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Criticality Studies for UREX Processes

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Task 35

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BACKGROUND

The completion of criticality experiments for mixtures of transuranic actinides (TRU–includes Np, Pu, Am, and Cm) that will be created during the separation of used nuclear fuel may be a requirement in order to construct prototype plants for the Global Nuclear Energy Partnership. In this program and the Advanced Fuel Cycle Research and Development (AFC R&D) program that supports it, economic and environmental methods are being developed to reduce the impact of waste from commercial nuclear fuel cycles.

Recycling of used fuel by chemically separating it into U, fission products, and TRU would be the first step in this new fuel cycle. Proposed mixtures and concentrations of TRU covering a wide range of conditions must be examined theoretically and experimentally to demonstrate criticality safety in advance of construction of a processing facility. Theoretical studies may be limited because of insufficient nuclear data for the rarer isotopes of Np, Pu, Am, and Cm. These data limitations include reaction cross sections in some energy regimes, thermal feedback coefficients, and delayed neutron fractions.

RESEARCH OBJECTIVES AND METHODS

In this project, which is a collaboration between UNLV, LANL, ANL, and ORNL, criticality studies will be conducted to support the development of future fuel cycle facilities. The first step in determining requirements for criticality studies is an examination of past experiments and criticality and sensitivity studies as well as available databases. Further sensitivity studies will determine what kinds of experiments should be performed to insure criticality safety in advanced processes. This information can then be used to formulate an optimum set of experiments that can be analyzed in advance using state-of-the-art radiation transport codes. As these facilities and experiments will include complex geometries, a Monte Carlo N-Particle (MCNP) transport code will be used in these sensitivity, scoping and design studies. The work may also require generation of new cross section libraries and thermal scattering coefficient databases. Future criticality studies may include cross section sensitivity studies and design of critical experiments including dilute mixtures of Pu, mixed higher actinides in solution, and fuels.

ACADEMIC YEAR HIGHLIGHTS

- L. Lakeotes, R. LeCounte, D. Beller, and R. Boehm, "Higher Actinide Cross-Section Sensitivity and Criticality Studies for the UREX+1 Process," oral presentation by L. Lakeotes at the ANS Student Conference, Corvallis, Oregon, March 31, 2007.
- Students and faculty participated in the Advanced MCNPX Workshop at UNLV where criticality studies and cross section perturbation techniques were discussed.

RESEARCH ACCOMPLISHMENTS

The project was initiated in September 2006. Discussions occurred with LANL, ORNL, and ANL regarding project scope and direction. The appropriate division of effort between cross-section sensitivity studies and design of required criticality experiments, such as measurement of thermal feedback coefficients in dilute mixtures of plutonium with varying isotopic constituents, needs to be determined. The project will likely focus on sensitivity studies. At UNLV, separations processing facilities and components will be concentrated on, as opposed to critical cores.

One conceptual study could focus on the capability to measure thermal feedback coefficients in dilute mixtures of plutonium with varying isotopic constituents. Another could involve the modeling of a liquid- or solid-core critical assembly to assess the ability to measure integral critical parameters with small quantities of TRU, rather than a full core of fuel containing TRU. Students collected information on code systems and references on criticality and sensitivity studies and to research cross section uncertainties for Am and Cm at room temperature in uranium extraction (UREX) separations processes.

The SCALE code system was acquired for processing cross sections for sensitivity studies. MCNP, MCNPX, SCALE, and data libraries were loaded for processing cross sections and conducting sensitivity studies.

FUTURE WORK

During the following year SCALE and MCNP/MCNPX will be used to investigate cross section sensitivity of UREX process and conceptual integral experiments.

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