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OCRWM Backgrounder

United States Department of Energy
Office of Civilian Radioactive Waste Management
Washington, D.C. 20585

CHARACTERISTICS AND INVENTORIES OF NUCLEAR WASTE

The purpose of this paper is to describe the characteristics and inventories of the various forms of nuclear waste that are generated during the production of electricity in nuclear power plants or during the production of nuclear materials for national defense.

Radioactive waste is broadly classified as spent nuclear fuel, high-level radioactive waste, transuranic (TRU) waste, low-level waste and uranium mill tailings.

Nuclear fuel that has been removed from a nuclear reactor core because it can no longer sustain an efficient chain reaction is referred to as "spent nuclear fuel." At this point, the spent nuclear fuel is highly radioactive and thermally hot. Spent fuel is stored temporarily in water basins adjacent to the power reactors. The water removes heat generated by the spent fuel and keeps the fuel cool. It also serves as an effective shield to protect workers at the reactor site from radiation.

High-level radioactive waste is generated from the reprocessing of spent nuclear fuel. Reprocessing is a chemical separation

(MORE)

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process that can extract plutonium, which is formed during the fission process, and the remaining usable uranium from the spent fuel. Although in some other countries reprocessing is a means of extracting usable fissile material for subsequent use in new fuel elements, in the United States reprocessing is only utilized in the production of nuclear materials for national defense.

Transuranic waste is material contaminated with certain alpha-emitting radionuclides in concentrations greater than 100 nanocuries per gram. Transuranic waste is generated primarily from defense reprocessing and fabrication operations. Almost all of the existing inventory of TRU waste was generated under the Nation's atomic energy defense programs. TRU waste is further classified as either "contact handled" waste in which little or no shielding is required, or as "remote handled" waste in which shielding and remote handling are required.

Low-level waste is defined by the U.S. Department of Energy's (DOE) Order 5820.2 as all wastes which are not classified as spent nuclear fuel, high-level radioactive waste, TRU waste, or byproduct material. Low-level wastes, which are produced by many commercial, industrial and medical processes, may require special handling, although extensive shielding is not usually required. The U.S. Nuclear Regulatory Commission (NRC), which regulates the commercial low-level waste, has developed a classification system that groups some low-level waste into three, separate categories, depending on the levels of radioactive contamination. These categories are designated as Class A, B or C. The Low-Level Radioactive Waste Policy Amendment Act of 1985 has directed the DOE to provide for the disposal of greater than Class C low-level waste and has directed that a report of recommendations for implementation be developed by DOE and presented to the Congress within one year of the passage of the Act.

Uranium mill tailings are radioactive rock and soil that are the byproducts of uranium ore mining and millings. Tailings are produced in very large volume and contain low concentrations of naturally occurring radioactive materials.

The following table depicts current and projected quantities of nuclear waste.

Table 1. Quantities of Nuclear Waste 1/
(in Thousands of Cubic Meters)

Type	Year			
Defense Waste	1984 2/	2000	2010	2020
High-Level 3/	368	330	335	342
Transuranic 4/	251	359	429	499
Low-Level	2,152	3,935	4,930	5,925
Commercial Waste 5/				
Spent Nuclear Fuel 6/	5	18	29	46
Low-Level 7/	1,101	3,345	5,380	8,730
Mill Tailings	98,900	184,400	272,800	389,900
High-Level 8/	2	8/	8/	8/

1/ DOE, Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics (DOE/RW-0006, Rev. 1), December 1985.

2/ Actual. Subsequent data are projections.

3/ Includes future immobilized and other forms of waste.

4/ Includes previously disposed suspect transuranic waste and stored waste.

5/ Assumes no reprocessing of spent nuclear fuel.

6/ Volumetric data for intact assemblies calculated from data contained in referenced document. Cubic meters are used for convenience and consistency. However, spent nuclear fuel quantities are usually expressed in terms of metric tons of uranium (MTU). See Table 2. In 1984, the inventory of spent nuclear fuel reached about 12,000 MTU.

7/ Includes waste from the decommissioning and decontamination of nuclear reactors, which may have higher than Class C concentrations of radioactivity.

8/ Less than 200 cubic meters of solidified high-level waste will be produced from reprocessing waste stored at a facility near West Valley, New York.

The Nuclear Waste Policy Act of 1982 (NWPA) authorizes activities leading to the safe, permanent disposal of commercial spent nuclear fuel and of commercial and defense high-level waste. These forms of waste 9/ contain relatively high concentrations of elements that remain radioactive for thousands of years and are potentially harmful and, hence, require isolation from the public and the environment for very long periods of time. Hence, spent nuclear fuel and high-level waste will be disposed of in deep, geologic repositories that will be licensed by the NRC.

Defense generated TRU waste will be sent to the Waste Isolation Pilot Plant (WIPP) in New Mexico for the demonstration of safe disposal. Low-level waste may continue to be disposed of by shallow land burial, although alternative methods, including engineered facilities and waste treatment, will be considered. Uranium mill tailings will be treated, stabilized and stored near the uranium mines.

This paper will focus on the two forms of nuclear waste that will be disposed of in the civilian repositories authorized by the NWPA.

Spent Nuclear Fuel:

Nuclear fuel is the heart of the reactor. For a commercial, light-water nuclear power plant, the fuel consists of pellets of ceramic uranium dioxide that are sealed in hundreds of metal rods bundled together within a rigid metal structure called a "fuel assembly". The fuel rods are carefully spaced in the fuel assembly to allow coolant to flow between them as they irradiate during the fission process. Each assembly is about 14 feet long and weighs about 1200 pounds; and it is designed to be readily handled with suitable hoists and cranes at the reactor site. After about three years of use, the fuel assembly is removed, or discharged, from the reactor.

The Department uses forecasts of commercial spent fuel discharges published annually by the U.S. Energy Information Administration (EIA) as one of the principal planning variables in the formulation of waste management program and funding requirements. These projections are generated from predictive macroeconomic computer models and other data sources, including industry surveys. These data sources are used by EIA to assess the status of commercial nuclear power plants as they move from the planning phase to operational status.

9/ For brevity and convenience, the term "waste" may be used in this paper to mean both spent fuel and high-level waste from reprocessing.

In developing its waste acceptance schedules for program planning purposes, DOE uses EIA's "Mid-Case" 10/ forecasts of commercial spent fuel discharges that assume "constant burnup" of fuel assemblies. Under this assumption, the irradiation levels 11/ of fuel assemblies removed from reactor cores remain basically unchanged for the entire planning period (i.e. from 1984 through the year 2020).

EIA recently published another Mid-Case series forecast of spent fuel discharges that incorporates "extended fuel burnup" as a major variable. The new projection allows for gradually increasing fuel irradiation as burnup design limits for fuel assemblies are raised, and as utilities expand their campaigns to lengthen commercial reactor fuel cycles. The following table displays these two sets of projections. Both extended burnup and improved capacity factors for nuclear power plants are treated in the EIA report. The Office of Civilian Radioactive Waste Management (OCRWM) of the Department is evaluating the methodologies underpinning these projections.

10/ The "Mid-Case" is one of four projection series devised by EIA. The others are the "Base-Case," "Low-Case," and "High-Case." DOE selected the Mid-Case series as its reference planning case because it typified a moderate growth condition in which projected demand for additional nuclear power is satisfied by new orders of light-water reactors.

11/ Fuel assembly irradiation (or burnup) is measured in units of megawatt-days thermal per metric ton of uranium (MWDT/MTU).

Table 2. Projections of Cumulative Commercial Spent Fuel Discharges - EIA Mid-Case 12/

Year	Extended Burnup Metric Tons	Extended Burnup Cubic Meters	Constant Burnup Metric Tons	Constant Burnup Cubic Meters
1984 13/	11,400	5,000	11,400	5,000
1985	12,500	5,300	12,700	5,400
1990	21,000	8,600	21,800	8,900
1995	31,400	12,500	33,500	13,400
2000	41,700	16,200	46,100	17,900
2005	52,500	20,200	59,700	22,700
2010	66,400	25,000	77,400	28,700
2015	86,400	31,700	101,200	37,300
2020	106,400	38,600	126,600	45,900

12/ EIA, World Nuclear Fuel Cycle Requirements (DOE/EIA-04336), November 1985. The post 1985 volumetric data computed by OCRWM were based on the projected mix of commercial boiling water and pressurized water reactors.

13/ Actual. Subsequent data are projections.

High-Level Radioactive Waste:

Radioactive Waste produced from the reprocessing of either commercial or defense spent fuel accounts for the other type of nuclear waste that DOE is required to accept and dispose of under the provisions of the NWPA and subsequent Presidential actions. High-level waste is distinguished from spent nuclear fuel by its much greater volume, substantially lower radioactivity and variety of forms, ranging from liquids to solids.

A small quantity of liquid high-level radioactive waste was generated during the commercial reprocessing of power reactor spent fuel at a facility near West Valley, New York from 1966 through 1972. No additional commercial, liquid high-level waste from reprocessing is being generated in this country. The liquid waste stored at the West Valley facility is scheduled to be solidified into glass and encapsulated in stainless steel canisters for eventual disposal in a geologic repository.

The preponderant share of immobilized high-level waste from reprocessing that is scheduled to be emplaced in geologic repositories comes the Nation's nuclear defense materials production.

Defense high-level waste is generated and stored at three DOE sites: a) the Savannah River Plant (South Carolina); b) the Idaho National Engineering Laboratory (Idaho); and c) the Hanford Reservation (Washington).

Neutralized defense high-level waste in the form of liquid, salt and sludge is stored in underground tanks at the Hanford and Savannah River Plant sites. At the Idaho National Engineering Laboratory site, acidic, liquid high-level waste is stored in stainless steel tanks. It is routinely converted to a dry, granular solid called calcine for storage in bins in underground concrete vaults. As a result of the President's decision, in April 1985, to accept the Secretary of Energy's recommendation that defense waste be emplaced in a civilian geologic repository, high-level waste stored at the three DOE sites will be converted to a solid waste form for ultimate disposal in a combined defense-commercial repository. The ultimate disposal of waste at Hanford is the subject of a draft Environmental Impact Statement. The following table depicts cumulative inventories of defense high-level waste from 1984 through the year 2020.

Table 3. Inventories of All Forms of High-Level Defense Waste 14/

Year	Cubic Meters (in Thousands)
1984 15/	368
1985	355
1990	326
1995	324
2000	330
2005	326
2010	335
2015	337
2020	342

14/ DOE, Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics (DOE/RW-0006, Rev. 1), December 1985. The changes in volume reflect DOE's program to convert quantities of defense waste to an immobile solid form for eventual geologic disposal, which will reduce the volume of waste.

15/ Actual. Subsequent data are projections.