



U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD

DEPARTMENT OF ENERGY-MANAGED SPENT NUCLEAR FUEL AT FORT ST. VRAIN

OVERVIEW

The U.S. Department of Energy (DOE) manages approximately 2,500 metric tons of heavy metal (MTHM)¹ 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 (INL) in Idaho, the Savannah 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](#)).² The former commercial nuclear power plant at the Fort St. Vrain site in Colorado was a 330 megawatt (electric) high-temperature, helium-cooled reactor that operated between 1979 and 1989.

The Public Service Company of Colorado, which operated the reactor, built the SNF dry storage facility (Figure 1) adjacent to the Fort St. Vrain reactor site in 1989 and completed Nuclear Regulatory Commission (NRC) licensing for the facility in 1991. In 1996, the Department of Energy (DOE) assumed responsibility for the SNF and in 1999, the NRC license for the dry storage facility was transferred to DOE (NRC 2011). Because the Fort St. Vrain SNF was fabricated with highly enriched uranium,³ there is a relatively small amount of uranium in the SNF compared to other types of SNF; the Fort St. Vrain SNF represents less than one percent of the total mass of DOE-managed SNF.

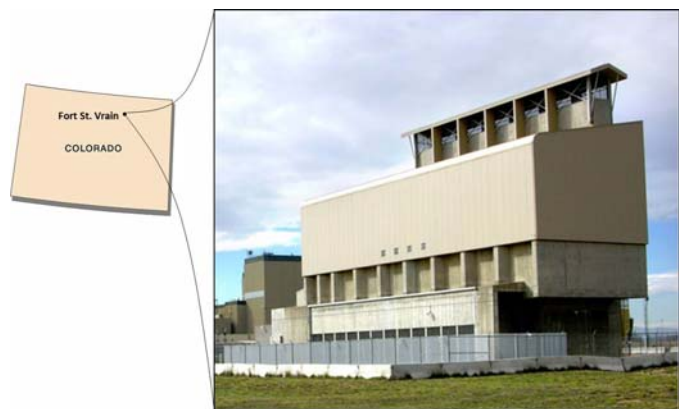


Figure 1. Fort St. Vrain SNF Dry Storage Facility. The building is 43.6-m (143-ft) long, 21.9-m (72-ft) wide, and 24.4-m (80-ft) tall (CH2M-WG Idaho, LLC 2012).

¹ 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.

² Fact sheets providing summary information on DOE-managed SNF stored at the Hanford Site, Savannah River Site, and Idaho National Laboratory 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).

³ Highly enriched uranium is uranium that has been enriched through isotopic separation to 20 percent or greater uranium-235 (naturally-occurring uranium contains uranium-235 at 0.72 percent on a mass basis).

SPENT NUCLEAR FUEL AND STORAGE FACILITY AT FORT ST. VRAIN

Spent Nuclear Fuel. Fort St. Vrain SNF consists of thorium-uranium carbide in a graphite matrix and is an uncommon type of SNF. The more common types of DOE-managed SNF are uranium metal SNF and uranium oxide SNF. As shown in Figure 2, the Fort St. Vrain fuel is made of small spherical particles comprising thorium-uranium carbide with three carbon-based protective coatings that seal the fuel material, prevent water from contacting and reacting with the fuel, and contain the fission products produced during reactor operation. The particles are mixed with graphite and compressed into cylindrical rods called “compacts” that are about 5.08-cm (2-in) long with a diameter of just under 1.27 cm (0.5 in). The compacts are then loaded into hexagonal graphite fuel elements that are approximately 78.7-cm (31-in) tall and approximately 35.6 cm (14 in) across the flat faces of the hexagon. Each fuel element has 210 fuel holes running almost the full length of the element that each contains up to 15 fuel compacts. Each fuel element also has 108 axial coolant holes through which the helium reactor coolant flowed during reactor operation (Lotts *et al.* 1992).

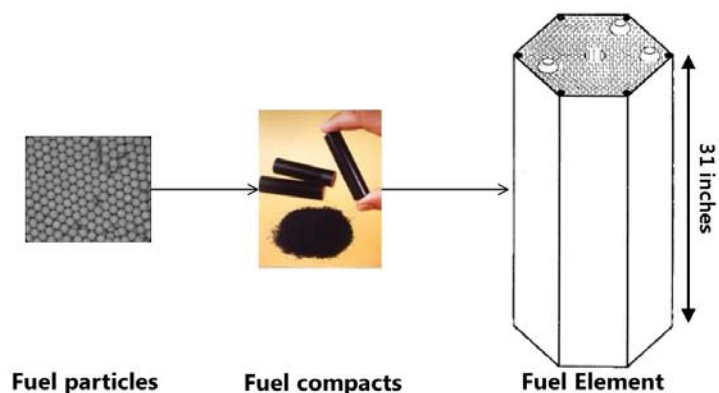


Figure 2. Details of a Fort St. Vrain Fuel Element (after Lotts *et al.* 1992; Hunn 2010; and Martin *et al.* 2012).

Fort St. Vrain SNF contains highly-enriched uranium (originally enriched to 93.5 percent uranium-235) within the thorium-uranium carbide particles. The volume of Fort St. Vrain SNF is relatively large compared to many other types of SNF that produce the same amount of energy because of the graphite in the fuel element. Because of the inert nature of the graphite and the outer protective coatings of the fuel particles, Fort St. Vrain SNF does not need to be stored in containers filled with inert gas (*e.g.*, helium) as is common with other types of DOE-managed SNF.

Spent Nuclear Fuel Storage Facility. The Fort St. Vrain dry storage facility holds the SNF inside a heavily reinforced concrete structure (see Figures 3 and 4). The storage facility includes a foundation structure that supports six SNF storage areas called vaults. Each concrete vault contains vertical storage positions that can each store one fuel storage container. A fuel storage container holds as many as six graphite SNF elements, which are kept in an air environment. The outside of the storage container is cooled by natural air circulation. The facility has a design capacity of 1,482 SNF elements. There are currently 244 positions with fuel containers loaded, giving a total inventory of 1,464 SNF elements (CH2M-WG Idaho, LLC 2012). The fuel storage containers are moved by a Container Handling Machine that can be positioned over each SNF storage location in each of the six vaults.

The Fort St. Vrain nuclear power plant generated approximately 23 MTHM of SNF. DOE transported 8 MTHM of the SNF to INL, where it remains in dry storage (see the Board’s fact sheet on [DOE-Managed Spent Nuclear Fuel at the Idaho National Laboratory](#)). As the result of

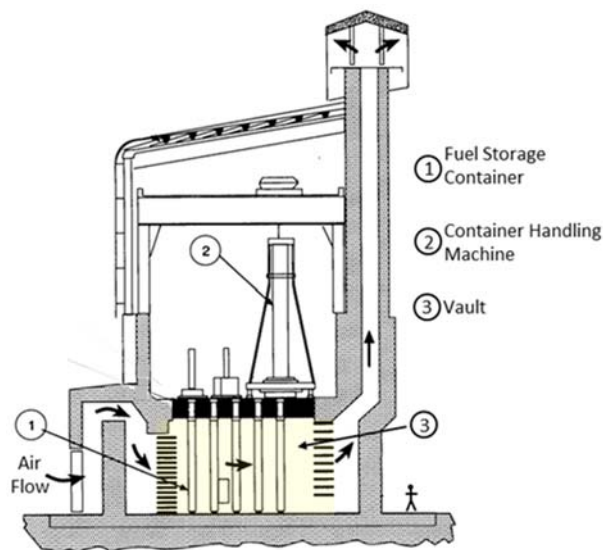


Figure 3. Major Features of the Fort St. Vrain SNF Dry Storage Facility (Cross-section of One of Six Storage Vaults) (Raddatz and Waters 1996).



Figure 4. Inside the Fort St. Vrain SNF Dry Storage Facility (CH2M-WG Idaho, LLC 2012).

an agreement with the state of Idaho (Idaho *et al.* 1995), the SNF shipments were stopped and approximately 15 MTHM of SNF remain in the storage facility at Fort St. Vrain. Additional details about the Fort St. Vrain SNF and dry storage facility are provided in the Board’s report *Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel* (NWTRB 2017).

PATH FORWARD FOR MANAGING AND DISPOSING OF FORT ST. VRAIN SNF

DOE has documented the following plans for managing and disposing of Fort St. Vrain SNF. First, DOE will continue to store SNF at the Fort St. Vrain facility consistent with the requirements of the NRC storage license that will be due for renewal on November 30, 2031 (NRC 2011). Second, DOE plans to transport Fort St. Vrain SNF to INL for repackaging prior to transporting the SNF to an interim storage facility or deep geologic repository. If storage at INL is needed, there are SNF dry-storage facilities available at INL. The exact timing of the shipments to the INL remains to be determined; however, DOE must remove the SNF from Fort St. Vrain by January 1, 2035, to meet a legal agreement with the State of Colorado (Beller 2014).

The sealed Fort St. Vrain fuel storage containers are designed to prevent the release of radioactive materials. The NRC approved these containers for transportation in combination with a transportation cask called the TN-FSV (NRC 2014) (Figure 5). One fuel storage container fits in one TN-FSV transportation cask. DOE used this



Figure 5. TN-FSV Legal Weight Truck Transport Cask (Greene *et al.* 2013).

configuration to transport Fort St. Vrain SNF to Idaho. DOE's preliminary plans include repackaging at INL the DOE-managed SNF into multi-purpose canisters for future transportation, storage, and disposal. Based on the preliminary design of DOE's multi-purpose canister, DOE estimates that all Fort St. Vrain SNF stored at INL and at Fort St. Vrain would require approximately 500 DOE canisters. Because of its design, the Fort St. Vrain SNF would require approximately 14 percent of all DOE canisters, even though it represents less than one percent of the total mass of DOE-managed SNF (NWTRB 2017).

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The U.S. Nuclear Waste Technical Review Board

is an independent federal agency established in the 1987 Nuclear Waste Policy Amendments Act.

The Board evaluates the technical and scientific validity of U.S. Department of Energy activities related to implementing the Nuclear Waste Policy Act. The Board also provides objective expert advice on nuclear waste management and disposal issues to Congress and the Secretary of Energy.

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

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