US DEPARMENT OF ENERGY STORAGE OF SPENT FUEL AND HIGH LEVEL WASTE

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ABSTRACT

This paper provides an overview of the Department of Energy's (DOE) spent nuclear fuel (SNF) and high level waste (HLW) storage management. Like commercial reactor fuel, DOE's SNF and HLW were destined for the Yucca Mountain repository. In March 2010, the DOE filed a motion with the Nuclear Regulatory Commission (NRC) to withdraw the license application for the repository at Yucca Mountain. A new repository is now decades away. The default for the commercial and DOE research reactor fuel and HLW is on-site storage for the foreseeable future. Though the motion to withdraw the license application and delay opening of a repository signals extended storage, DOE's immediate plans for management of its SNF and HLW remain the same as before Yucca Mountain was designated as the repository, though it has expanded its research and development efforts to ensure safe extended storage. This paper outlines some of the proposed research that DOE is conducting and will use to enhance its storage systems and facilities.

INTRODUCTION

This paper provides an overview of the DOE's SNF and HLW management. Like commercial reactor fuel, DOE's SNF and HLW were destined for the Yucca Mountain repository. In March 2010, the DOE filed a motion with the NRC to withdraw the license application for the repository at Yucca Mountain. Following that decision, the Secretary of Energy appointed a Blue Ribbon Commission to review the policies for managing the back end of the fuel cycle and within two years make recommendations for a long term solution to manage the US nuclear fuel and nuclear waste. This decision to withdraw the license is being contested in the courts and under review at the NRC though it appears the project is not going to move ahead given the Congressional decision to discontinue funding for the project. Ultimately, the decision to terminate the repository will likely require a legislative change to the US Nuclear Waste Policy Act by Congress and that is many years away.

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Through the National Environmental Policy Act, a decision was made in 1995 to consolidate DOE-owned SNF at existing DOE sites that have the skills, facilities, and technologies to best handle the fuel. Based on the decisions from the associated environmental impact statement, DOE planned to temporarily store its SNF at the Hanford Site in Washington, the Idaho National Laboratory (INL) in Idaho, and the Savannah River Site (SRS) in South Carolina until a repository was completed. Plans were for the Hanford Site to retain most of its current inventory of SNF. The remaining DOE SNF were to be consolidated at either the INL or SRS, depending on the type of fuel.[1] The end state baseline plan for DOE's ~2500MTHM is to process aluminum clad fuel at Savannah River and package all remaining fuel in standardized canisters at Idaho for disposal at a repository. Hanford will also continue to store fuel in multi canister over-packs until a repository is available. In part due to the high cost of operating the processing facility at Savannah River, the DOE is considering different disposition alternatives for aluminum clad fuel. If DOE decides to stop reprocessing, the aluminum clad fuels will also be moved to dry storage and packaged in a standardized canister for ultimate disposal at a repository.

The high costs of new facility construction and the DOE focus on higher risk priorities drive a preference to maximize the life of existing storage systems. The DOE plans to continue operating storage facilities by ensuring compliance with safety authorization bases, maintaining institutional controls, developing the technical bases for extended storage, and assessing the environmental impacts of these storage systems. The DOE will ensure that fuel and waste related records and safety equipment are maintained under an auditable quality assurance program that addresses expected off-site disposal requirements. If properly maintained, it is reasonable to assume that life extensions would be achievable for many of these storage systems. A brief description of the site storage facilities and expected operating and design life for those systems follows.

SPENT FUEL STORAGE AT DOE SITES

The INL maintains a variety of wet and dry storage facilities for its SNF and HLW across its large 880 acre site. The spent fuel consists of some commercial fuel including core debris from the Three-Mile Island Unit 2, a small amount of sodium-bonded fuels, and fuel from a variety of defense, government research, and commercial demonstration programs. Each of the INL spent fuel storage facilities has a monitoring and surveillance plan to ensure the facility remains within its safety authorization basis. Existing storage capacity is adequate for the foreseeable future, however, additional dry storage capacity may be needed if aluminum clad fuel is not shipped to Savannah River for processing by 2020. All fuels will require repackaging for shipment to a repository and some may require repackaging for shipment off-site.

INL spent fuel storage facilities include[2]:

- Two NRC licensed facilities, one of which is undergoing a 20 year license extension and the other with a license through 2019

- A concrete pad that provides storage for a small number of dry storage casks that have been stored for up to 30 years. One of these casks houses the fuel analyzed to support existing commercial storage license extensions in the US
- Two underground storage facilities, the larger consisting of carbon steel pipes with grouted bottoms constructed in the 1970's. Corrosion has been observed in the fuels loaded in 1971. Second generation vaults were designed to prevent water intrusion and maintain an inert internal atmosphere though some moisture has been observed
- An above ground shielded storage vault containing vertical tube storage positions that is used to support consolidation of fuels into dry storage for most of INL's fuel, and
- A third generation wet basin with a stainless steel liner and leak detection system placed in service in 1984. The pool contains ~2900 fuel storage ports of 5 different sizes and two deep unloading pools that provide the capability for cask unloading and transfer of commercial-length fuels. This basin stores spent fuel from the Naval Reactors Program that is being returned to the Naval Reactors Facility for on-site dry storage, with completion expected ~2017 to 2020. The basin mission will be to continue storage of DOE owned fuels until it reaches the end of its 40-year design life in 2024

Hanford stores most of its SNF in a steel structure covering three below-grade vaults each containing 220 tubes. The first vault is full but excess capacity exists in the remaining two vaults. Some fuel is also stored in above ground dry casks placed on reinforced concrete pads. Both facilities were placed into operation in 2000 and have a design life of 75 years. Although designs are based on providing 75 years of storage, the safety authorization basis is 40 years, consistent with other licensed spent fuel storage facilities. Most of the fuels are packaged today for acceptance at a repository though some fuels will require repackaging prior to shipment off site. The facilities include surveillance programs for assessing storage system performance. This data may be used to support a technical justification for extending the facility storage lifetimes beyond 40 years and/or to demonstrate that these materials can be safely transported[3].

Savannah River stores all its fuel in an underwater pool area called L-Basin. The majority of the fuel is aluminum clad fuel from domestic and foreign research reactors. The L-basin is an unlined concrete pool built in the 1960’s. It has no active leak detection system, but monitoring and trending of the basin makeup water is considered sufficient to detect any unplanned losses. The basin was inspected and new filters were placed into operation in the 1980's. The authorization basis for the L-basin does not include a specified design life but presumes operation through 2019. No storage of fuels in L-basin is planned beyond 2019. However, this mission presumes

- Continued processing operations for aluminum clad fuel
- Transfer of non aluminum clad fuel to Idaho, and
- Identification of a new location to receive and store aluminum fuels after 2019[4].

HIGH LEVEL WASTE STORAGE AT DOE SITES

Four sites have high level radioactive waste: West Valley, NY, Savannah River, SC, Hanford, WA, and Idaho. The planned end state for DOE's HLW is vitrified borosilicate glass or immobilized waste as a monolith solid. DOE anticipates approximately 20,000 canisters of HLW[5] will be stored until a repository is available.

Two sites have processed HLW into borosilicate glass and are storing today: West Valley and Savannah River. West Valley completed its production mission and stores 275 HLW canisters in the now closed production facility. These HLW canisters must be moved to allow the process facility to be decontaminated and decommissioned. A conceptual design was issued for the storage of these HLW canisters in a commercially designed dual purpose canister (DPC) system with a planned design life of 50 years. Plans are to inspect the DPCs during service to determine if the storage period can be extended beyond 50 years. The HLW canister relocation work has been put on hold due to budget constraints so for the near term the canisters will remain in the production facility. Through March 2010 SRS had produced about 2900 HLW canisters or about 45% of their expected total. These canisters are a 300-series low carbon stainless steel tubes and are stored in three Glass Waste Storage Buildings. The third storage building will be sized to accommodate the total projected inventory. The design life of each building is 50 years but they are expected to last 100 years and perhaps beyond with active maintenance. SRS expects to complete the glass production mission in about 20 years[6].

At Hanford, the HLW production facility is scheduled to come on line in 2018 and is expected to produce ~10,000 canisters of vitrified HLW at a rate of ~400 per year. An interim canister storage system that will hold 4,000 canisters is scheduled to be operational by FY-2017. Given the likelihood of extended storage, Hanford will need additional capacity for storing all HLW on-site until the availability of a disposal system. This storage will be needed by 2028. The design and service life of the required HLW storage facilities has not been determined[6].

Idaho has about 4,400 cubic meters of HLW stored in above ground bin sets designed for 500 years. The HLW exists as calcine which is a dry free-flowing solid. In 2010, the DOE issued a Record of Decision to retrieve the calcine and convert it into a monolithic waste-form using the Hot Isostatic Pressing process to prepare it for disposition. This treatment option is largely driven by regulations for surface disposal and the State of Idaho's desire to prepare the material for movement out of the state rather than a repository waste form requirement. The HIP process will require ~2,900-4,600 HLW canisters or DOE Standardized Canisters. Facilities are required to store these HLW canisters until a disposal system becomes available. The design and service life of the required HLW storage facilities is not determined[6].

RESEARCH AND DEVELOPMENT TO BENEFIT DOE STORAGE SYSTEMS

The DOE does not envision any near term technical or safety issues for storing these materials in the next 50-60 years in existing systems so there is time to evaluate alternative disposal and packaging options, modify existing storage system designs and facilities to accommodate longer storage periods,

and develop or deploy new technologies that would enhance or improve management of extended storage systems. Though there is no need to take immediate action regarding its storage systems, the DOE Office of Environmental Management is moving forward with a research and development program that includes future storage system needs. Examples of work scheduled for 2011 include:

- Development of a unified approach to packaging, using a standardized canister that will save money in procurement, training, loading, and handling at generator sites and a future repository
- Development of technologies for retrieval, characterization, and stabilization of degraded DOE fuels from temporary storage containers
- Development or deployment of technologies for drying in preparation for placement in a sealed canister for long-term sealed storage
- Development and deployment of a system to remotely weld, inspect, and repair standardized spent fuel canisters to decrease dose, increase throughput, and increase loading capacity
- Development of an advanced neutron absorbing material for fuel baskets that will allow increased loading of spent fuel canisters
- Development or deployment of technologies to allow dry storage canister inspection without removal from an over-pack
- Development of improved melter technologies to improve through-put, waste loading, and minimize waste generation.

The DOE Office of Environmental Management (DOE-EM) is not pursuing these research and development efforts without understanding the challenges and contributions of others who are working in the field of storage and transportation. In September 2010, the office conducted a joint workshop with the UK Nuclear Decommissioning Authority to identify areas of collaboration for technology development. Some areas of similarity with DOE needs included storage capacity determinations, security vulnerabilities of storage systems, and the need for a technical basis for extended storage.

Though most of the DOE owned fuel is managed by the DOE-EM, the Office of Nuclear Energy has expanded its Used Fuel Disposition technical area to conduct more research and development for storage, transportation, and disposal options for used nuclear fuel and high-level waste. Several individuals from the DOE-EM are participating in a storage campaign within the Used Fuel Disposition area. Though 2011 efforts are focused on commercial fuel, DOE-EM staff will contribute research and expertise that will benefit both the commercial and DOE storage efforts. Specific work in 2011 that will benefit the management of DOE storage systems includes:

- Identification of technical information gaps for extended fuel storage and development of experimental and analytical approaches to obtain that information
- Development of sensor and monitoring technologies for existing and new storage facilities and systems that allow for real time monitoring of system and fuel behavior,
- Development of modeling tools for extended storage to understand risk and performance.

DOE staff members are also participating in an effort led by the US Electric Power Research Institute and the NRC to develop a technical justification for very long term storage of fuel. The DOE is participating in this initiative to ensure DOE is fully integrated and informed of material degradation and ageing management issues for fuel elements and storage systems and will likely be a contributing partner to offer a site for an extended storage demonstration.

Finally, the DOE will also benefit from storage related research at the Idaho National Laboratory. Specific work includes:

- Evaluation of methods to mitigate and measure stress on storage canister closure welds
- Long term gas analysis monitoring of stored commercial fuel to determine fuel degradation and establish a no reopen case after 50 years of storage prior to transport
- Evaluation of coatings to minimize cracking on storage canister closure welds.

The DOE's National Spent Nuclear Fuel Program is participating in all these initiatives and provides the nexus to share information from these initiatives with DOE's management and operating contractors for their use in planning for and managing storage systems.

ADDITIONAL CONSIDERATIONS AFFECTING STORAGE

DOE's research, technology development, and active management of storage facilities and systems will ensure safe and secure operations as long as storage systems are needed. Other considerations may include:

- A technical basis for storage beyond 120 years is being developed for commercial storage systems. What will DOE use as a basis to extend storage system life beyond 120 years?
- What will improve stakeholder confidence in DOE's extended storage systems?
- Assuming policies for SNF and HLW change over decades, what factors do or do not justify early packaging of the SNF and HLW that will require packaging for final disposal?
- Should land disposal regulations be applied to HLW forms destined for a geologic repository?
- How long can DOE's storage systems last before they must be replaced? Given the long lead times to construct new facilities how will DOE determine when should these activities begin?
- Are there factors that would drive DOE to further consolidate SNF and HLW for storage?
- Will alternative disposal options present significantly different requirements for packaging DOE SNF and HLW than those developed for Yucca Mountain?

CONCLUSIONS

Generally, there are no technological barriers to safe storage of DOE's SNF and HLW. With active management, DOE's SNF and HLW can be safely and securely stored in existing dry casks, vaults, and facilities for decades leaving options open for the future and allowing time for research, development, and deployment to improve its storage facilities and systems. DOE's research and development

program and full integration with entities like the UK's Nuclear Decommissioning Authority, EPRI, NRC, and the DOE's Used Fuel Disposition campaign will undoubtedly contribute to more efficient and successful extended storage of DOE's SNF and HLW. However, while extended storage is achievable until disposal is available, it will be expensive and the DOE does not assume it to be forever. DOE will actively maintain its storage facilities for as long as they are needed and is prepared to reroof facilities, install new ventilation systems, repair and upgrade equipment, retrieve material from existing systems for over-packing or recanning, or even construct new facilities when necessary. The key for DOE will be to make sure that storage can be managed within existing cash flows and that the total liability for storage is not cost prohibitive but, it will not be zero. Ultimately, DOE, like the commercial sector, will require a disposal facility unless its storage sites are accepted by the public as a final end state for SNF and HLW, something that is highly unlikely given today's environment.

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