments Research Center

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Imagine a resource so unique and specialized that there is only one in the country which services needs from around the world. Welcome to the National Criticality Experiments Research Center (NCERC), home to some of the most highly trained individuals and specialized capabilities on Earth. As Los Alamos National Laboratory celebrates 75 years of scientific excellence and nuclear expertise, it is fitting to recognize this essential capability focused on assuring the safety and security of operations involving nuclear materials throughout the United States and the world.

NCERC's foundation began in Los Alamos at the Laboratory's Technical Area-2 in 1943, but moved to TA-18 in 1946, where it remained until 2010. "NCERC has long been part of the Laboratory's iconic history and its unique science will continue to drive the art of the possible," said Evelyn Mullen, Associate Director for Threat Identification and Response. "The contributions of this important facility will be felt far into the future supporting key mission areas of the Laboratory. These include the nuclear weapons enterprise, global security, space exploration and clean energy solutions for our national security partners in addition to successfully executing its core mission in the Nuclear Criticality Safety Program." After a complex transition from Los Alamos to the Device Assembly Facility (DAF) at the Nevada National Security Site (NNSS), the facility restarted critical experiment operations in 2011. Operated by Los Alamos National Laboratory for the DOE National Nuclear Security Administration (NNSA), NCERC maintains an essential skill base of nuclear material handling and criticality safety expertise based on experimental capability. Funded through the Nuclear Critical Safety Program (NCSP), it remains the nation's only general-purpose critical experiments facility. NCERC's mission is to conduct experiments and training with critical assemblies and fissionable material, at or near the critical state, in order to explore reactivity phenomena. Criticality experiments are generally low power operations with fissile materials, such as plutonium or enriched uranium, conducted to bring these materials to the critical point. This is the point at which the fission process becomes self-sustaining. This fission process must be inherently understood and controlled to ensure the safety, security, and reliability of both the nation's nuclear weapons stockpile and future reactor designs.

The safe handling of large quantities of plutonium and uranium is heavily dependent on the data generated over past decades at NCERC and its predecessor facility. Many of these unique experiments are part of the Nuclear Criticality Safety Program (NCSP), an essential program to the nuclear community. The program is designed to protect nuclear operations personnel, the public and the environment from the consequences of a criticality incident using formality of operations, written operating procedures, criticality safety evaluations, criticality safety controls (engineered features & administrative features), training and other programmatic features. The criticality safety discipline is enhanced by the training of specialists nationwide by NCERC personnel using the facility's unique nuclear materials and capabilities.

What began in the 1970s as a two-day hands-on course for fissionable material operators has evolved to include one-week courses for managers and process supervisors, and a two-week course for criticality safety analysts. During the courses held year-round, personnel from DOE, other government agencies, the commercial nuclear community and the military are provided a rare opportunity to witness criticality demonstrations while attending the training. Supported out of DOE NA-50, Infrastructure and Environment, the program demonstrates how varying the properties of a fissionable material system can affect criticality. The first part of training is a classroom discussion of historical criticality accidents and their impact on how operations are performed today. During the second half of training, students take part in hands-on demonstrations with fissionable material in sub-critical configurations and then have the opportunity to observe critical demonstrations conducted remotely. These trainings are now core requirements for criticality safety analysts, and support fissionable material operations across the DOE complex.

One very illuminating demonstration uses a general purpose, light-duty vertical lift assembly machine named Planet to assemble a configuration of plastic plates and uranium foils. A container with 26 foils of uranium is opened and the foils are removed and layered between plastic plates that mimic water. Students monitor the increasing neutron count rate as the layers are added--ten layers on the moveable lower portion and twelve on the top stationary platform. The students and NCERC staff then move to the remote control room and bring the two halves together. They observe the system reach criticality, graphically illustrating that 22 foils can form a critical system when a neutron moderator such as plastic (or water) is present, whereas 26 foils can be in a single container with no moderator present and remain in a subcritical state. This demonstration allows criticality safety personnel to observe a vivid example of the importance of moderators as related to establishing criticality safety limits.

The data generated and analyzed from the experiments conducted at NCERC significantly reduces the margins of uncertainty for criticality safety evaluations by determining the exact point where a given system will attain the critical state. Without this facility's capability, the confidence in the U.S. nuclear stockpile assessment would decrease, the accuracy with which analysts provide criticality safety guidance to those working with fissile materials in production and R&D facilities nationwide would diminish, and operating costs would increase.

Additionally, the research, design and development of new nuclear reactor designs must include experimentation and today NCERC is the only place critical experiments can be conducted to prototype new reactors. Nuclear energy is considered by many to hold future benefits for clean, environmentally safe energy, power grid resilience, national security and deep space exploration. One of the most novel technologies to recently be tested at NCERC is the Kilopower Reactor Using Stirling Technology experiment. A joint project with NASA, Kilopower is a power system that can operate in extremely harsh environments and is efficient, reliable, safe, low cost, and compact. The experiment demonstrated the efficiency of fission power for lunar and planetary exploration. It is anticipated this new nuclear power system could enable long-duration crewed missions to the Moon, Mars and destinations beyond.

Beyond the support NCERC provides to the Nuclear Criticality Safety Program, NCERC performs experiments to validate nuclear data and computer codes. This work is essential because the United States and its allies no longer test nuclear weapons and as a result the nuclear community at large relies on complex experiments and computer analyses to predict how nuclear weapons will perform. “NCERC is a capability that provides a vital underpinning to the entire mission of the Department of Energy,” said Robert Margevicius, Program Director for Strategic Materials and Infrastructure at the Lab. “I think of NCERC in terms of the Navy’s fleet of submarines: performing its function largely out of view, but with accomplishments that help enable the military’s overarching success.” He continued, “And this happens organically through the highly dedicated team of Lab personnel at the core of NCERC’s functionality.”

The experiments, demonstrations, and training conducted at NCERC also support the Laboratory’s nuclear weapons capability in the handling and processing of nuclear materials. This is achieved through scientific and engineering expertise in concert with highly advanced, state-of-the-art equipment often also developed at the Lab. Throughout the years many critical assembly machines have been developed, four of which are in operation today. These machines, and the experiments conducted using them, are essential to understanding the phenomenology of criticality accidents.

Criticality accidents are situations where fissile material unintentionally exceeds the critical state. In over 75 years of processing and handling of nuclear materials worldwide, there have been 22 known criticality accidents in processing facilities around the globe. Of these, seven have occurred in the United States, the most recent over 40 years ago. This track record of safety has been in no small part due to the tireless work conducted at NCERC. Throughout the DOE complex, criticality safety evaluations are performed before any operations with fissile material begin. The evaluations determine that controls are in place such that the entire process will remain subcritical under both normal and credible abnormal process conditions. In contrast, the experiments at NCERC intentionally take fissile material to and above the critical state but only under extremely well controlled conditions. These experiments provide the data required which allows operations with fissionable material throughout the DOE complex to proceed. The Godiva critical assembly at NCERC can be used to simulate a criticality accident under controlled conditions with no personnel present.

As concerns have grown that rogue states and organizations might obtain and use nuclear materials to disrupt democracies, this specialized discipline has become part of the comprehensive training that nuclear incident response personnel receive. NCERC is the only place in the United States nuclear incident responders can train and hone their diagnostic skills with nuclear material in quantities and configurations that they could encounter in realistic scenarios. In addition to Criticality Safety and Nuclear Emergency Response, NCERC also supports Arms Control, Nuclear Nonproliferation and National Technical Nuclear Forensics.

Because of the uniqueness of NCERC capabilities, Los Alamos National Laboratory collaborates with the French, British, Japanese and others on integral critical experiments. These collaborations provide invaluable information and data to the nuclear community for the continued development and maintenance of global nuclear safeguards. The International Criticality Safety Benchmark Evaluation Project (ICSBEP) organized by the Nuclear Energy Agency, provides a link between experiments and the world's nuclear data libraries. Critical experiments are essential to the continued refinement of these libraries maintained by the United States, Japan and Europe.

The National Criticality Experiments Research Center is an asset to our country, national security programs, and the nuclear energy community at large. NCERC is a vital component to maintaining and advancing the capability (people, techniques, analytical methods, materials, and equipment) to conduct fissionable material operations. From the early days of the Manhattan Project to the safety and security of nuclear material operations, clean energy, and the future of space travel, NCERC is an integral part of it all.

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