DISPOSITION OF ORNL’S SPENT NUCLEAR FUEL*

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ABSTRACT

This paper describes the process of retrieving, repackaging, and preparing Oak Ridge spent nuclear fuel (SNF) for off-site disposition. The objective of the Oak Ridge SNF Project is to safely, reliably, and efficiently manage SNF that is stored on the Oak Ridge Reservation until it can be shipped off-site. The project required development of several unique processes and the design and fabrication of special equipment to enable the successful retrieval, transfer, and repackaging of Oak Ridge SNF. SNF was retrieved and transferred to a hot cell for repackaging. After retrieval of SNF packages, the storage positions were decontaminated and stainless steel liners were installed to resolve the vulnerability of water infiltration. Each repackaged SNF canister has been transferred from the hot cell back to dry storage until off-site shipments can be made. Three shipments of aluminum-clad SNF were made to the Savannah River Site (SRS), and five shipments of non-aluminum-clad SNF are planned to the Idaho National Engineering and Environmental Laboratory (INEEL). Through the integrated cooperation of several organizations including the U.S. Department of Energy (DOE), Bechtel Jacobs Company LLC (BJC), Oak Ridge National Laboratory (ORNL), and various subcontractors, preparations for the disposition of SNF in Oak Ridge have been performed in a safe and successful manner.

INTRODUCTION

The Environmental Management Program for the DOE–Oak Ridge Operations Office (ORO) resolved a major vulnerability, first identified by DOE Headquarters in an assessment performed in 1993. The identified vulnerability was the potential for water intrusion into the outdoor, below-grade storage positions for the Oak Ridge SNF. Video inspection revealed that approximately one-half of the storage positions contained water at depths ranging from trace coverage to 8 ft. The stored SNF packages had known external contamination due to the hot cell conditions when the SNF was originally packaged. As a result, the potential existed for the spread of contamination beyond the boundary of the storage facility. (Note: Subsequent groundwater sampling and analysis demonstrated that there was no migration of contamination from the storage facility.) Deterioration of the SNF packages due to their prolonged contact with water was an additional concern. Many of the contaminated packages of sectioned SNF were stored in these positions for more than 20 years. It was determined that as the packages of SNF were retrieved to resolve the vulnerability, they were to be taken to a hot cell on-site at ORNL.

With the issuance of the Programmatic Environmental Impact Statement Record of Decision (60 FR 28680) for SNF in 1995, smaller sites, like Oak Ridge, were directed to ship aluminum-clad SNF to the SRS and non-aluminum-clad SNF to INEEL. These two sites serve as the regional storage and interim management sites for DOE SNF. The SNF would be repackaged in a hot cell into acceptable canisters to meet the acceptance criteria at those sites. Figure 1 illustrates the sequential process.

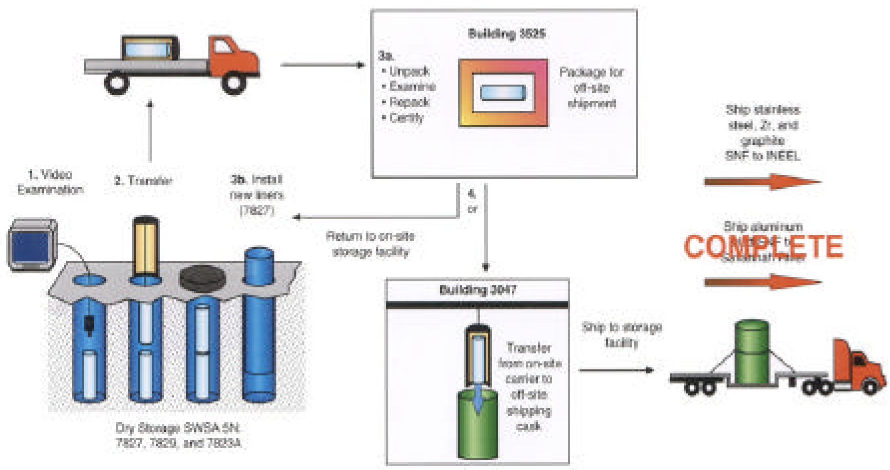

Fig. 1. SNF Process.

RETRIEVAL OF SNF

Retrieval of SNF from storage was required to resolve the vulnerability of water intrusion into some of the storage positions and to repackage SNF in preparation for off-site shipment. SNF was stored in below-grade storage positions in facilities 7823A, 7827, and 7829, which are located in Solid Waste Storage Area 5 North (SWSA 5N) at ORNL. In addition, one package of SNF was stored in SWSA 6 at ORNL. SNF retrievals were initiated in early 1996, with retrievals prioritized based on positions known to contain water. The last of the storage positions with known water infiltration was emptied in November 1998, and retrieval of the original 80 packages of sectioned SNF from SWSA 5N was completed by July 2000. The storage facility where sand was used as backfill material for shielding purposes (facility 7823A) was emptied in September 1999 and will no longer be used for SNF storage. The final SNF package was retrieved from SWSA 6 in February 2001.

To retrieve an SNF package from storage, the storage position's shield plug/lid was removed, and the on-site shielded carrier was placed over the storage position where the package was stored. Lanyards were attached to the packages before they were placed in storage and remained attached. The lanyard was attached to a winch, which was used to raise the SNF package into the carrier, and the carrier door was closed. The carrier was placed on a truck using a crane and transferred to the hot cell for examination, sorting, repackaging, and certification. After the carrier was removed from the truck at the hot cell facility, the canister was unloaded and the carrier was decontaminated. Figure 2 illustrates the process of an SNF retrieval. As each group of storage positions was emptied from facility 7827, the positions were decontaminated and new stainless steel liners were installed. Grout was placed in the annulus between the old casing and the new liners to prevent water infiltration due to flaws in the original materials of construction.

Fig. 2. SNF Retrieval from SWSA 5N.

Operations in SWSA 6 were unique in that they involved the excavation and retrieval of the Keuring van Electrotechnische Materialen (KEMA) fuel from well WF-104. This fuel was embedded in concrete within an 18-ft-long pipe assembly and required excavation work prior to retrieval of the KEMA unit. The complete unit (about 19,500 lb) was retrieved and loaded on a truck for transfer to the hot cell (see Figure 3).

Fig. 3. Retrieval of KEMA Fuel from SWSA 6.

HOT CELL EXAMINATION AND REPACKAGING OF SNF

All retrieved SNF, except for the final SNF KEMA package from SWSA 6, was examined and repackaged. Repackaging of the KEMA fuel is in process and planned for completion in FY 2002. Examination of SNF was performed remotely in hot cells at the Irradiated Fuels Examination Laboratory in Bldg. 3525 at ORNL. Prior to retrieving the SNF package from storage, the project team verified that the transfer did not exceed the inventory or fissile limits of the hot cell facility. After the SNF package was transferred to Bldg. 3525, it was inserted into the hot cell horizontally through a port in the cell wall. All surfaces of the SNF package were visually examined for cracks, corrosion, bulging, leakage of liquid, or any other unusual feature. The incoming package number was written on the outside of the container.

To disassemble the incoming package for examination, the lid was loosened from the SNF package in the hot cell. With the KEMA fuel, the excess concrete on the KEMA unit had to be cut/removed for the fuel to be removed for repackaging. The hot cell operators allowed for any potential reaction or any emerging water to drain into a catch pan before removing the lid. The contents were removed and placed into work pans to be visually examined and documented. Non-fuel contents were separated for disposition as waste. The fuel contents were then weighed.

After examination of incoming SNF, fuel segments were sorted and loaded. Wet SNF contents were allowed to dry before proceeding to packaging. The contents of some SNF packages sometimes required segmentation to allow for the SNF to fit into a canister. Some small SNF segments and debris were collected into a quart-sized steel can or a small aluminum can using manipulators. Larger pieces of SNF and the small cans were assembled into sleeves, which fit into the final canisters. The loaded sleeve was weighed, documented, and closed. The sleeve number, description, and quantity of the loaded SNF pieces, along with the weight and the original package number, were documented as required.

CLOSURE OF SNF CANISTERS

For repackaging aluminum-clad SNF, an aluminum canister (4 ¾ inches in diameter and 38 inches in length) was designed and fabricated. For repackaging non-aluminum-clad SNF, a stainless steel canister (4 ¾ inches in diameter and 34 ¾ inches in length) was designed and fabricated. Both canister designs consisted of three main design components: a canister body, a handling head, and a closure head. Canister specifications were based primarily on SRS and INEEL requirements, handling ability in the hot cell and in on-site carriers, storage requirements, and off-site shipping cask limitations. Fabrication of both canisters was performed at ORNL.

After the inner canister sleeve was loaded with SNF, the sleeve was placed into an SNF canister for final closure, and the location of the sleeve was documented. A freeze plug was submerged into liquid nitrogen and then placed into the mouth of the canister to seal the canister. A data package was prepared for each canister by the hot cell facility and certified by the SNF Certification Official.

The SNF team developed several processes and designed and fabricated equipment to ensure that SNF could be repackaged to meet off-site shipment requirements. To avoid external contamination of the closed canisters, equipment was developed to allow the canisters to be loaded and closed without bringing the canisters into the hot cell. The open end of the canister was brought to the inner wall of the hot cell, and the freeze plug was inserted and locked. Using equipment specifically developed for this task, the ability to remove incompletely closed freeze plugs was demonstrated. The sleeve was then removed and repackaged into a canister with a new freeze plug inserted and locked.

RETURN OF SNF TO STORAGE

After SNF was repackaged into canisters, radiation measurements were performed on the completed canisters to verify radiation levels, and the canisters were transferred from the hot cell facility to interim storage. Because it was difficult to make radiation measurements in the hot cell due to high background levels, radiation measurement equipment was developed to perform these measurements after the canisters were removed from the hot cell.

An autohandler was designed and fabricated to permit remote engagement and disengagement of the new SNF canisters. The autohandler promoted as-low-as-reasonably-achievable principles by eliminating the need for lanyards and facilitating canister handling. The autohandler featured an audible alarm system that would alert the operators when the autohandler was in the final engaged position, thus preventing the unintended disengagement of the SNF canister during a transfer.

To return canisters to storage, an SNF canister was placed into the on-site carrier at the hot cell facility, and the carrier was loaded on the truck and transferred to facility 7827. After the storage position’s shield plug/lid was removed, the carrier was transferred from the truck using a crane and placed over the storage position. The canister was lowered into the lined storage position using an autohandler device; after the carrier was removed from the position, the shield plug was replaced. While awaiting shipment to INEEL, the finished canisters of SNF are being stored in relined storage positions in SWSA 5N.

OFF-SITE SHIPMENTS OF SNF

Agreements were established with SRS and INEEL to receive shipments of Oak Ridge SNF. Three shipments of aluminum-clad SNF (11 canisters) were made from Oak Ridge to SRS in October, November, and January of FY 1998. Five shipments of SNF (approximately 73 canisters and 9 intact Peach Bottom fuel assemblies) are planned from Oak Ridge to INEEL.

SNF work was divided into phases to accommodate limitations in the hot cells and in funding. It was determined that the initial shipments would be the aluminum-clad SNF to SRS, so the aluminum-clad SNF repackaging was completed first. An aluminum canister was designed and fabricated to package the aluminum-clad SNF to meet the requirements for receipt at SRS. The BMI-1 shipping cask was selected for these shipments based on the experience at SRS with receiving and unloading the BMI-1 cask and the availability of the shipping cask. Nuclear Regulatory Commission (NRC) approval was obtained to make the shipments using the BMI-1 cask, and a new insert was designed to accommodate the aluminum Oak Ridge SNF canisters.

After agreement was reached with INEEL on a canister for packaging the non-aluminum-clad SNF, repackaging of SNF into stainless steel canisters for shipment to INEEL proceeded. The Transnuclear Fort St. Vrain (TN-FSV) shipping cask was selected for shipment of SNF to INEEL based on its availability and its compatibility with receipt at the INEEL storage facility. A new inner container for the TN-FSV cask was designed and reviewed by the NRC for licensing. The inner container will be fabricated to accommodate the stainless steel Oak Ridge SNF canisters and the intact Peach Bottom fuel assemblies that are stored at Oak Ridge. A license amendment for shipping the SNF to INEEL in the TN-FSV cask was received in October 2001. A cask loading facility was also constructed in 2000 to load the SNF into the cask for off-site shipments to INEEL.

ROLES AND RESPONSIBILITIES

The SNF team consists of several organizations, including DOE, BJC, ORNL, and BJC subcontractors. Each organization has contributed to the streamlined management of the Oak Ridge SNF. The SNF Project was initially managed by Lockheed Martin Energy Systems for DOE. Many of the original team members have transitioned to various organizations, and most still remain a part of the SNF team. Figure 4 illustrates the roles and responsibilities of each organization during the preparation and shipment of the Oak Ridge SNF.

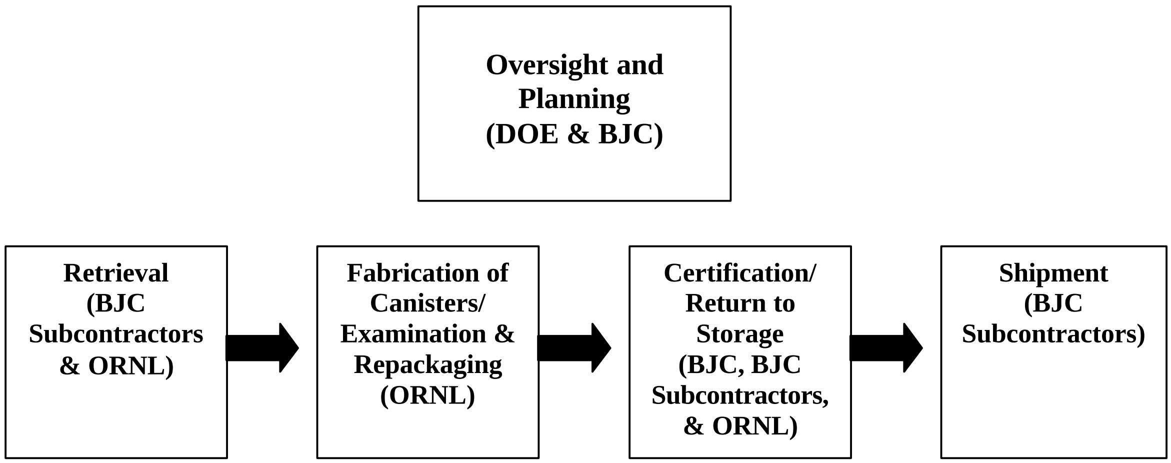

Fig. 4. Roles and Responsibilities of Organizations on the SNF Team.

EFFICIENCIES

The SNF team has worked to provide a cost-effective process for preparing Oak Ridge SNF for off-site shipment, and this process has resulted in several innovative efficiencies. The SNF project fabricated several items that utilized recycled lead for shielding. One item was the interface equipment for the SWSA 5N cask loading station that will be used during the transfer of SNF canisters into the TN-FSV cask for shipment to INEEL. The lead used in this equipment will provide shielding during those transfers. Another item fabricated that included lead for shielding was a new section for the 10-inch Experiment Removal Shield carrier, which is used for on-site transfers of the intact Peach Bottom SNF canisters. In both cases, recycled lead (in excess of 10,000 lb) was used from the ORNL inventory.

Several efficiencies in repackaging activities were also realized. Fuel items from the SNF packages were segregated from non-fuel items and some size reduction was performed. In addition, pyrolysis of epoxy-coated fuel pieces was performed. Thermal treatment of epoxy-coated fuel transformed organic material to non-organic carbon residue significantly reducing the volume of material to be repackaged. Larger clumps of epoxy-coated material were reduced to granular residue, which provided an increased packing efficiency and less void volume. Preloading of SNF into the sleeve made handling more efficient. The ability to relock a canister in which the freeze plug did not completely close eliminated the need to return the material to the hot cell for complete repackaging.

CONCLUSIONS

In summary, work to resolve the water intrusion vulnerability and to ship the aluminum-clad SNF to SRS has been successfully completed. Work to complete repackaging, transfer to interim storage, and off-site shipment of non-aluminum-clad SNF from Oak Ridge to INEEL is proceeding toward a successful completion. Each SNF retrieval and transfer was subject to the uncertainties associated with unknown storage conditions and aging equipment. The nature and degree of unexpected conditions encountered when operations were performed with SNF containers that have not been handled for an extended period can be diverse and present numerous operational challenges. This project demonstrated that with a cohesive project team, appropriate planning, and attention to safety, the Oak Ridge SNF could be successfully retrieved, repackaged, and shipped off-site.

FOOTNOTE

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