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Highly Enriched Uranium Blend Down Program at the Savannah River Site "Present and Future"

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ABSTRACT

The Department of Energy (DOE) and Tennessee Valley Authority (TVA) entered into an Interagency Agreement to transfer approximately 40 metric tons of highly enriched uranium (HEU) to TVA for conversion to fuel for the Browns Ferry Nuclear Power Plant. Savannah River Site (SRS) inventories included a significant amount of this material, which resulted from processing spent fuel and surplus materials. The HEU is blended with natural uranium (NU) to low enriched uranium (LEU) with a 4.95% ^{235}U isotopic content and shipped as solution to the TVA vendor. The HEU Blend Down Project provided the upgrades needed to achieve the product throughput and purity required and provided loading facilities. The first blending to low enriched uranium (LEU) took place in March 2003 with the initial shipment to the TVA vendor in July 2003. The SRS Shipments have continued on a regular schedule without any major issues for the past 5 years and are due to complete in September 2008. The HEU Blend program is now looking to continue its success by dispositioning an additional approximately 21 MTU of HEU material as part of the SRS Enriched Uranium Disposition Project.

"PRESENT" SRS HEU BLEND DOWN PROGRAM

INTRODUCTION AND BACKGROUND

At the end of the Cold War, SRS ceased production of special nuclear materials. At that time, approximately 33 metric tons of uranium materials were frozen in the fuel cycle processing pipeline. In 1995, this HEU material was included in the 174 metric tons declared as surplus to national security needs by the President. A commitment was made by the United States to permanently remove this material from the U. S. defense stockpile and to use it for peaceful commercial use if possible. The Office of Fissile Material Disposition was established within DOE to disposition material to a final end state that also meets nonproliferation goals. This office, which houses the HEU Disposition Program, is within the National Nuclear Security Administration (NNSA) and is working on disposition plans for the entire 174 metric tons of HEU. The DOE Environmental Management (EM) program is also working to stabilize and disposition the SRS materials to reduce landlord costs.

In the 1980's the SRS operated four production reactors, two chemical reprocessing facilities, and a fuel fabrication facility. The chemical reprocessing facilities dissolved the fuel, separated and purified the HEU from high level waste constituents. The SRS occupies an approximately 800 square kilometer reservation located along the Savannah River in South Carolina near Augusta, Georgia.

MATERIAL DESCRIPTION

The HEU materials in SRS inventory had elevated levels of ^{232}U, ^{234}U, and ^{236}U due to numerous cycles through the reactor and recovery process. It was also contaminated with various levels of transuranic actinides. These elevated levels caused the material to be considered off-specification (off spec) surplus HEU due to the fact when the material is downblended to LEU, it will not meet the American Society for Testing and Materials (ASTM) specification for commercial nuclear fuel. The off-spec inventory included

irradiated fuel, unirradiated fuel, solution in various stages of purification, ingots of recast fresh fuel, and metal buttons. The irradiated fuel and the solution material were committed to be stabilized and dispositioned under the Department of Energy (DOE) Implementation Plan response to the Defense Nuclear Facilities Safety Board Recommendations 94-1 and 2000-1. The unirradiated fuel and metal buttons were considered stable but needed to be dispositioned to meet Departmental non-proliferation goals.

DISPOSITION PROGRAM

Several alternatives were considered for the dispositioning of this off spec material. The primary ones were: (1) Blending HEU to Low Enriched Uranium (LEU) for commercial use, and (2) Blending HEU to LEU and discarding as waste. Both pathways met the non-proliferation and permanent disposition goals. Beneficial use in a commercial power reactor could have significant cost savings as opposed to the blend down to waste alternative. Several conceptual studies were done to simulate performance of off spec fuel in commercial power reactors which projected satisfactory performance results (reference 1).

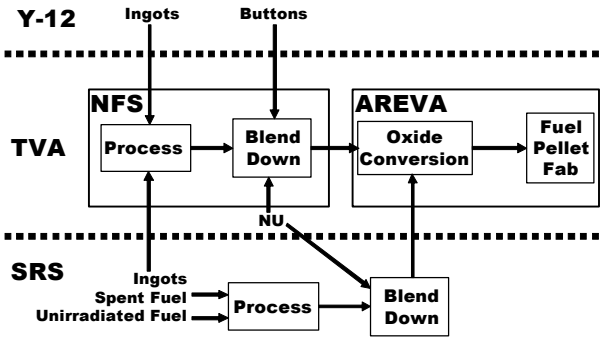
Discussions between DOE and Tennessee Valley Authority (TVA) for this material began in early 1997. After much negotiation and lead unit assembly testing, DOE and TVA signed an Interagency Agreement for the Off-Specification Fuel Project in April 2001. Approximately 33 MTU of the approximately 55 MTU of surplus off-spec HEU was sufficiently characterized to be initially allocated to this agreement. The Interagency Agreement (IA) contains a provision which allows for the addition of new HEU/LEU material to the Off-Spec Fuel Project, if both parties agree. Based on subsequent characterization and evaluation, approximately 6 MTU of additional surplus off-spec HEU was incorporated into an IA modification in April 2004 and another 1 MTU was added in a 2005 modification. These additions brought the total off-spec HEU allocated to the Off-Spec Fuel Project to approximately 40 MTU.

Per this IA, this 40 MTU is being blended down to a 4.95% ^{235}U isotopic and used as off spec commercial nuclear fuel. This fuel is currently being used in TVA's Browns Ferry Nuclear Station boiling water reactors (BWR).

SRS HEU BLEND DOWN PROGRAM AND PROJECT

Included in the original 40 MTU was approximately 20 MTU of SRS irradiated fuel, unirradiated fuel, HEU solution in various stages of purification, and ingots of recast fresh fuel. The SRS ingots were prepared for shipment to a TVA vendor for processing, and these shipments were completed in February 2007. The remaining SRS inventory is being dissolved, purified by solvent extraction, blended with natural uranium solution and shipped to a TVA vendor as LEU solution. See figure 1.

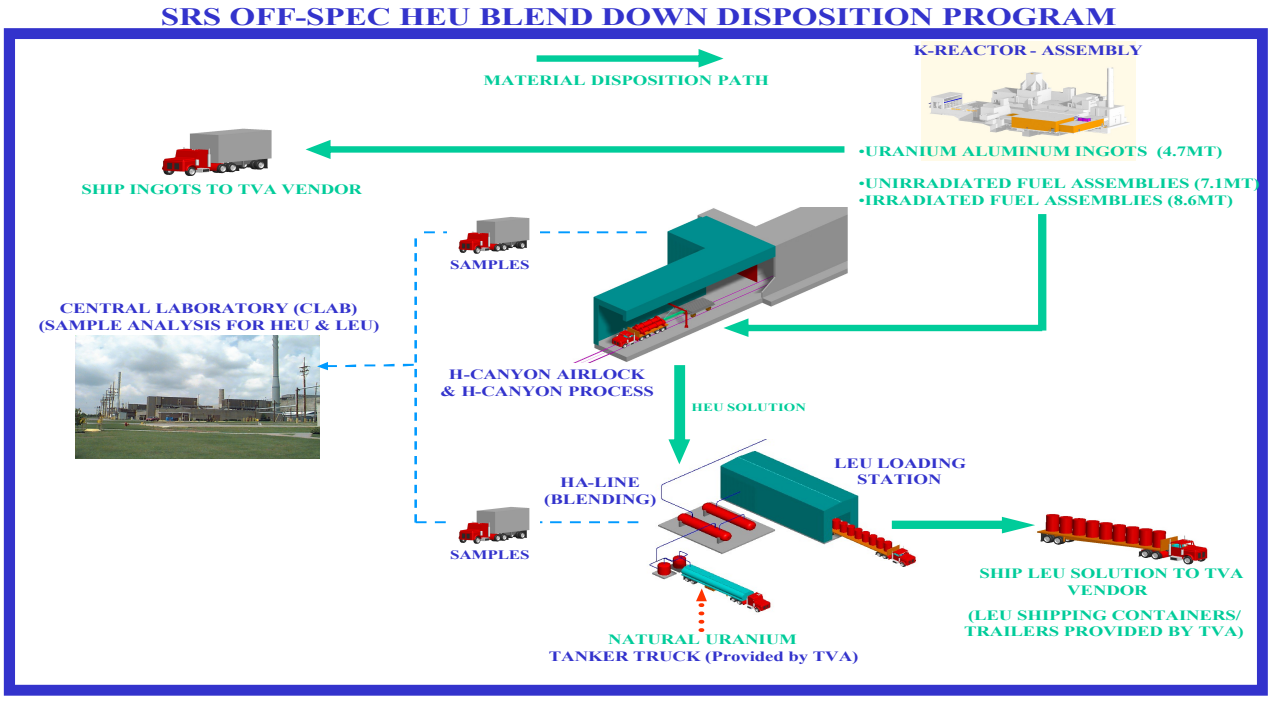
Figure 1 Material Flow Diagram



SRS uses one of the two chemical reprocessing facilities (H Canyon) to dissolve and purify the HEU to meet the IA HEU specification for blending. SRS then receives the Natural Uranium (NU) from TVA, and performs the down blending process to produce a 4.95% ^{235}U isotopic solution in HA-Line. This solution is loaded into transport containers and shipped to a TVA vendor, AREVA in Erwin, Tennessee. SRS has processed approximately 17MT HEU which includes completion of the irradiated and unirradiated fuel and a significant portion of the solution. This material produced approximately 250.5 MT LEU. The current IA requires a minimum of 254 MT LEU to be shipped, and this is expected to complete in August 2008. The material is converted to an oxide in Erwin, and then shipped to Richland, Washington. There the material is palletized and fabricated into fuel. This blended low enriched uranium (BLEU) fuel has been part of two reloads in both Brown's Ferry units two and three beginning in March 2005 and alternating from year to year. Since the fuel has performed as predicted, TVA expanded installation to the Sequoia 2 unit in May 2008.

In order for SRS to meet the HEU and the resulting LEU specifications for this program, the HEU Blend Down Project was authorized to install the needed improvements. The final design for these modifications was completed in January 2002. These activities included: modifications in the SRS K Area (one of the four reactor area where the fuel was being stored) to allow for fuel packaging and shipment to H Canyon.; modifications in H Canyon to receive the unirradiated fuel bundles as well as processing control improvements; modifications in the Central Laboratory facility to re-establish product specification capabilities; and installation of new tanks and a LEU loading station in HA-Line, a facility east of H Canyon. Construction on this project began in March 2001 and was completed in March 2003, nine months ahead of schedule. The flow of material is shown in Figure 2. SRS performed the initial HEU down blend in February 2003, and shipped the first trailer to TVA in July 2003.

Figure 2



The HEU Blend Down Program has proven to be a highly successful HEU disposition program for the off spec surplus HEU.

"FUTURE" SRS HEU BLEND DOWN PROGRAM

ADDITIONAL HEU MATERIALS

In 2005, the HEU Disposition Program office began re-evaluating the disposition options for the remaining surplus off spec HEU. It was determined that some of the surplus HEU material alloyed with molybdenum would be better suited for disposition via the off spec route rather than the "on spec" route. In another NNSA initiative to support nuclear material consolidation and disposition, the NNSA Deputy Administrator directed all NNSA sites to identify and describe inactive nuclear materials at NNSA sites with no defined use, including some plutonium bearing items. Both studies identified a combined approximately 7 MTU of material. The most viable potential disposition path for this material was through the H Canyon facilities at SRS for either recovery and downblend, or disposal as waste. These off spec HEU materials are excess to national security needs and are located across the DOE complex, including SRS, Y-12 National Security Complex, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratory, as well as at several naval reactor program sites.

SRS performed an evaluation of the combined list of materials provided by NNSA, and determined the feasibility and technical compatibility of using H Canyon facilities for disposition of these items. The evaluation included the ability to receive, store, process (including facility modifications) and manage the waste associated with the processing of these items. Along with the evaluation, SRS proposed an integrated processing schedule for the NNSA materials and integrated them with the materials included in the EM missions for H Canyon. The processing schedule extends the operation of H Canyon through 2019. The evaluation report was issued in July 2006.[2]

Concurrently, EM was evaluating the mission need for continued operations of the existing SRS H Area facilities. During this evaluation, an alternative was to suspend operations at these facilities and continue storage of these NNSA enriched uranium materials and the EM spent nuclear fuel. Currently, H Area has the only process for stabilizing this material into a non-proliferable form, and pending any new processing capabilities to stabilize this material, it would continue to be stored at risk. The strategic plan drivers included the need for EM cleanup of the SRS and to eliminate or consolidate enriched uranium materials which allows several NNSA site to deinventory. Also, the Defense Authorization Act for Fiscal Year (FY) 2001, as amended in FY 2004, requires that the H Canyon facility continues operation and maintains a high state of readiness and for DOE to provide the technical staff necessary to support this effort. EM incorporated the materials from the NNSA studies and the EM-owned spent nuclear fuel and other reactor fuel materials (Table 1), and proposed the Enriched Uranium (EU) Disposition Project to EM management. The Deputy Secretary of Energy approved the Mission Need and selected continued operations of H Canyon as the Preferred Alternative in August 2006.

ENRICHED URANIUM (EU) DISPOSITION PROJECT

In order to establish an item level baseline for this project, SRS and HEU Disposition program personnel worked closely with the various NNSA sites to reconcile inventory differences between the original feasibility study and a subsequent nuclear material consolidation data call. Through collaborative efforts and clarifications on material group descriptions, the material group quantities were verified. The agreed upon baseline is approximately 21 MTU of enriched uranium. This material consists of enriched uranium, plutonium contaminated enriched uranium, and foreign research reactor/domestic research reactor returns, including projected future returns. (Table 1) Additional characterizations are being completed to establish or validate process flow sheets.

Table 1 – Summary of proposed materials to be processed in H Canyon

Material Description	Location	Proposed SRS Processing Schedule
U/Molybdenum Metals (Super Kukla)	Y-12	FY08
U/Molybdenum Metals (APRF, HPPR, SKUA, SPR II)	Y-12	FY09
HEU Metals with Plutonium Contamination	LLNL, LANL	FY08 – FY09
HEU Oxides with Plutonium Contamination	LLNL, LANL	FY08 – FY09
HEU-Plutonium Oxides	LANL	FY09
HEU/^{233}U Oxides and Metals	Y-12	FY09, FY12
HEU/Neptunium, DU/Neptunium	Y-12	FY10
Mound, PNNL, University plates	SRS	FY10
HEU/Plutonium Oxides (High in HEU)	SRS	FY08
U/Aluminum (Naval Reactors [NR])	NR Sites	FY10 – FY19
U/Aluminum Spent Fuel (FRR/DRR Returns)	SRS, future	FY10 – FY19
U/Thorium	Y-12	FY19

The recovered HEU will be included in the HEU Down Blend Program and the resultant LEU will be dispositioned as off specification fuel. Rather than simply add the additional approximately 250 MT of off specification LEU to the existing TVA Agreement, NNSA issued a formal request for expressions of interest (EOI) in October 2007 to gauge market interest and determine the most cost effective alternative for the disposition of the LEU, consistent with NNSA's missions and objectives. After evaluating the responses to the EOI (a total of three responses were received), NNSA determined the TVA proposal was the most technically sound and financially beneficial to the U. S. taxpayer. TVA was the only company able to deliver, process, and transport materials in the forms required by SRS. This will take advantage of this established disposition pathway while enhancing the economics of the DOE-TVA Interagency Agreement.

The unirradiated HEU materials are scheduled to be processed first. Shipments from Y-12 to SRS of the uranium/molybdenum material from the Super Kukla reactor, which has been stored at Y-12 for over 25 years, began in January 2008 and will continue through July 2008. The bulk of this material is being stored at SRS waiting processing. SRS began processing this material through H Canyon in February 2008 and plans to complete in December 2008. Shipments of the uranium metals and oxides from Lawrence Livermore National Laboratory (LLNL) and the Los Alamos National Laboratory (LANL) have also begun and are scheduled to complete in FY2009. Processing of the LLNL oxides are also in progress. Various facility safety basis documents, criticality safety evaluations, process flow sheets, and procedures; as well as shipper/receiver agreements which state sizing and packaging requirements, have to be approved to allow for each group of material to be received and processed through SRS facilities. This work continues for each item on the list.

CONCLUSION

The Enriched Uranium Disposition Project and continuation of the Off Specification Fuel Program support DOE goals of nuclear material consolidation, legacy material cleanup, nonproliferation, risk reduction, and recovering the uranium for a use as an energy source. The integration of these additional enriched uranium materials into the current disposition program allows for use of existing equipment and processes through FY2019. At the end of the program, the HEU down blended from SRS is estimated to be approximately 40

MTU. The LEU resulting from the down blending of this approximate 40 MTU, after to off specification fuel for commercial reactor use, is estimated to produce enough electricity to power every household in the United States for approximately 4 months.

REFERENCES:

1. D. Biswas and W. Bickford, "*Potential Utilization of SRS Uranium with High ^{236}U Content as Commercial LWR Fuel*," Transactions of the American Nuclear Society, Volume 72, 1995.

2. *"Potential Use of H-Canyon Facilities for Disposition of Materials Identified by NNSA"*, Revision 0, January 2006, Issued July 2006.