STATUS OF SPENT FUEL STORAGE AT SAVANNAH RIVER SITE (OCTOBER 2003)

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ABSTRACT

The Savannah River Site continues to be the U.S. Department of Energy's primary receipt and storage location for aluminum based research reactor fuel. A number of initiatives have been implemented which enhance the site's storage capabilities while reducing the long term operating cost. The L-Basin facility improvements include projects that allow handling of the TN7/2 and LWT casks, improved basin chemistry, modernized the cask handling cranes, and increased basin capacity. In an effort to provide the most cost-effective long-term storage of material, the project to de-inventory the RBOF storage basin and consolidate spent nuclear fuel at L-Basin is nearly complete.

INTRODUCTION

The Savannah River Site (SRS) continues to receive and store foreign and domestic research reactor (FRR/DRR) fuel in a pool-type storage basin at the former L-Reactor Facility (commonly referred to as L-Basin). The Receiving Basin for Offsite Fuels (RBOF), which began receiving fuel in the early 1960s, will be de-inventoried of all spent nuclear fuel (SNF) by the end of October 2003 and deactivated in late 2004. L-Basin, which was converted to an offsite SNF receipt and storage facility in 1997, has been continuously upgraded in order to fulfill the long-term objectives of the US Department of Energy's FRR/DRR program. The purpose of this paper is to provide an update of the above changes that have occurred at SRS over the past 2 years.

To reduce long-term site operating costs, the RBOF De-Inventory Project was initiated to consolidate fuel storage into L-Basin. The initial shutdown schedule completed fuel transfers by 2007. Because of operations efficiencies gained by pre-planning, unique engineering solutions, and an integrated basin receipt/shipment schedule, de-inventory was accelerated to be complete by the end of October 2003. Other facility projects underway that impact L-Basin capabilities include the addition of fuel storage racks and cask bay[1] modifications that allow handling of the TN7/2 and LWT casks which previously could only be unloaded in RBOF. Additionally, a project to modernize the cask handling overhead cranes was completed in 2001.

To ensure long-term storage capabilities, improvements to the basin chemistry system are underway. At present, a new sand-filter system is being designed and tested which will maintain basin clarity.

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[1] Facility terminology is Transfer Bay.

RBOF DE-INVENTORY PROJECT

L Basin, which has served as the Savannah River Site's primary FRR/DRR receipt and storage facility since 1997, is soon to be the sole operational basin at the site. The de-inventorying and deactivation of RBOF will allow the reprogramming of operating funds into new SRS facilities and operations to support timely disposition of legacy materials including SNF. L-Basin will continue to meet the needs of the FRR/DRR program and current and future modifications will accommodate additional inventory requirements. The de-inventory project that was to be completed by 2007, is fully expected to be finalized by the end of October 2003. Some particulars of the project are discussed below.

Fuel Transfer

The RBOF de-inventory project consisted of three major campaigns: shipment of aluminum-based fuels, shipment of non-Al fuels, and shipment of processable fuels to the site's chemical separations facilities for processing and disposal.

Figure 1. Nuclear Fuel Element Cask

Transfer of the majority of the Al-based SNF was completed between February 1997 and May 2001 with the movement of approximately 3,800 Material Test Reactor (MTR) assemblies and 14 High Flux Isotope Reactor (HFIR) cores. In May of 2003, the Al-based fuels were completed when 4 RHF assemblies were shipped. The MTR fuels were repackaged into new bundles[2] in RBOF and transferred to L-Basin using the DOE owned Nuclear Fuel Element (NFE) casks (Figure 1). These bundles were stored in racks with the FRR/DRR fuels. The 14 HFIR fuel cores were also shipped via the NFE casks and stored in HFIR specific racks. With the installation of multi-purpose racks, the 4 RHF assemblies (similar in size to a HFIR core) were transferred.

The first transfer of non-Al fuels began in March 2001 and about 99% of the approximately 800 fuel handling unit (FHU) inventory has been moved. Many of these fuels were packaged into L-Basin bundles and stored in the existing FRR/DRR racks (called EBS racks). About 300 FHUs were packaged into 5" square bundles that could accommodate fuel assembly weights of about 360 lbs. These square bundles were also designed to be compatible with the EBS racks. The success of utilizing the EBS rack storage system in the

[2] Bundles are handling and storage cans that hold multiple fuel elements or assemblies. L-Basin bundles are 5" in diameter x 11' long and of aluminum construction.

transfer of non-Al fuels resulted in a substantial acceleration of the de-inventory completion date. The remaining non-Al inventory, which consisted of large, over-size cans that contained leakers or post-irradiation examinations (PIE) remnants, are being stored in new over-size can racks.

Transfer Requirements

The transfer of the non-Al SNF presented a significant challenge due their varied size, shape, and condition. Non-Al SNF primarily consists of Zr or SST-clad power demonstration fuel assemblies irradiated before 1975 (Table 1). The movement of this fuel required the development of fuel physical descriptions, criticality analysis for shipping and storage, and the cask studies for the varied fuel materials and conditions.

Reactor	**Core Type(s)**	**U-235 Enrich.**	**Cladding**	**Storage Form**
Carolina-Virginia Tube Reactor	UO2	~3%	Zr-4, SST	Rods
Dresden Nuclear Station	ThO2-UO2 UO2	Up to 93.5%	SST	Rods
Experimental Boiling Water Reactor	U-Zr-Nb UO2-ZrO2-CaO PuO2-UO2	Up to 93.5%	Zr-2	Intact Assemblies Scrap Cans
Elk River Reactor	ThO2-UO2	93.2%	SST	Rods
Gas Cooled Reactor Experiment (including ML-1)	UO2 and UO2-BeO	93.1%	Hastelloy X, SST	Pin Bundles, Plates
Heat Transfer Reactor Experiment	UO2-BeO	93.4%	Non-Clad	Pins in Scrap Cans
Heavy Water Components Test Reactor	U-Metal, Th-U, UO2, U-Zr	Up to 93.5%	Zirconium, Zr-2, Zr-4	Tubes, Slugs, Scrap Cans
Portable Medium Power Plant 3A	Eu2-O3-TiO2	Non-fuel	SST	Intact Assemblies
Saxton Nuclear Experimental Reactor	UO2 PuO2-UO2	Up to 12.5%	SST, Zr-4	Rods
Scrap (HEDL, B&W, ORNL)	PuO2-UO2 PuO2		Up to 93.2%	Scrap Cans
Shippingport	UO2	Natural	Zr-2	Rod Bundle
Sodium Reactor Experiment	U-C Th-U	Up to 93%	Declad	Canned Slugs
Vallecitos Boiling Water Reactor	UO2	Up to 30%	Zr-2	Plates and Rods

Table 1. Non-Aluminum Fuel Listing

Fuel description documents are also called DOE "Appendix A" Contracts. They provide dimensions, weights, materials of construction, and irradiation history. Since many of the non-Al fuels were received prior to 1980, the original Appendix A contracts were verified and converted to an updated contract form. When the original contract was not available, a new Appendix A was assembled using information from the SRS shipment files and when necessary, DOE's Office of Scientific and Technical Information (OSTI). The Appendix A's are the basis for 1) criticality analysis that enables storage and handling, 2) facility Authorization Basis acceptance, and 3) material control and accountability reports. Shielding analysis for handling and transportation is also based on the Appendix A's.

Criticality analyses considered both intact and non-intact assemblies and elements. The analyses included evaluation of storage, shipment, and accident conditions such as dropping a bundle containing fuel on top (or beside of) of a rack or cask. It also determined the safe number of assemblies or elements that can be handled at one time during bundle re-packaging with consideration of concrete reflection. A loaded bundle is compared to a bounding fuel assembly for both storage and shipping. In the case for storage, the goal is to allow bundle storage in any rack position without special limitations. In the case for shipping, the goal is to determine how bundles may be shipped at one time without special limitations. Criticality analyses for many canned scrap pieces that included oxidized fines had to consider the possibility of material slumping to the bottom of the bundle.

Cask studies that were specific for each shipment or fuel type included shielding and hydrogen deflagration. For most cases, the NFE cask provides acceptable gamma shielding. In a couple of instances, extra precautions were required because of neutron exposures from higher actinide fuels. Hydrogen deflagration was considered because no credit was given for cask venting and there were specific concerns for the U-metal fuels that were known to have exposed cores. Time limits were estimated for how long a fuel may remain in a cask between facilities. Because the U-metal fuels would generate hydrogen at a faster rate than alloyed fuels, inspections at the time of cask loading were employed to determine leak rates. In the case of a Sodium Reactor Experiment (SRE) uranium-carbide fuel, it was determined that exposure of fuel to water would result in an almost instantaneous buildup of methane exceeding the flammability limits. In this case, a detailed inspection was performed on the sealed canister that contained the declad U-C slugs.

HWCTR Over-Size Can Flushing

Another major achievement that allowed schedule acceleration was the success of the flushing and repackaging of the nine (9) HWCTR[3] over-size cans. These cans were of such a size and shape that they could not be handled in L-Basin. It was also estimated that there was potentially up to 620 Curies of Cs-137 activity saturated in the water within all 9 cans combined. The 2007 schedule estimated that the repackaging of these cans would take about almost a year. That timeframe included a slow flush to the RBOF Filtration-Deionization (F-D) system to remove activity, design and fabrication of new racks and failed fuel canisters, and the operational time to package and ship. Instead of the that path, an engineered solution was developed in which an underwater deionizer was developed that would remove the cesium from water from inside the over-size can. The system was mounted on a skid that included pumps that would take suction from the over-size cans and flush the water through a resin column that was mounted on the skid. The water exiting the resin column would be cleaned to such a high efficiency that there would be no impact to basins operations, specifically contamination.

[3] Heavy Water Components Test Reactor

The total time to physically perform the flushing operation was about 10 hours. The Cs-137 activity removed was calculated to be about 319 curies. A little over 3 curies was released to the basin (99% efficient). An added benefit of using the underwater deionizer was the reduction in waste generation that would have occurred using the facility's F-D system in terms of waste water sent to the site's high level waste tanks. It is noted here that in the process of sampling the cans prior to flushing, it was determined that 4 of the over-size cans could be opened with out flushing.

Prior to the flushing operation, new cans were designed and fabricated to specifically receive the contents of the HWCTR over-size cans. These new cans would be compatible with new large position racks that were installed in L-Basin. The entire time to flush, package and ship the HWCTR items was reduced to about 2.5 months.

Other Considerations

Facility authorization basis analyses for the L-basin changed from a Basis for Interim Operation (BIO) to a Documented Safety Analysis (DSA) during the de-inventory process. The change over was generally seamless and many of the pending BIO revisions were incorporated into the DSA. Significant revisions that were made included the flexibility to store different bundle designs in the EBS racks, increasing the weight capacity of the EBS racks from 4,500 to 13,320 pounds, and the use of missile shield covers over long bundles. The missile covers were placed over the top end of bundles that extend above the top of the EBS racks. The missile shields protect the bundle and their contents in the case of a seismic event where non-seimic equipment could fall into the basin.

The environmental impact statement (EIS) for SNF Management at SRS, DOE/EIS-0279, recognized L-Basin as an alternate location for the RBOF inventory. DOE/EIS-0220, Interim Management of Nuclear Materials documented certain fuels and materials in RBOF to be dispositioned through the separations facilities. Because of schedule acceleration, these fuels were required to be transferred to L-Basin first because of the out-year processing schedule of the canyons. One change of significance from DOE/EIS-0220 was the redirection of Co-60 slugs from disposition to reuse. These Co-60 slugs were utilized for self-protection of slightly irradiated, highly enriched uranium fuel rods. The Co-60 slugs and fuel rods were packaged together in cans and bundles in order to achieve >15 R/hr at 1 meter (unshielded) for 20 years.

The processable fuels, as listed in DOE/EIS-0220, to be shipped to the separations facilities primarily consists of fuels and material considered to be "at-risk". These fuels could impact basin operations because of their potential to release activity to the basin water. The last of these fuels were removed from RBOF in the Spring of 2003.

L-BASIN EXPANDED STORAGE

L-Basin was initially provided with storage capacity for 9,180 MTR equivalent[4] assemblies. In 1998, storage capacity for sixty (60) HFIR cores was added. The RBOF de-inventory effort in combination with the FRR/DRR program projected L-Basin to reach full capacity in FY2002. A project was started in FY2000 to install new fuel storage racks in L-

[4] MTRE

Basin to provide adequate storage capacity through FY2009. In 2002, the MTRE capacity was increased by 2,700 and HFIR was expanded by 60 cores. In 2003, MTRE capacity was increased by 3,870 bringing the total capacity to 15,750 MTREs. As of September 2003, the EBS racks are 60% full and the HFIR racks are 53% full. The percentage of the EBS rack inventory consisting of non-Al fuel in 10%.

Also occurring in 2003, was the installation of the over-size can racks (42 positions) and the multi-purpose (bucket) racks (36 positions). The installation of these racks in 2003 was necessary to support the acceleration of RBOF de-inventory. Other near term rack installations specifically supporting the FRR/DRR program are 5 EBS racks (675 MTREs) in the Dry Cave basin and 30 HFIR racks (60 cores). Future rack installations will be based upon program needs if SNF receipts continue significantly past FY2010.

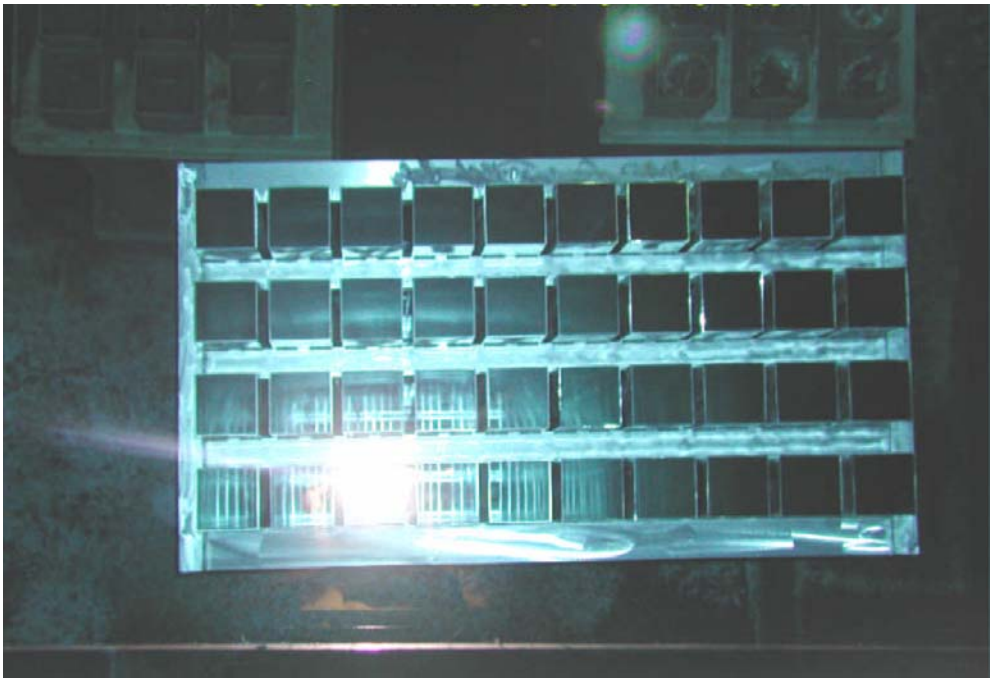

Figure 2: EBS Rack 4 x 10 Type

ADDITIONAL CASK HANDLING CAPABILITIES

Two projects have been completed which allow L-Basin to receive additional types of casks. The LWT and TN7/2 casks are too tall to be unloaded in the manner that most casks are handled in L-Basin. Casks are normally placed on the basin floor in an area with a water depth of fifteen and one half(15.5) feet. With the two taller casks, there was insufficient water shielding to unload the fuel assemblies underwater in this area.

The LWT Shielded Transfer System (STS) provides a means to unload fuel baskets remotely into a shielded cell. The shielded cell (or STS) contains a fuel grapple that operators use to remotely engage and lift fuel baskets into the STS. Once the fuel grapple and basket have been positioned into the STS, the system transports the fuel basket to an area where it can be lowered into the basin water. Once underwater, the fuel basket is connected to a portable fuel grapple that carries the basket to an unloading area. The LWT STS has been operational since 1998 and has unloaded approximately a dozen LWT casks.

Figure 3. Legal Weight Truck Shielded Transfer System

The modifications to unload the TN7/2 casks proved to be much simpler than the LWT since a deeper area existed in the unloading basin where this cask could be unloaded. However, this deep area of the pool could not be accessed by the fuel handling operators due to existing facility obstructions. The TN7/2 project provided a removable work platform that is installed over the deep section of the unloading basin for handing a TN7/2. The project also provided all necessary crane rigging and fuel handling tools needed to handle the cask and unload the fuel.

Preparations have been completed that enable L-Basin to receive the new TN-MTR cask. The first shipment that included the TN-MTR was received in June 2002.

Figure 4. TN 7/2 Work Platform

BASIN CHEMISTRY PROJECTS

A new sandfilter system is being designed and tested for L-Basin. This sandfilter, which is used to maintain basin clarity, will replace the existing system that was installed in the early 1980s. The new sandfilter will be a skid mounted pressurized system consisting of two parallel flow paths at a nominal rate of 1000 gpm that will return filter effluent to the basin at less than 5 NTU turbidity (Figure 5). The nominal passable filter size will be 15 micron with 95 percent efficiency. This system is being designed to significantly reduce the maintenance cost associated with the old system (Figure 6) and provide service through the duration of the FRR/DRR fuel storage program. The sandfilter feeds the continuous deionizer system that was installed in 1996. This system continues to maintain excellent basin chemistry with conductivity remaining below 10uS/cm. It is expected that the new sandfilter will be on-line by June 2004.

Figure 5. New Sandfilter (one train) in Fabricator Testing

Figure 6. Existing Sandfilter

CRANE MODERNIZATION

L-Basin contains two overhead cranes that handle spent fuel casks. These cranes were installed in the 1950s. Modernization projects have been recently completed on both cranes to improve crane performance and reliability.

The 120-ton crane in L-Stack Area is used to perform initial receipt and breakdown of the spent fuel cask prior to unloading in the basin. The crane is also used after cask unloading to support decontamination and re-assembly of the cask package for shipment off site. The upgrades performed to the crane were to modernize the electrical controls and power systems, and to replace the crane hoists and trolleys.

The 85/30-ton crane used to handle casks in the spent fuel pool has also been modernized. The cranes electrical systems have been modernized by installation of variable frequency drives, new motors, and radio control capability.