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Continuing Progress toward Research and Test Reactors Conversion to Low Enriched Uranium Fuel

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Nuclear research and test reactors have been built and operated across the globe to serve many missions in science, engineering, and medicine. Over time, many of the reactors have been operated with High Enriched Uranium (HEU, with U-235 enrichment ≥ 20%) fuel. In response to concerns about the potential misuse of HEU, the U.S. Department of Energy (DOE) initiated a program –the Reduced Enrichment for Research and Test Reactors (RERTR) - in 1978 to develop the technology necessary to reduce the use of HEU fuel in research reactors by converting them to low enriched uranium (LEU) fuel. In 2004, the reactor conversion program became the driving pillar of the Global Threat Reduction Initiative (GTRI), a program established by the U.S. DOE's National Nuclear Security Administration (NNSA) to minimize, and to the extent possible eliminate, the use of HEU in civilian commerce. As an integral part of the GTRI, the Conversion Program accelerated the schedules and plans for conversion of additional research reactors operating with HEU. In 2015, the NNSA weapons-usable material efforts were realigned into the Office of Material Management & Minimization to further integrate permanent threat reduction. A summary of the technical aspects of the conversion program was presented at the previous IAEA International Meetings on Research Reactors in 2007, and 2011. This paper provides an update on the progress made since 2011 and describes current technical challenges that the program faces.

Since the inception of the Conversion Program, 66 research reactors have been converted to LEU fuel and 25 have shutdown prior to conversion. Furthermore, an HEU-target fission-product Mo-99 producer has converted to the use of LEU targets. The total count of 92 facilities no longer using HEU is an increase of 13 since the Rabat conference in 2011 (i.e., 16% more than the 79 reported in 2011).

A key element for the success of the program is the establishment of international collaborations, especially with the IAEA. The major technical activities of the Reactor Conversion Program include: (1) the development of advanced LEU fuels and (2) conversion analysis and conversion support.

The most challenging factor in enabling the conversion of a research reactor lies in the availability of an LEU fuel with density high enough to compensate for the reduction in the content of U-235 and the associated absorption of neutrons in the increased U-238 in the LEU material. The conversion of all U.S. civilian research reactors that were able to convert with existing LEU fuel was completed in 2009. The remaining research and test reactors in the U.S. are all high flux reactors (U.S. High Performance Research Reactors - USHPRR) and require higher density fuels not currently available. Significant efforts have been ongoing for the development of a monolithic form of Uranium-Molybdenum (UMo) alloy fuel that provides densities of U high enough to enable the conversion of the U.S. high flux reactors. In addition, the Conversion Program has long been engaged in cooperation with Russian organizations to develop high density dispersion UMo fuel for use in Russian designed reactors. Finally, the Conversion Program has a strong partnership with the European effort LEONIDAS that has grown into the HERACLES Group for the development of high density dispersion UMo fuel for the conversion of the European High Flux research reactors that use HEU fuel.

The analysis and support activities provide the required analytical and design evaluations to support the conversion of research reactors involved in the program. Since the inception of the program, analysis methods and codes have been developed specifically for the analysis of research reactors. The methods and codes are currently evolving to incorporate the latest tools and data, with an increased emphasis on validation with experimental data. Conversion analysis in general includes three major tasks:

- Feasibility studies to determine suitable LEU fuel assembly designs which minimize performance impacts for each reactor.
- Operational and safety analysis, necessary to demonstrate that the transition from HEU to LEU fuel can be done safely and without interrupting normal operations
- Resolution of regulatory issues to obtain regulatory approval for the conversion to LEU fuel. It must be demonstrated that all safety requirements are met.

A project established through the IAEA has moved the previous cooperative project for determining the feasibility of converting Chinese-designed MNSR reactors to LEU fuel, into a project for the actual fabrication and testing of fuel and conversion of the reactors. The first LEU conversion core for an MNSR was tested

successfully in the new Zero Power Test Facility (ZPTF) and will be used to convert the prototype MNSR-IAE in Beijing.

The paper will provide a more detailed overview of the status of the program, the technical challenges and accomplishments, and the role of international collaborations in the accomplishment of the Conversion Program objectives.

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