Hanford K Basins Spent Nuclear Fuel Project Update

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HANFORD K BASINS SPENT NUCLEAR FUEL PROJECT UPDATE

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N.H. Williams, Fluor Daniel Hanford, Inc.

ABSTRACT

Twenty one hundred metric tons of spent nuclear fuel (SNF) are currently stored in the Hanford Site K Basins near the Columbia River. The deteriorating conditions of the fuel and the basins provide engineering and management challenges to assure safe current and future storage. DE&S Hanford, Inc., part of the Fluor Daniel Hanford, Inc. lead team on the Project Hanford Management Contract, is constructing facilities and systems to move the fuel from current pool storage to a dry interim storage facility away from the Columbia River, and to treat and dispose of K Basins sludge, debris and water.

The process starts in K Basins where fuel elements will be removed from existing canisters, washed, and separated from sludge and scrap fuel pieces. Fuel elements will be placed in baskets and loaded into Multi-Canister Overpacks (MCOs) and into transportation casks. The MCO and cask will be transported to the Cold Vacuum Drying Facility, where free water within the MCO will be removed under vacuum at slightly elevated temperatures.

The MCOs will be sealed and transported via the transport cask to the Canister Storage Building
(CSB) in the 200 Area for staging prior to Hot Conditioning. The conditioning step to remove chemically bound water is performed by holding the MCO at 300°C under vacuum. This step is necessary to prevent excessive pressure buildup during interim storage that could be caused by continuing corrosion. After conditioning, MCOs will remain in the CSB for interim storage until a national repository is completed.

Deactivation and Decommissioning of the 100K Area facilities will follow removal of fuel, sludge, and debris.
1.0 INTRODUCTION

In February 1995, the US Department of Energy (DOE) approved the Spent Nuclear Fuel Project (SNFP) Path Forward recommendation for resolution of the safety and environmental concerns associated with the deteriorating spent nuclear fuel stored in the Hanford Site's K Basins. The Path Forward recommendation involved an aggressive series of projects to construct and operate systems and facilities to safely retrieve, package, transport, condition, and store K Basins fuel and sludge, and dispose of debris and water. Along with the approval of the Path Forward, DOE assigned an accelerated schedule goal to start fuel removal and to complete fuel conditioning for dry storage as soon as feasible.

2.0 BACKGROUND

Approximately twenty-one hundred metric tons of uranium spent nuclear fuel (SNF) associated with more than 100,000 individual SNF assemblies are presently stored in K East and K West Basins. Most is Hanford N Reactor fuel, which is low enriched metallic uranium clad with a Zirconium alloy. Spent fuel is stored in 2300 open stainless steel and 1400 open aluminum canisters in K East Basin and it is estimated that about one percent of the original mass has corroded and contributed to the radioactive sludge in K East basin. Fuel located in the separate K West Basin is stored in 3000 sealed stainless steel and 800 sealed aluminum canisters. Because the K West SNF was placed in closed canisters before storage, corrosion products were contained within the canisters and sludge buildup on the floor of K West basin is much smaller in
volume than in K East basin. However, recent characterization efforts in K West basin have determined that corrosion is worse than originally expected and, dissolved fission products within the sealed canisters are greater than previously expected. A significant fraction of K basins fuel has become degraded due to cladding breaches during reactor discharge and subsequent corrosion during underwater storage. K East canister sludge characterization determined that the corroding metallic fuel and some of the sludge samples generate hydrogen gas, prompting safety concerns. Laboratory testing of K East fuel is underway to determine drying behavior and ignition temperature.

To remove the SNF, two major innovations were proposed. First, a method of repackaging the fuel into more efficient storage baskets was identified which achieved a nearly 50 percent reduction in storage space and containers for the fuel. Fuel is currently stored in canisters composed of two cylindrical containers linked together containing seven fuel elements each (Fig. 1). Unloading the canisters and loading a basket with the fuel assemblies allows a significantly higher packing density. In addition to fuel repackaging, removal of fuel corrosion products and sludges, treatment of K Basins water and disposal of debris are also planned. The second innovation was the proposed application of a two-step fuel drying and conditioning process involving cold vacuum drying that would achieve the earliest possible removal of free water from the repackaged fuel. Drying the fuel will significantly reduce further fuel degradation and improve the safety basis. Subsequent hot conditioning prior to interim storage will remove chemically bound water.
Figure 1. Spent Nuclear Fuel in K Basin
The proposed pretreatment of K Basin sludge will allow subsequent storage of sludge within the Tank Waste Remediation System (TWRS). Contaminated water and debris from the K Basins will be treated and transferred to appropriate disposal sites based on their respective waste designations.

3.0 BRIEF PROCESS DESCRIPTION

3.1 SUMMARY

Fuel is retrieved from the basins using existing monorail systems. The fuel elements and scrap fuel are cleaned and loaded into MCO tier baskets. The MCOs have been pre-loaded into transport casks and the baskets are loaded into the MCOs. The MCOs shield plug is installed followed by the cask lid. The casks are transferred to the cold vacuum drying (CVD) facility where the cask lid is removed and the MCOs are drained of standing water and placed under vacuum at 50°C to remove free water from the contents. The transport cask lid is reinstalled and the cask is transferred from the CVD to the CSB for staging prior to hot vacuum conditioning. Once the fuel has been hot conditioned, the MCOs are placed into interim storage in the CSB, pending availability of the national geologic repository. The process flow is summarized in Fig.2.
Spent Nuclear Fuel Project Process

Figure 2. Spent Nuclear Fuel Project Process Flow
K Basin sludge will be pretreated for safe storage in TWRS, and subsequent treatment which will involve the immobilization of transuranic (TRU) waste and low-level waste (LLW). Debris will be treated and/or disposed of as LLW or TRU waste as appropriate. K Basins water will be treated at the basins to maintain water quality and reduce tritium levels.

3.2 FUEL RETRIEVAL

In April 1996, a conceptual design for fuel retrieval recommended a processing strategy that utilized a combination of manual and remote systems for fuel handling. The design intent is to employ the existing manual trolley and hoist systems to transport the fuel to processing areas within the basins. Once in the processing area, remotely operated manipulators will be used to undertake a series of functions to prepare fuel for repackaging and subsequent removal from the basins.

The first stage of a procurement process is underway to acquire manipulators to support the successful retrieval of fuel from both K East and K West basins. In keeping with the fast-track nature of the SNF program, a specification is being prepared in parallel with the development and testing of equipment. The aim of the procurement will be, where possible, to pursue a strategy of “off-the-shelf” buying and to minimize additional novel design.

Canisters containing SNF assemblies will be transported from their storage racks in the K Basins using the existing fuel handling system, which consists of a network of interlocking monorails.
and hoists. The canisters will be delivered to a processing area which begins with a staging zone. From there, the fuel will be transferred by hoist to the primary cleaning machine. After an agitate-and-rinse cycle within the cleaning machine, the canister will be removed using a hoist and the SNF will be emptied into the primary cleaning machine, where it will undergo an additional agitate and rinse cycle. Using a hoist, the SNF will then be transferred in a wash basket to a tipping station and tipped onto the processing table. Up to this point all operations will be remote operations from above the basin.

The SNF will undergo a series of processes to prepare it for repackaging. These processes include disassembly, sorting, and inspection prior to placement into the Multi-Canister Overpack (MCO) tier baskets. Each of these fuel handling functions will be accomplished using tele-operated manipulators. The manipulators will be operated underwater in a radioactive environment. After the tier baskets are filled, they will be removed to an MCO tier basket staging area, again using the hoist.

The MCO is composed of a 24-inch O.D. standard schedule 304 stainless steel pipe that is closed at one end and sealed at the other using a metal seal. Tier baskets containing the SNF assemblies are stacked inside the MCO. Because of heat transfer issues associated with decay heat, the baskets are designed for heat dissipation.

Fuel elements that have been passed to the MCO basket loading station will be loaded into an
MCO basket (centered on the process table) or an MCO scrap basket (outboard of the process table) depending on fuel size and damage. Fuel gauges will be used to piece together broken fuel elements. The MCO scrap baskets that have been partially loaded with damaged fuel will be transferred, as necessary, to the scrap basket station for loading of fuel bits.

Prior to transfer to the MCO loading queue, the MCO baskets will be weighed for accountability purposes.

3.3 COLD VACUUM DRYING

Following loading of the retrieved and repackaged fuel, the cask and MCO are transferred to the Cold Vacuum Drying (CVD) facility. The MCO remains in the cask on the trailer during processing. The MCO is heated to 50°C, drained of standing water, and placed under vacuum to remove free water. Cold vacuum drying will not remove all adsorbed or chemically bound water, but once vacuum drying has been accomplished, the hydrogen production rate is controlled by decomposition of uranium hydrates and radiolysis of chemically bound water rather than temperature-dependent corrosion processes. Thus hydrogen production will occur at a much slower rate. Once dry, the MCOs are transported to the CSB for staging. Currently, the CVD facility design is complete. The construction contract was awarded to a local vendor and site preparation has been initiated.
3.4 CANISTER STORAGE BUILDING

The design of the CSB allows the MCO canisters to be staged, hot conditioned, and stored in the building. MCOs are transported in casks from the CVD facility to the CSB where they will be unloaded from the casks and placed in storage tubes for staging prior to hot conditioning. The length of the staging period is dependent on the availability of the Hot Conditioning System, but is expected to be on the order of 2 years. After the staging period the assemblies will go through a hot vacuum conditioning step at the CSB in which supplemental heating is applied and the temperature of the assemblies held at 300°C. The additional heating will remove nearly all of the chemically bound water from the fuel within the MCO. The removal of the water will allow for safe storage by minimizing further corrosion. After hot conditioning the MCOs are reinserted into the storage tubes for interim storage of up to 40 years. The SNF stored at the CSB will be permanently disposed of at the national geologic repository when it is available.

The Canister Storage Building operating deck concrete was poured in February 1997 and superstructure construction began in April 1997. An artist’s drawing of the CSB is shown in Fig. 3.

3.5 SPENT NUCLEAR FUEL SLUDGE TREATMENT, STORAGE AND DISPOSAL

After evaluating several strategies using a risk-based decision process for processing, storage and disposal of SNF sludge, the recommended approach was chemical pre-treatment under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
at the 100-K Area, followed by interim storage and treatment using the existing Tank Waste Remedia
treatment plants.

Non-TWRS alternatives were evaluated but all had major disadvantages that precluded feasibility or drove costs far beyond TWRS alternatives. These centered on overall feasibility of spent nuclear fuel corrosion products disposal at the Waste Isolation Pilot Plant (WIPP) and the viability of non-TWRS waste forms disposal at the national geologic repository.

3.6 K BASIN WATER

New and upgraded systems are being added to the existing water treatment systems at the K Basins to create an Integrated Water Treatment System (IWTS) for each of the basins. The IWTS will provide the necessary collection of cloudy water, treatment of the water, and return of treated water to all water users such as canister capping, fuel retrieval, debris cleaning, and sludge retrieval. During SNF retrieval, some water will be removed with the SNF inside the MCOs. When the water is drained from the MCOs during later processes, it will be recycled to the basins and managed with the bulk of the contaminated water. This recycle will help maintain necessary water levels in the basins and reduce volumes of waste water generated.

At the end of the SNF retrieval, a sufficient quantity of contaminated water will be removed from the K East basins and replaced with clean water to reduce the average tritium concentration in the basins to less than 300,000 pCi/L. The U.S. Environmental Protection Agency (EPA) has determined that with this tritium activity level, any water that would be released to the
environment, in the event of major loss of containment, would be below the Maximum Concentration Level for tritium before reaching the Columbia River.

The removed water will be treated via the IWTS. The IWTS will consist of a pre-filter to remove particulate and an ion exchange column to remove remaining radioactive contaminants, with the exception of tritium which cannot be chemically separated from water.

3.7 SPENT NUCLEAR FUEL DEBRIS MANAGEMENT AND DISPOSAL

Debris is defined as any solid waste resulting from the CERCLA removal action, except for sludge and wastewater. Debris is located above and below the water in the K Basins and includes items generated from operations at IWTS. The Environmental Impact Statement (EIS) for K Basins assumes that debris would be considered as LLW and would be disposed of at onsite LLW disposal facilities. In addition to the assumed LLW designation, debris might also be designated as solid waste, low-level mixed waste, TRU waste, or TRU mixed waste, depending on contaminant concentrations.

Debris will be removed from the K basins throughout the course of the cleanout. All debris will be drained of free liquid and visually inspected for sludge as it is removed from the basins. A weight percent will be determined for the amount of TRU and/or PCBs on each piece of debris. Waste designation will be established based on this characterization. Most debris is expected to
be non-TRU and non-PCB. Debris management will depend on the waste designation:

- **Radioactive Low Level Waste** - Most of the debris is expected to be LLW and will be disposed of at the low-level burial grounds at Hanford.

- **Mixed Waste** - Some debris may be designated a mixed waste and will be disposed of at either the radioactive mixed waste trenches or the Environmental Restoration Disposal Facility (ERDF) at Hanford.

- **TRU Waste, Mixed TRU Waste** - A small fraction of the debris is expected to be TRU waste or Mixed TRU Waste. This might happen if sludge or fuel particles are trapped inside of debris. The TRU designated debris will be temporarily stored at the Central Waste Complex until it can be repackaged and certified at the Hanford Waste Receiving and Processing Facility (WRAP) for eventual disposal at WIPP in New Mexico.

- **Solid Waste** - Debris that is not contaminated will be managed as solid waste. To the extent possible such debris will be recycled.

### 4.0 DEACTIVATION, DECONTAMINATION AND DECOMMISSIONING

At the conclusion of the SNF Project the K Basins and other area facilities will be transferred to
the Hanford Facility Stabilization Project for deactivation. This effort will include deactivation of facility operating systems, reduction of residual radioactive contamination within the facilities, and removal of the basin water.

The plan which will establish the transition criteria for transfer to the K Basins Deactivation Project is currently under development. The K Basin Deactivation Project will develop facility endpoint criteria in conjunction with the Hanford Environmental Restoration Project to enable safe and cost-effective, long-term surveillance and maintenance.