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Preliminary Fuel Development and Reactor Design Milestones for the LEU Conversion of the U.S. High Performance Research Reactors

The continued presence of highly-enriched uranium (HEU) fuel in civilian installations such as research and test reactors poses a threat to national and international security. Minimization, and ultimately elimination, of HEU in civilian research and test reactors worldwide has been a goal of policy in many countries, including in the United States, since 1978. In order to reduce the threat posed by HEU while allowing the facilities concerned to continue operating and achieving their important and diverse missions in science and medicine, conversion to low-enriched uranium (LEU) fuel often requires the development of high uranium density fuel to compensate for the enrichment reduction.

The United States Department of Energy / National Nuclear Security Administration (DOE/NNSA) Reactor Conversion Program is working collaboratively with many countries worldwide towards the conversion of remaining reactors to the use of LEU fuel. Conversion of civilian research reactors from HEU to LEU, and the return of the HEU to the country of origin is an important component of the NNSA non-proliferation program. Worldwide, 71 reactors have been converted to the use of low-enriched uranium (LEU) fuel, and an additional 28 have been confirmed to be permanently shut down. These 99 reactor conversions include 20 U.S. reactors among the 39 countries on six continents where conversions have occurred. With two recent conversions in Africa, in Ghana and Nigeria, this completes an important milestone. Africa is the third continent to have completed all HEU to LEU reactor conversions, following Australia and South America. For the remaining conversions in Europe, the U.S. and elsewhere, reactor conversions underway commonly require higher density fuel and qualification under more extreme conditions.

For the six U.S. high-performance research reactors (USHPRR), NNSA has developed a very high-density uranium-molybdenum (U-10Mo) alloy LEU fuel that would allow the conversion of all the facilities. This paper will discuss the fuel development milestone that has been completed, leading to a Preliminary Report on U-Mo Monolithic Fuel for Research Reactors submitted to the U.S. Nuclear Regulatory Commission (NRC) in 2017. This was accomplished in addition to a Preliminary Design Milestone for each of the USHPRR reactors where each reactor's unique fuel element was re-designed from 2010 to 2018. Three Preliminary Safety Analysis Reports for conversion to LEU fuel were submitted have to the U.S. NRC by the National Institute of Standards Reactor (NBSR), the University of Missouri Research Reactor (MURR), and the Massachusetts Institute of Technology Reactor (MITR). The DOE-operated Advanced Test Reactor (ATR), and the associated critical assembly (ATRC), and High Flux Isotope Reactor (HFIR) reactor have also completed preliminary designs with U 10Mo fuel. However, an opportunity to convert HFIR using uranium silicide fuel at, or near, the standard density used worldwide has been made possible using a longer fuel plate and advanced design techniques. For HFIR, silicide fuel is now being pursued for LEU conversion, along with the fuel qualification testing required at higher power densities than is currently available, and, like HFIR requires today, for a contoured fuel design including boron in the plate.

Continuing efforts are required following these Preliminary USHPRR Milestones. Using the commercial fabrication pilot line that has been installed and is currently operating, full-size fuel plates and assembly fabrication are planned to perform qualification irradiations and flow testing that will ultimately lead to USHPRR conversions to LEU fuel.

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Track Classification: PP: Minimization, on a voluntary basis, of high enriched uranium within civilian stocks and where technically and economically feasible