U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD

DEPARTMENT OF ENERGY-MANAGED SPENT NUCLEAR FUEL AT THE HANFORD SITE

OVERVIEW[1]

The U.S. Department of Energy (DOE) manages approximately 2,500 metric tons of heavy metal (MTHM)[2] of spent nuclear fuel (SNF) that resulted mostly (85% by mass) from defense-related nuclear activities (primarily, weapons plutonium production reactors and naval propulsion reactors). Nearly all the SNF is stored at four locations: the Hanford Site in Washington State, the Idaho National Laboratory in Idaho, the Savanah River Site in South Carolina, and the Fort St. Vrain Independent Spent Fuel Storage Installation in Colorado (see the Board's fact sheet on DOE-Managed Spent Nuclear Fuel).[3] Approximately 2,130 MTHM of SNF (NWTRB 2017) are in dry storage at the Hanford Site, a 586-square mile area in southeastern Washington State (Figure 1). Most of the SNF at Hanford was generated from the operation of nine defense-related plutonium production reactors located along the Columbia River (in the site area known as the 100 Area). The reactors began operating in 1944, when the B Reactor was commissioned, and ended in 1987, when the N Reactor was permanently shut down. Other SNF at Hanford was generated from the operation of the Fast Flux Test Facility (FFTF)[4] at Hanford and from commercial nuclear power reactors and research reactors.

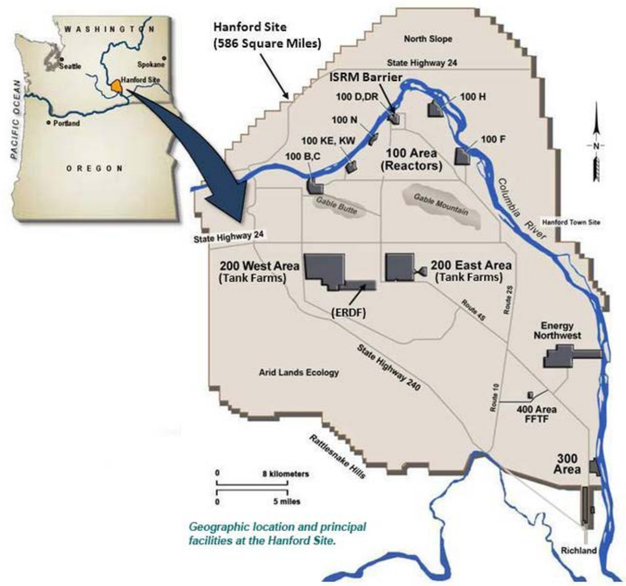

Figure 1. Hanford Site (DOE 2020).

Note: ERDF = Environmental Restoration Disposal Facility
FFTF = Fast Flux Test Facility

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[1] Unless explicitly stated, this fact sheet does not present Board findings, conclusions, or recommendations and none should be inferred from its content.

[2] Metric ton of heavy metal is a commonly used measure of the mass of nuclear fuel. Heavy metal refers to elements with an atomic number greater than 89 (*e.g.*, thorium, uranium, and plutonium) in the fuel. The masses of other constituents of the fuel, such as cladding, alloy materials, and structural materials (and fission products in spent nuclear fuel), are not included in this measure. A metric ton is 1,000 kilograms, which is equal to about 2,200 pounds.

[3] Fact sheets providing summary information on DOE-managed SNF stored at the Savannah River Site, Idaho National Laboratory, and Fort St. Vrain can be found at the Board website: http://www.nwtrb.gov/our-work/fact-sheets. A more detailed description of DOE-managed SNF and SNF storage facilities is provided in the Board report, *Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel* (NWTRB 2017).

[4] The FFTF reactor was a liquid-sodium-cooled DOE test and research reactor.

SPENT NUCLEAR FUEL AND STORAGE FACILITIES AT HANFORD

Spent Nuclear Fuel. There are ~ 2,096 MTHM of SNF from the Hanford N Reactor, a DOE plutonium production reactor that also was used to produce electric power. Of the remaining ~34 MTHM of SNF at Hanford, ~18 MTHM are from commercial nuclear power reactors, ~10 MTHM are from the FFTF, and ~5 MTHM are from other Hanford plutonium production reactors. The balance of the SNF includes small quantities of SNF from test and research reactors. Table 1 provides a summary of information on the predominant SNF types stored at Hanford, including the source, fuel type, cladding type, amount, and the corresponding storage facility.

N Reactor SNF is uranium metal fuel with zirconium alloy cladding. N Reactor SNF elements (example shown in Figure 2) consist of two concentric annular tubes with lengths that range from 15 to 26 in (38 to 66 cm) and an outside diameter of 2.5 in (6.4 cm). All N Reactor SNF has been vacuum-dried and sealed in packages called Multi-Canister Overpacks (MCOs) (Figure 3). MCOs are 25.3 in (64.3 cm) in diameter and 160 in (406 cm) in height, have a welded closure lid, and can each accommodate 270 N Reactor SNF elements. MCOs are designed for storage, transportation, and disposal of SNF. The SNF from the other Hanford production reactors all have metallic uranium fuel similar to N Reactor SNF, but have aluminum cladding (DOE 1993). All the SNF from the other reactors is contained in one MCO.

The MCOs are stored in the Canister Storage Building (Figure 4a) at the Hanford Site and will need to be placed into Nuclear Regulatory Commission-certified transportation casks for transportation offsite (Lorenz 1997). Also stored at the Canister Storage Building are 18 Shippingport spent fuel canisters that contain Shippingport Core 2 Blanket SNF (Hartlieb 2002). This SNF is from a pressurized water reactor and has natural uranium dioxide fuel with

Table 1. Spent Nuclear Fuel and Storage Facilities at the Hanford Site (NWTRB 2017)

Storage Facility	Main source of SNF	SNF Mass (MTHM)*	SNF Description (fuel type, cladding type)
Canister Storage Building	Hanford N Reactor	~2,096	Uranium metal fuel with zirconium-based[†] cladding
	Other Hanford plutonium production reactors	~5	Uranium metal fuel with aluminum cladding
	Shippingport Atomic Power Station: pressurized water reactor Core 2 blanket	~16	Uranium dioxide fuel with zirconium-based cladding
200 Area Interim Storage Area	Fast Flux Test Facility	~10	Mostly uranium-plutonium oxide fuel (20 to 30% plutonium) with stainless-steel cladding
	Commercial nuclear power reactors	~2	Uranium dioxide fuel with zirconium-based cladding
	Los Alamos Molten Plutonium Reactor Experiment	<1	Steel-clad metallic plutonium alloy with iron, cobalt, or cesium
	TRIGA®[‡] assemblies	<1	Uranium zirconium hydride (with 8.0 to 8.5% uranium) with aluminum or stainless-steel cladding

*Mass rounded to nearest metric ton
[†]Zirconium-based cladding includes zirconium cladding and Zircaloy™ cladding. Zircaloy is a trademarked name that refers to any of several alloys of zirconium with tin or other metals.
[‡]TRIGA is a type of test and research reactor provided by General Atomics

Figure 2. N Reactor Fuel (NRC 2003).

zirconium cladding. The Shippingport SNF canisters are welded stainless-steel canisters with the same dimensions as the MCOs described above.

The ~10 MTHM of SNF from the Fast Flux Test Facility is stored in 49 stainless-steel/nickel-alloy cylindrical containers, known as Core Component Containers, that have been placed inside shielded concrete overpacks called Interim Storage Casks. Most of the Fast Flux Test Facility SNF has a mixed uranium-plutonium oxide fuel matrix (with 20–30 percent plutonium) and stainless-steel cladding (Carrell 2002). The Interim Storage Casks are located on a concrete pad called the Hanford 200 Area Interim Storage Area.

DOE also stores ~2 MTHM of SNF from other commercial and test reactors, as well as research reactors, that is packaged in shielded dry-storage casks. Most of this SNF comes from commercial reactors and is uranium dioxide fuel with zirconium-alloy cladding. This SNF is stored at the 200 Area Interim Storage Area. Additional details on the SNF stored at Hanford are provided in NWTRB (2017).

Canister Storage Building. The Canister Storage Building at Hanford is a 42,000-sq ft (3,900-sq m), rectangular, enclosed steel-framed structure (Figure 4a) with a reinforced concrete floor at grade level that covers a ~42-ft (12.8-m) deep, reinforced-concrete vault. The floor has 220 circular penetrations large enough to accommodate standard storage tubes and shield plugs. Each storage tube can hold a stack of two multi-purpose canisters (MCOs or Shippingport spent fuel canisters). The Canister Storage Building, which began operations in 2000, can store 440 multi-purpose canisters but contains only 412 canisters (394 MCOs and 18 Shippingport SNF canisters). No additional storage canisters are expected to be loaded into the Canister Storage Building (DeLeon 2011). The heat generated by the SNF is removed from the concrete vault by natural air convection.

200 Area Interim Storage Area. The 200 Area Interim Storage Area is a 200,000-sq ft (18,600-sq m), at-grade facility located west of the Canister Storage Building. The facility consists of a boundary fence with gates, perimeter lighting, three concrete pads, and gravel pads on which a variety of dry-storage cask systems can be placed (Figure 4b). DOE began operations at the 200 Area Interim Storage Area in 2002 and has transferred SNF to the facility

Figure 3. Multi-Canister Overpack (McCormack 2014a).

(a) **(b)**

Figure 4. Hanford Spent Nuclear Fuel Storage Facilities. (a) Canister Storage Building; (b) Interim Storage Cask Being Placed on a Concrete Pad at the 200 Area Interim Storage Area (McCormack 2014b).

from other Hanford site locations (*e.g.*, the 300 Area and 400 Area—see Figure 1). As indicated previously, DOE stores SNF from the Fast Flux Test Facility, from commercial plants, and from various research and test reactors at the 200 Area Interim Storage Area.

PATH FORWARD FOR MANAGING AND DISPOSING OF HANFORD SPENT NUCLEAR FUEL

As part of a legal agreement between DOE, the State of Washington, and the Environmental Protection Agency (the Tri-Party Agreement[5]), DOE provided a high-level description of the disposition path for Hanford SNF (DOE 2012, 2019) and details on this disposition path (DeLeon 2011; McCormack 2010; 2013). The SNF stored in the Canister Storage Building in MCOs and Shippingport spent fuel canisters will be transported to a planned Hanford shipping facility, the canisters will be placed in transportation casks, and the casks will be transported to a geologic repository (DOE 2012, 2019). The SNF at the 200 Area Interim Storage Area will be repackaged into DOE standard canisters at a hot cell facility. The loaded canisters will be transported to the planned shipping facility, the canisters will be placed in transportation casks, and the casks will be transported to a geologic repository (DOE 2012, 2019).

Given the uncertainty on when a geologic repository will become operational, it is likely the SNF stored at Hanford will remain onsite for decades. DOE's interim storage baseline study concluded that its current technology is sufficient for the first 40 years of SNF storage (McCormack 2010). However, the study also indicated that DOE needs supplemental technology for extended interim storage of SNF (*e.g.*, for predicting serviceable lifetime of packaging and facility components) and final disposition (*e.g.*, remote welding of DOE standard canisters) (McCormack 2010). The technology that will be needed in the future depends on the timing of and requirements for final disposal.

[5] The Tri-Party Agreement, known formally as the Hanford Federal Facility Agreement and Consent Order, is a legal document that requires DOE to perform certain actions to comply with the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation and Liability Act, and the State of Washington's Hazardous Waste Management Act.

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The U.S. Nuclear Waste Technical Review Board is an independent federal agency established in the 1987 amendments to the Nuclear Waste Policy Act (NWPA).

The Board evaluates the technical and scientific validity of U.S. Department of Energy activities related to implementing the NWPA and provides objective expert advice on nuclear waste issues to Congress and the Secretary of Energy.

The eleven Board members are nominated by the National Academy of Sciences and are appointed by the President.

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