U.S. DEPARTMENT OF ENERGY
INTERNATIONAL NUCLEAR ENERGY RESEARCH INITIATIVE
DOE/CEA

ABSTRACT

OSMOSE – An Experimental Program for Improving Neutronic Predictions of Advanced Nuclear Fuels

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The objective of this collaborative program with the French CEA is to measure very accurate integral reaction rates in representative spectra for the actinides important to future nuclear system designs and to provide the experimental data for improving the basic nuclear data files. These data will support advanced reactors designed for transmutation of waste or Pu burning, sub-critical systems such as found in advanced accelerator applications, and the waste disposal and treatment program in the area of criticality safety. This program is very generic, in the sense that it will measure these reaction rates over a broad range of isotopes and spectra and will be used to provide guidance to all nuclear data programs in the world. These data will provide information valuable to a large number of projects as noted above.

The design of nuclear systems has shifted over the years from a “test and build” approach to a much more analytical methodology based on the many advances in computational techniques and nuclear data. To a large extent current reactors can be calculated almost as well as they can be measured. This is due in particular to the high quality nuclear data available for the few major isotopes which dominate the neutronics of these systems. Nevertheless, most future nuclear systems concepts and advanced fuels development programs currently under way use significant quantities of minor actinides to address modern day issues such as proliferation resistance and low cost. For example, proliferation resistant reactors and fuels are typically based on ^{232}Th and ^{233}U. High burnup fuels contain large quantities of americium and curium. Systems designed for plutonium and minor actinide burning are very sensitive to uncertainties in Americium and Curium data. There are also several other programs where the minor actinide data are essential. These include the Accelerator Transmutation of Waste concepts, and Burnup Credit programs.

The need for better nuclear data has been stressed by various organizations throughout the world, and results of studies have been published which demonstrate that current data are inadequate for designing the projects under consideration. In particular, a Working Party of the OECD has been concerned with identifying these needs and has produced a detailed High Priority Request List for Nuclear Data. The first step in obtaining better nuclear data consists of measuring accurate integral data and comparing it to integrated energy dependent data: this comparison provides a direct assessment of the effect of deficiencies in the differential data. Several US and international programs have indicated a strong desire to obtain accurate integral reaction rate data for improving the major and minor actinide cross sections. Specifically, these include: ^{232}Th, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, and ^{247}Cm. Data on the major actinides

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(i.e. ^{235}U, ^{236}U, ^{238}U, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, and ^{241}Am) are reasonably well-known and available in the Evaluated Nuclear Data Files - (JEF, JENDL, ENDF-B). However, information on the minor actinides (i.e.^{232}Th, ^{233}U, ^{237}Np, ^{238}Pu, ^{242}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, and ^{247}Cm) is less well-known and considered to be relatively poor in some cases, having to rely on models and extrapolation of few data points. This is mainly due to the difficulty of obtaining relatively pure samples of sufficient quantity (up to about one gram) to perform reliable reaction rate measurements.

The French Atomic Energy Commission (CEA) has also recognized the need for better data and has launched an ambitious program aimed at measuring the integral absorption rate parameters in an experimental facility located at the Cadarache Research Center. A complete analytical program is associated with the experimental program and aims at understanding and resolving potential discrepancies between calculated and measured values. The final objective of the program is to reduce the uncertainties in predictive capabilities to a level acceptable to core designers and government regulators.

Argonne National Laboratory has expertise in these areas. In the past, ANL teams have developed very accurate experimental techniques and will strongly enhance the content of the experimental program. Furthermore, current ANL staff have heavily participated in the development of the French experimental and analytical program, and have contributed to the computational tools used by the French teams.

In this program, ANL staff will participate in the experimental measurements made in the MINERVE reactor at Cadarache, and all the data will be available to the U.S. in exchange for this participation.

ANL also has the facilities to perform independent measurements using the NRAD reactor. The characteristics of the NRAD reactor are significantly different from the MINERVE reactor and the results will complement the French measurements. NRAD also offers the flexibility to tailor the neutron spectrum, thereby, broadening the useful energy range of the experiments. In addition to the samples prepared by the French (and loaned to ANL for measurements), ANL will be preparing additional samples for measurements, depending on availability.

This three-year project has three critical outcomes:

1. High quality experimental data representative of the major and minor actinides will be made available to the US programs.

2. The US neutronics and criticality safety codes will be validated for reactivity effects from the major and minor actinides.

3. Potential deficiencies in US nuclear data and analysis tools will be identified.

In addition to the critical outcomes from the project, there are general benefits to the nuclear program in the United States. Specifically, by cross-calibration with measurements in the NRAD facility, the uncertainties in the data will be better known and deficiencies in the cross-section data will become apparent. This will lead to a better understanding of the available cross-section data and which areas need further development and research plans. This project also intends on involving a graduate student in the measurement and analysis tasks. By introducing young experimentalists to the project through key involvement in tasks, expertise is developed within the United States. This is vital since there are very few remaining experimentalists in this area.