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Media Alert
February 25, 2016

New Oak Ridge National Lab (ORNL) Document Important as it Outlines Status of Worldwide Research Reactors Using and Converting from Highly Enriched Uranium (HEU)

"**NEEDS AND REQUIREMENTS FOR FUTURE RESEARCH REACTORS (ORNL PERSPECTIVES)" Helps in Understanding of Use of Bomb-Grade Uranium and Efforts to Curtail its Use - Document Linked here:** http://info.ornl.gov/sites/publications/files/Pub59842.pdf

Columbia, SC -- The Oak Ridge National Lab (ORNL) has just released an important and useful document documenting worldwide use of highly enriched uranium (HEU) in research and test reactors, according to the public interest organization Savannah River Site Watch.

The document, dated February 10, 2016 and released publicly this week, affirms the goal of the National Nuclear Security Administration's admirable goal to convert reactors: "Under NNSA support, feasibility studies are under way to study the conversion of the US high performance research reactors (HPRRs) and the US-supplied high flux European research reactors still operating with HEU fuel. The main limitation in this endeavor is the lack of an appropriate, robust, licensed LEU fuel. The LEU fuel would also need to allow a safe, reliable, affordable conversion with no significant impact on the reactor's performance or its ability to perform its scientific missions, and with no major changes to reactor infrastructure."

"Documenting the reactors that use so-called "bomb-grade uranium" and outlining efforts to convert them away from weapon-usable uranium is an important contribution to nuclear non-proliferation," according to Tom Clements, director of SRS Watch, an organization concerned about HEU and plutonium proliferation and DOE's role in such programs (including at the Savannah River Site). "The NNSA program to convert reactors away from use of bomb-grade uranium merits positive assessment and the release of this document is a step in that direction," said Clements.

"While the ORNL document presents research reactor needs at the site, its greatest importance may be its discussion of use of HEU in reactors worldwide and the efforts led by NNSA in converting the reactors to LEU use," according to Clements.

At the upcoming Nuclear Security Summit (NSS) in Washington, achievements in converting reactors may be discussed. But the summit is also resulting in shipment of foreign-origin plutonium to SRS, where it will be stored with no viable exit strategy. A shipment of 331 kilograms of plutonium from Japan, now stored at the Fast Critical Assembly at Tokai, will soon be on its way to SRS. That FCA plutonium includes 236 kilograms of UK-origin and 2 kg of French origin. As the United Kingdom is a nuclear weapon state with a stockpile of over 125 metric tons of plutonium, DOE and NNSA have made no attempt to justify shipment of the UK-origin (or French-origin plutonium) plutonium from Japan to SRS. Much information about this issue is available on the SRS Watch website: http://www.srswatch.org/

The UK-flagged ships Pacific Egret and Pacific Heron are now approaching Japan to pick up the plutonium and bring it to SRS. The shipment may also include HEU now stored at the FCA and it is unclear if that material would be taken to SRS or Y-12. The removal of the plutonium and HEU was discussed in a White House statement issued after the last NSS in 2014: "FACT SHEET: Cooperation at Japan's Fast Critical Assembly" - https://www.whitehouse.gov/the-press-office/2014/03/24/fact-sheet-cooperation-japan-s-fast-critical-assembly

Little has yet been written about the upcoming Nuclear Security Summit or that it appears to be unfortunately stimulating the dumping of foreign-origin plutonium at the Savannah River Site.

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Notes:

URL for document and extracts on HEU use and conversion:

http://info.ornl.gov/sites/publications/files/Pub59842.pdf

Reactor and Nuclear System Division
Research Reactors Division

NEEDS AND REQUIREMENTS FOR FUTURE RESEARCH REACTORS (ORNL PERSPECTIVES)

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Only three of the 13 reactors listed in Table 1 use LEU fuel. Two are in China, the CARR and the High Flux Engineering Test Reactor (HFETR) (using U3Si2-Al fuel). The third one is the Kazakhstan's research reactor, which is currently under testing with an LEU UO2-Al fuel core.
Three of the 10 reactors using HEU are Russian: SM-3, MIR.M1, and BOR-60 [4]. The BOR-60 and SM-3 reactors are planned to be operated until ~2020, when their current operating licenses expire. The LEU conversion of MIR.M1 has been investigated under a Rosatom – National Nuclear Security Administration (NNSA) Implementing Agreement (December 2010) to conduct feasibility studies for conversion to LEU fuel of six Russian research reactors [5]. The HFIR peer-level non-Russian reactors operating with HEU that are located in US and Western Europe are actively engaged in LEU conversion feasibility studies. These studies consider high density uranium molybdenum (U-Mo) fuel in alloy or dispersion form. A U-Mo alloy fuel (~15gU/cm3 fuel) is being developed at the Idaho National Laboratory (INL) under the NNSA reactor conversion program. A U-Mo dispersion fuel (~8gU/cm3 fuel) is being developed in Europe under the LEONIDAS and HERACLES projects, with participants from Studiecentrum voor Kernenergie - Centre d'Étude de l'Energie Nucléaire (SCK•CEN) in Belgium, and Institut Laue-Langevin (ILL), Commisariat à l'Énergie Atomique (CEA), and Areva's subsidiary Compagnie pour l'Étude et la Réalisation de Combustibles Atomiques (Company for the Study of Atomic Fuel Creation) (CERCA) in France. Under HERACLES, a U-Mo dispersion fuel with fuel particle coatings is being developed [5].

There are only three high flux research reactors under construction worldwide (see Table 2). One is the Jules Horowitz Material Testing Reactor (JHR), under construction in France and designed to be the forefront European nuclear experimental facility of the next decade [6]. Construction of JHR started in 2009 [6] and is ongoing at the CEA center in Cadarache [7,8]. This reactor was designed to reach peak fast and thermal fluxes of 1.0 × 1015 and 5.5 × 1014 n/cm2s. It was planned to reach its first critical state

in 2014, but startup has been delayed. The reactor is planned to use U3Si2 (HEU, 27wt% 235U/U, 4.8g
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U/cm3) as startup fuel and to operate with LEU U-Mo dispersion fuel (8g U/cm3). However, the U-Mo LEU fuel is still undergoing qualification testing and is not yet available.

The PIK reactor, which is located in St. Petersburg, Russia, aims to be the most powerful thermal research reactor, with estimated peak thermal fluxes higher than 1015n/cm2s in both the core and the reflector [9,10]. Designed to operate at 100 MW, PIK reached its first critical state in 2011. The construction was completed in 2013, with licensing of facility planned for 2015, and operation at full power scheduled for 2018 [10]. The PIK uses HEU (90wt% 235U/U) fuel that consists of enriched UO2 dispersed in a Cu-Be matrix. It is unlikely that this reactor will ever be converted to LEU; scoping studies indicate that reactor performance will not be maintained if converted using existing LEU fuel [11].

The MBIR reactor, located in Dimitrovgrad, Russia, is a multipurpose, sodium-cooled, fast research reactor with an estimated peak flux of 5.5 × 1015 n/cm2s. It is designed for an operating power of 150 MW. The considered fuel is a Russian variant of mixed oxide (MOX) fuel - a mixture of MOX granulated (93 wt%) and uranium metal powder (7 wt%) [12]. The construction license for this facility was issued in May 2015, and construction officially started in September 2015. The MBIR is planned to become operational in 2020, in time to replace BOR-60, the world’s only fast research reactor in operation.

page 10 on MOX in Russia's MBIR (to replace BOR-60)

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Table 1. Main characteristics [4] of high performance research reactors

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5. RECENT DESIGN STUDIES

5.1. LEU CONVERSION

Through programs directed at reducing the use of weapons-grade nuclear materials in civilian applications, the NNSA has supported the conversion of domestic and international research reactors from using HEU to LEU since 1978. In 2004, the reactor conversion was incorporated as one of the main pillars of HEU minimization [5] in the Global Threat Reduction Initiative (GTRI) program. This program was formerly known as the Reduced Enrichment for Research and Test Reactors (RERTR). Currently, the LEU conversion effort is overseen by the NNSA Office of Material Management and Minimization (M3).

Under NNSA support, feasibility studies are under way to study the conversion of the US high performance research reactors (HPRRs) and the US-supplied high flux European research reactors still operating with HEU fuel. The main limitation in this endeavor is the lack of an appropriate, robust, licensed LEU fuel. The LEU fuel would also need to allow a safe, reliable, affordable conversion with no significant impact on the reactor’s performance or its ability to perform its scientific missions, and with no major changes to reactor infrastructure [5,13]. The five US HPPRs operating with HEU fuel and undergoing LEU conversion feasibility studies are: the Massachusetts Institute of Technology Reactor (MITR), MURR at University of Missouri, NBSR at NIST, the Advanced Test Reactor (ATR) at INL, and HFIR at ORNL. The high flux European reactors operating with HEU fuel are: BR-2 at SCK•CEN in

Belgium, RHF at ILL in France, and FRM-II in Munich, Germany.
Conversion of these reactors is challenging because they would all need a high or very high density LEU fuel to perform adequately at a very high power density and burnup while at the same time meeting the conversion program requirements. The current LEU fuel under consideration by NNSA for conversion of all US HPRRs is a U-Mo foil fuel (~15g U/cm3 fuel), which is under development/fabrication. The European reactors are considering a U-Mo dispersion fuel (~8g U/cm3); activities for qualification of this fuel are ongoing.
Feasibility studies for HFIR conversion [14] have analyzed optimizing or eliminating those features of a preliminary HFIR LEU design that were identified as problematic for manufacturing. Preliminary performance and safety analyses indicate that HFIR could be converted and maintain its current performance if the LEU fuel is qualified to HFIR conditions, manufactured to HFIR specifications, and demonstrated to be reliable and affordable [15]. In addition, to maintain its current performance after converting to LEU, while meeting the constraints required by the NNSA conversion program, HFIR would need to increase the operating power from the current 85 MW value to 100 MW.
Development of a qualified, commercially available, suitable LEU fuel [14] for US HPRRs conversion is a challenging, long-term endeavor. The U-Mo fuel development effort is led by INL, while the fuel fabrication effort is led by Pacific Northwest National Laboratory (PNNL). U-Mo foils and mini-plates have been undergoing irradiation testing since 2006. A fuel qualification report for the U-Mo foil fuel is planned to be submitted to the US Nuclear Regulatory Commission (NRC) in 2023 [16]. Special fuel fabrication or fuel qualification efforts may be required for reactors with specific fuel designs [5]. Irradiation experiments of a HFIR LEU full-size plate are planned to be conducted in the BR-2 reactor in Belgium in 2023–2026 [17].

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5.2. DESIGN EFFORTS FOR FUTURE RESEARCH REACTORS
There are only three facilities under construction internationally: the Russian PIK, which is designed for HEU fuel; the French JHR, which is designed to work with LEU fuel; and, the Russian MBIR, which is designed to use MOX fuel. JHR was planned to start in 2014, but it has been delayed by a redesign effort to address additional regulatory requirements following the 2011 Fukushima event in Japan, as well as by setbacks in certification of the LEU fuel (U-Mo dispersion, 19.7wt% 235U/U, 8 U/cm3) that was used as the basis for the initial design. At this time, the first JHR core is planned to use HEU fuel (U3Si2, 27wt% 235U/U, 4.8g U/cm3) that is commercially available; the LEU U-Mo dispersion fuel is still under qualification testing.

etc.

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