Spent Nuclear Fuel Disposition at the Savannah River Site - 17153

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ABSTRACT

For over forty years, the H-Canyon facility at the Savannah River Site (SRS) performed remotely operated radiochemical separations of irradiated targets and fuels to produce materials for national defense. Although the materials production mission has ended, the facility continues to play an important role in the stabilization and safe disposition of proliferable nuclear materials.

INTRODUCTION

As part of the US HEU Disposition Program, SRS down-blended legacy off-specification HEU to produce LEU from 2003 to 2011. This down-blended HEU material (over 22 MT) produced 301 MT of ~5% enriched LEU which has been and continues to be fabricated into light water reactor fuel being utilized in Tennessee Valley Authority (TVA) reactors (Tennessee and Alabama). This process has also been used to disposition excess HEU from various sites within the Department of Energy (DOE) complex. This "down-blending" capability remains a viable disposition path for additional excess weapons-usable HEU. An Amended Record of Decision (AROD) was approved in April 2013 allowing additional spent fuels to be processed through SRS's H-Canyon.

The primary facilities for the chemical separations process, called "canyons," are located in F and H-Areas. F-Canyon and H-Canyon are where nuclear materials historically have been chemically recovered and purified. F-Canyon has fulfilled its mission and has been deactivated. H-Canyon has continued to operate for over sixty years and provides the capability to process various types of highly radioactive materials in a safe, environmentally acceptable manner.

H-Canyon continues to disposition excess uranium and plutonium-bearing materials as well as assist with nuclear research and development. The main H-Canyon mission is to process spent nuclear fuel (SNF) currently stored in the SRS L-area "wet" basin. Approximately one-third of the SNF inventory in L-Basin will be processed through the Canyon, as part of the AROD. One of the primary drivers for processing the SNF is to create room for all the Foreign and Domestic Research Reactor Fuel anticipated for shipment to the basin. It is estimated that the disposition of the spent fuel bundles and High Flux Isotope Reactor (HFIR) cores will result in approximately 40

MTU of down-blended LEU. During these processes, the H-Canyon is also being used as a large scale radiochemical test bed for research and development activities including on-line monitoring.

DESCRIPTION

The Savannah River Site (SRS) was constructed during the early 1950s to produce primarily tritium and plutonium 239, the basic materials used in the fabrication of nuclear weapons. In support of our nation's defense programs, five reactors were built to produce these basic materials, along with support facilities including two chemical separations facilities. The primary facilities for the chemical separations process, called "canyons," are located in F and H areas. F Canyon and H-Canyon, together with FB Line and HB Line, which are located atop the canyons, respectively, are where nuclear materials historically have been chemically recovered and purified.

Due to the end of the Cold War in 1991, the need to produce nuclear weapons materials ended and SRS reactor operations ceased. Both F and H-Canyon facilities continued operation processing legacy materials. In 2001, Public Law 106-398 was established stating "The Secretary of Energy shall continue operations and maintain a high state of readiness at the H-Canyon facilities and shall provide technical staff necessary to operate and so maintain such facility". F Canyon and FB Line completed processing their last material in 2002, and have been deactivated.

Fig. 1 - H-canyon facility

H-Canyon (figure 1) is a large robust structure with remote chemical processing capabilities. The canyon is a hardened structure with 18 remote processing sections with both a "warm" side and a "hot" side. Each section is approximately 13 meters (43 feet) long, 4 meters (14 feet) wide, and can accommodate 7 meter (22 feet) high structures. Each section has 4 cells (figure 2) where equipment can be arranged as needed for a particular operating process using remote cranes.

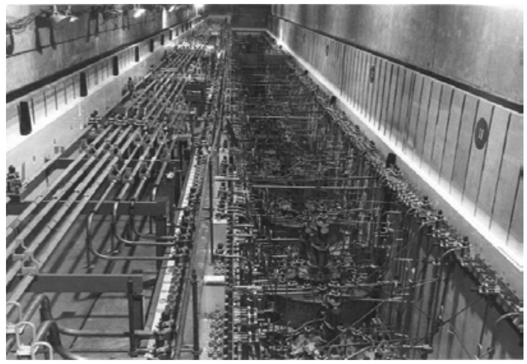

Fig. 2 - Interior of a SRS canyon chemical separations facility prior to operations

H-Canyon was based upon a facility design to provide the ability to remotely handle material with the highest potential for radiation exposure, and the ability to do remote maintenance. It also has the capability for complex separations processes to be inserted, modified in place and removed if necessary, with low radiation exposure to the operators.

Accomplished Post Cold War Missions

H-Canyon is supporting the DOE Enriched Uranium Disposition Programs by reducing the quantity of fissile materials in storage throughout the United States. To date, the H-Canyon facility has processed all the SRS legacy uranium materials that remained in the pipeline when the cold war ended, putting this material in a non-proliferable form which allowed the removal of the material from the site and state. The final endpoint of this material has found a peaceful purpose producing power via commercial nuclear reactors. This supports both the environmental cleanup and nuclear nonproliferation efforts and the creation of a smaller, safer, more secure and less expensive nuclear weapons complex.

After the Cold War ended, the DOE in conjunction with the Tennessee Valley Authority (TVA) entered into an Interagency Agreement for the disposition of weapons-usable highly enriched uranium (HEU) to low enriched uranium (LEU) for use as commercial reactor fuel in commercial TVA reactors. Since March 2003, approximately 22 metric tons of surplus highly enriched uranium, mainly legacy HEU from SRS reactor fuels, has been down blended to low enriched uranium and shipped to TVA for use in its reactors in Tennessee and Alabama. This material is now providing electricity for homes throughout the Southeast. This process has also been used to assist in deinventorying excess HEU from various sites within the DOE complex. This “down blending” capability remains a viable disposition path for additional excess weapons-usable HEU.

Current Approved Enriched Uranium Recovery Missions

H-Canyon continues to disposition excess uranium and plutonium-bearing materials as well as assist with nuclear research and development activities. The main H-

Canyon mission is to process the spent nuclear fuels (SNF) currently stored in the L-area "wet" basin. Research and development activities utilizing these facilities during these campaigns have also been approved.

In April 2013, the Record of Decision pursuant to the Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement, Aiken, SC (DOE/EIS-0279, 2000; SRS SNF EIS) was amended to allow conventional chemical separations processing of approximately 1,000 aluminum clad fuel bundles and up to 200 High Flux Isotope Reactor (HFIR) cores, as well as target residue materials containing enriched uranium through H-Canyon at SRS. Allowing this chemical separations processing, will disposition this uranium material for a useful purpose and alleviate the potential need to increase SNF storage capacity at SRS L Basin.

The approximate 1,000 fuel bundles and 120 HFIR cores (maximum SRS capacity) are currently in inventory at SRS L Basin. Additional HFIR spent fuel cores are at the Oak Ridge National Laboratory (ORNL) awaiting shipment to SRS once HFIR processing begins. The chemical compositions of the HFIR spent fuel cores (Figure 3) received from ORNL are uniform.

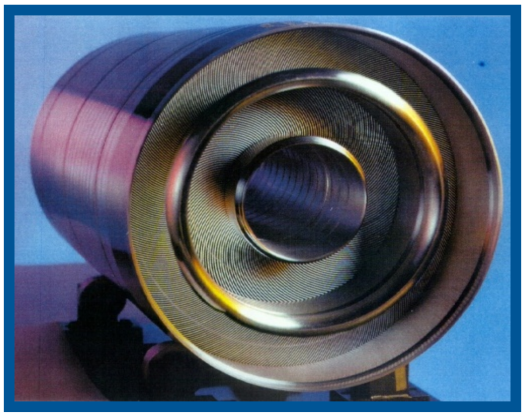

Fig. 3 – High Flux Isotope Reactor (HFIR) Fuel Core

The aluminum-clad fuels are return receipts to L Area from both foreign and domestic research reactors. The aluminum clad fuels are Material Test Reactor (MTR) type similar to those shown in Figure 4. The fuel design and make-up for these MTR type fuels may vary significantly from reactor to reactor. As the fuel assemblies are received at L Basin, they are packaged into "L" Bundles which are compatible with remote handling for transport to H Area, loading into the H-Canyon dissolver, and dissolver chemistry. A single L Bundle can store up to 5 assemblies depending on the type of fuel.

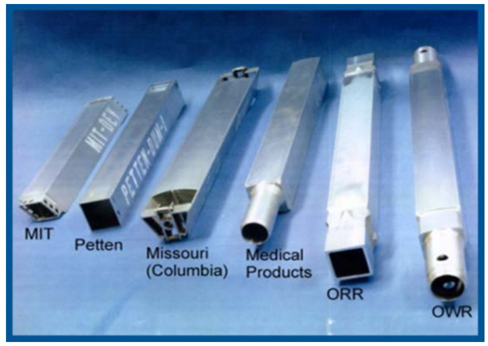

Fig. 4 – Material Test Reactor (MTR) Type Fuels

The L Bundles are transported to H-Canyon in a 70 Ton Cask Car via the SRS rail system. The cask car is moved into H-Canyon where the fuel is removed and staged. After the H-Canyon dissolver is prepped, using the remote crane on the "hot" side of the canyon, the bundles are retrieved from the staging area one by one and inserted into the dissolver to begin solvent extraction of the uranium.

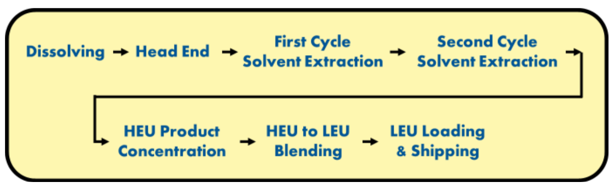

Fig. 5 – H Area HEU Solvent Extraction, Blending, and Shipping

H-Canyon currently has two operable dissolvers which can be used for either uranium scrap or fuel dissolving. Nitric acid and other chemicals (depending on flowsheet) are employed as well as steam heating to dissolve the solid materials into solution.

The dissolver solution is then sent through a Head-End evaporation process used to concentrate and clarify via a centrifuge process which prepares it for the First Cycle Solvent Extraction process.

The purpose of the First Cycle Solvent Extraction process is to separate the HEU from impurities in the feed solution, such as fission products, plutonium, neptunium, and aluminum. Preparations are in progress to receive liquid target residue material directly to H-Canyon and blend with the feed solutions from the dissolver for processing through First Cycle. The HEU separation occurs in a series of three mixer-settler vessels using an organic solvent in the first vessel to extract the HEU. A reductant is added to the second vessel to further remove impurities, and the third vessel is to remove the HEU from the solvent. The solvent is washed, recycled and stored to be re-used for the next First Cycle run. The aqueous product stream is decanted to remove entrained solvent and then sent for additional processing through the Second Uranium Solvent Extraction Cycle.

The Second Uranium Cycle Solvent Extraction process is used to produce a high quality HEU product solution that, when blended-down with natural uranium (NU) in A-

Line, will meet the DOE/TVA Interagency Agreement (IA) LEU specifications for reactor fuel fabrication. The Second Uranium Cycle Solvent Extraction process consists of two additional mixer-settler vessels. Again, solvent is used in the first vessel to extract the HEU and the second vessel is used to remove the solvent. This solvent is also recycled for use in the next Second Uranium Cycle run.

The purified HEU solution from the Second Uranium Cycle Solvent Extraction process is first sampled to confirm the HEU is within blend specification limits. The solution is then blended with a natural uranium (NU) solution to produce an LEU solution with a nominal U-235 isotopic of 4.95%. After confirming the solution is within IA acceptance limits, the LEU is transferred into shipping containers and transported to an off-site vendor for TVA commercial reactor fuel fabrication.

It is estimated that the disposition of the approximately 1,000 fuel bundles and approximately 200 HFIR cores (materials included in the amended record of decision) will result in approximately 40 MTU of down blended LEU.

CONCLUSION

H-Canyon is the only remaining large scale, remote radiochemical separations facility in the U.S. capable of processing SNF and other U, Pu and Np components. While H-Canyon's main use over the next eight-year period will be the stabilization of SNF from foreign and domestic research reactor fuel returns, there are significant opportunities for research, development, and demonstration activities that could benefit various government, university, or commercial programs. This nuclear facility has the potential for a variety of remote radiological uses simultaneously.

This facility has capabilities that are unique in the U.S. and rare in the world. Its replacement would cost tens of billions of dollars and would require sustained construction funding over many government budget cycles. At a time of fiscal constraint, maximizing the use of these capabilities deserves careful consideration.

REFERENCES

1. U.S. Department of Energy, Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement, DOE/EIS-0240, Washington, D.C., June 1996.

2. National Nuclear Security Administration, Supplement Analysis – Disposition of Surplus Highly Enriched Uranium, DOE/EIS-0240-SA1, October 2007.