Spent Nuclear Fuel Management

By

Brian Gutherman, P.E.

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SPENT NUCLEAR FUEL MANAGEMENT

CONTENTS

NOTE: This course uses generic names and acronyms for spent nuclear fuel-related structures, and components (SSCs) and other terminology. These names and acronyms are chosen to best provide an indication of the function of the SSC based on the author's experience. Actual SSC names and acronyms vary by technology and designer and generically applicable terms are used where possible. The reader should not expect exact alignment of these SSC names and acronyms for any particular SNF storage or transportation technology. Acronyms are defined at first use in the text. In addition, a list of acronyms is provided at the end of this course material to help the student.

1.0 Overview of the Course, Nuclear Energy and Spent Nuclear Fuel

This course describes the management spent nuclear fuel (SNF) discharged from commercial nuclear reactors, which is an unavoidable byproduct of the benefits provided by nuclear energy-based electrical generation. There are three areas involving SNF management addressed in this course: 1) SNF storage, 2) SNF transportation, and 3) SNF disposal. This course focuses on storage and transportation, addressed in Sections 2.0 and 3.0, respectively, and provides a brief discussion of the status of SNF disposal in the United States in Section 4.0. While SNF can also be reprocessed into a different type of fuel and re-used (as is done in France), SNF re-processing is not performed in the United States and is not part of this course.

Chapter 1.0 begins with a brief summary the evolution of nuclear technology from its military beginnings as a weapon used in World War II to its use at commercial nuclear electrical generating stations. It proceeds with summary-level discussions of SNF policy and law and the types of commercial SNF in the United States.[1] This overview necessarily includes non-technical law and policy information because the topic of SNF management is both heavily regulated and politically charged. Both of these realities have historically driven, and continue to drive the evolution of the technologies used for SNF storage, transportation, and disposal.

1.1 Origins of Commercial Nuclear Technology

Shortly after the Manhattan Project culminated in the use of two nuclear weapons to end World War II, the United States Congress passed the Atomic Energy Act (AEA) to regulate the development and use of nuclear technology for peaceful purposes. While nuclear weapons development continued for decades, two other efforts involving nuclear technology began in the late 1940s: 1) nuclear propulsion for Naval vessels and 2) nuclear energy for

[1] References to SNF in this course mean only SNF generated by commercial nuclear power plants in the United States. Additional SNF owned and managed by the U.S. Department of Energy (e.g., from weapons production, research, and the Naval Nuclear Propulsion Program) is not addressed in this course.

commercial electricity generation. The latter involved an expansion of the control of nuclear technology and information from the federal government to include the civilian sector.

The Atomic Energy Commission (AEC) was created by the AEA to both develop and regulate commercial use of nuclear technology to generate electricity. The federal government's national laboratory program was expanded from solely supporting the nuclear weapons program to performing the necessary research and development for the Naval Nuclear Propulsion Program (NNPP) and commercial use of nuclear energy.

Another key provision of the AEA was that it allowed private companies access to nuclear technology information that had previously been classified. Private companies began investing in this new source of energy that required no transportation infrastructure to continuously deliver fuel to the generating site, as was the case for coal- and oil-fired plants.

The first large-scale nuclear power plants came on line in the late 1960s and grew to more than 100 operating reactors at over 70 plant sites around the country by the mid-1980s. As the private nuclear power industry grew, Congress recognized a need to separate its nuclear technology advocacy and research from its licensing and oversight responsibilities.

In 1974, Congress dissolved the AEC created two new agencies to assume the AEC's responsibilities. The Nuclear Regulatory Commission (NRC) was created to regulate all civilian use of nuclear materials. The Energy Research and Development Administration (ERDA) was created to coordinate energy programs formerly subdivided among several federal bureaus and serve as focal point for the major national effort research and develop all forms of energy, including nuclear. In 1977 the ERDA was further consolidated with other energy-related federal agencies to create the U.S. Department of Energy (DOE). The NRC currently performs all licensing and oversight of the commercial reactor fleet today and DOE maintains involvement in federal government activities involving nuclear materials and technology.

1.2 Spent Nuclear Fuel Policy

Because SNF is the source of weapons-grade material for nuclear weapons (e.g., plutonium), the U.S. government has always maintained ultimate responsibility for control of this material to guard against proliferation. The AEC began with control of weapons-related spent fuel and other generated waste from weapons production, research, and the NNPP before commercial nuclear power plants existed.

The AEC's role in SNF and high-level radioactive waste (HLW) management grew over time with continued weapons production, the expansion of NNPP, and the civilian use of nuclear fuel. Once the DOE was created, it took over these defense-related responsibilities and acquired responsibility for commercial SNF disposition in addition to government-owned SNF.

Of course, in developing atomic weapons to end the war, long-term waste management and disposal was, understandably, not a high priority for the federal government. However, government scientists at the time understood that the waste produced by the nuclear fission process was long-lasting and would be dangerous to public health and safety if not properly managed and disposed of. As early as 1949, the AEC concluded that "a better means of isolating, concentrating, immobilizing, and controlling wastes will ultimately be required."[2] In 1957 the National Academy of Sciences reported that disposal in salt deposits was "most promising."[3] Subsequently, the AEC launched efforts to find one or more suitable geologic disposal options and salt bed repository sites.[4] The decade of the 1960s was entirely spent on geologic disposal research and potential site locations.

As potential sites began being identified, research continued and narrowed toward specific candidate sites, with no particular site being selected through the 1970s. However, it was determined by scientific consensus world-wide that deep geologic disposal was the most

[2] Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy, January 2012, Section 3.4.1.
[3] Ibid.
[4] Ibid.

technically sound method of disposing of SNF. At the same time, as potential sites became publicly known, state opposition began to grow. By 1977, the AEC no longer existed and the new DOE came into existence, taking over commercial SNF disposition responsibilities. At this time, the first large-scale nuclear power plants had been in operation for several years, permanently discharging SNF to on-site spent fuel pools. The spent fuel pools were sized in anticipation of the federal government periodically removing SNF from the sites for disposal, creating the pool storage space needed to support reactor operation until the end of its life.

In 1978, Congress realized they needed to act on the SNF disposition issue, for three primary reasons:

- The spent fuel pools at the power plants would eventually run out of room, causing the associated reactors to have to cease operation until SNF was removed,
- Most states opposed hosting a repository,
- The country needed a technically sound, fair process to select a repository site

Work began on what was to become the first comprehensive federal legislation exclusively focused on SNF management in United States history.

1.3 The 1982 Nuclear Waste Policy Act

In 1982, Congress passed, and President Reagan signed the Nuclear Waste Policy Act (NWPA). The NWPA created an office within DOE dedicated specifically to solving the commercial SNF disposition issue, as well as dealing with disposal of DOE-generated SNF, NNPP SNF, and HLW from the nuclear weapons program. The Office of Civilian Radioactive Waste Management (OCRWM) was created with a primary objective of recommending to the President a repository site for permanent disposal of SNF and HLW. In addition, among other directives, the NWPA directed DOE to select two geologic repository sites and enter into contracts with utility owners of nuclear power plants for removal of SNF. The latter became known as the “Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste," or simply the "Standard Contract," which was codified in the federal regulations at 10 CFR 961.11

1.4 The Standard Contract

In 1983, DOE approved the final rule that established the terms of the Standard Contract between DOE and the nuclear plant owners. Each owner would sign an identical contract with DOE that required the federal government to remove from the site, transport, and dispose of the SNF discharged from the reactor(s) at the site in exchange for a fee. The Standard Contract also included other terms and conditions, such as DOE taking ownership of the SNF. That fee, paid by all commercial SNF generators to the federal government, created the Nuclear Waste Fund (NWF). The NWF was to be used to site, license, design, construct, and operate one or more SNF repositories as well as fund the transportation of SNF from all nuclear sites to that repository.

Every nuclear plant owner in the country signed the Standard Contract and began paying into the NWF in the 1980s based on how much nuclear-generated electricity they produced. The Standard Contract was intended to ensure SNF was being removed from the nuclear plant sites beginning no later than January 31, 1998 on a schedule and rate that would maintain sufficient room in the plant spent fuel pools for indefinite continued plant operation at most sites. A copy of the Standard Contract is provided as Appendix A to this course material.

1.5 The 1987 Amendments to the NWPA

The NWPA was significantly revised in 1987 to attempt to further refine the solution to the SNF disposition problem and accelerate the availability of a repository. The key elements of the 1987 NWPA amendments were:

- Cancelled the second repository
- Designated Yucca Mountain as the sole repository site to be considered
- Created Yucca Mountain licensing milestones

- Created financial incentives for states to host a repository

1.6 Standard Contract Breach

While the nuclear plant owners paid the required fees to the NWF, the federal government did not meet their obligation under the Standard Contract to begin removing fuel from the plant sites by January 31, 1998. Thus, the nuclear plants needed to design, license, construct and operate additional spent fuel storage facilities on their sites to allow the reactors to continue operation. This process began with older plants and plants with smaller-sized spent fuel pools. Because these extra SNF storage costs would not have been incurred if the government had met its obligations under the Standard Contract, the plant owners began litigation against the federal government for breach of the Standard Contract. The commercial SNF owners entered litigation as the date passed for their sites to have fuel removed and as they accumulated damages in the form of extra SNF storage costs.

As of 2022, all but one of the 70-plus nuclear power plant sites in the United States operates augmented SNF storage facilities for which the federal government reimburses most of the operating and maintenance expenses under settlements or successful litigation related to the breach of contract.

While the federal repository design for the Yucca Mountain site has received an affirmative safety evaluation report and a final environmental impact statement, no facility construction has begun. In fact, since 2010, the repository program no longer exists and no utility is paying into the NWF any longer. However, the NWF continues to accumulate interest and is estimated to be at over $40 Billion. (Reimbursements of SNF storage fees from Standard Contract litigation and settlements come from the federal government's judgement fund, not the NWF.

2.0 Spent Nuclear Fuel Storage

This section describes the two types of SNF assembly designs used in the United States. It further summarizes the regulatory framework, design, and operations aspects of both wet and dry SNF storage.

2.1 Nuclear Fuel Design and Spent Nuclear Fuel Characteristics

There are two types of reactors currently used at nuclear power plants in the United States. There is the Pressurized Water Reactor (PWR) and the Boiling Water Reactor (BWR). They are known as light-water reactors. About two-thirds of the operating reactors in the United States are PWRs and the remainder are BWRs.[5] There are currently 92 operating commercial reactors in the United States.

Commercial nuclear plant fuel is in the form of small, cylindrical pellets that contain uranium, enriched in the uranium-235 isotope (U-235) to a concentration of five percent or less. The fuel pellets are installed at the fuel fabrication facility inside thin-wall zirconium fuel rods about 12 feet (3.7 m.) long. The fuel rods are assembled into 8.5-inch square arrays that vary based on the type of reactor and fuel design from 14x14 to 17x17 fuel rods. The fuel assemblies include top and bottom fittings that facilitate lifting and handling and precise placement into each fuel cell location inside the reactor. A PWR reactor contains anywhere from about 120 to just shy of 200 fuel assemblies, each weighing up to about 1,720 lbs (780 kg) depending on the design. Nuclear fuel assemblies are completely solid material inside and out, and remain in that state from fabrication to disposal – there is no liquid waste in an SNF assembly. An example of a typical PWR nuclear fuel assembly and the pellets inside a fuel rod are shown in Figures 1-1a and 1-1b.

[5] See the course "Introduction to Nuclear Energy" for a fuller description of nuclear power plant design and operation.

Figure 1-1: Example PWR Nuclear Fuel Assembly

1-1a: Full Fuel Assembly

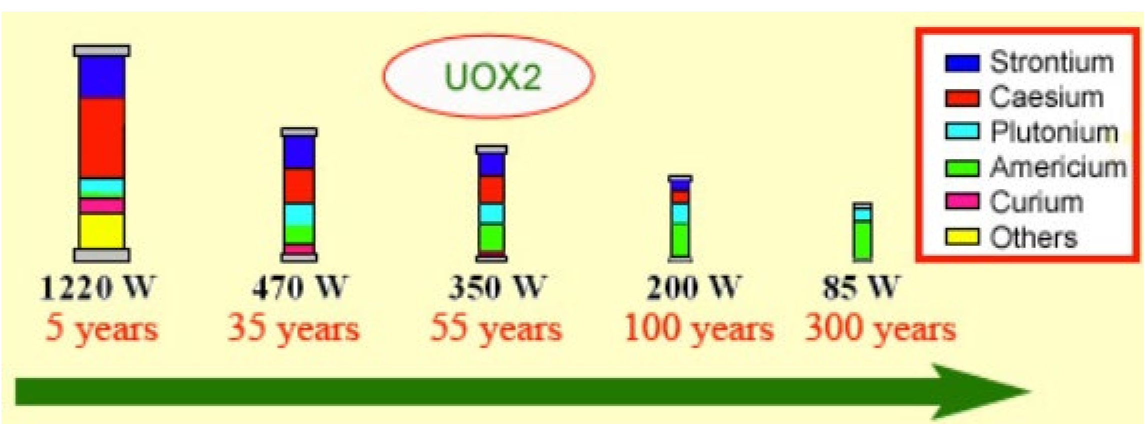
1-1b: Fuel Pellets

A BWR reactor core is comprised of smaller nuclear fuel assemblies than a PWR reactor and many more of them. BWR fuel assemblies may be found in fuel rod arrays ranging from 6x6 to 10x10 and are about 6 inches (15.2 cm) square. BWR reactor cores contain anywhere from about 500 to 760 fuel assemblies, each weighing up to about 730 lbs (331 kg), depending on the design.

Newly fabricated nuclear fuel assemblies are harmless to workers and give off negligible radiation. During reactor operation, batches of fuel assemblies typically are used for three cycles of operation that last 18 to 24 months each, depending or core and reactor design. Once irradiated in the reactor, the fission process creates two sources of long-lasting and highly radioactive material: the fuel pellets (fission products) and the fuel assembly hardware (activation by neutron flux). Irradiated SNF must always be heavily shielded to prevent harm to plant personnel.

Additionally, SNF continues to produce heat after the fission process ceases at a rate that exponentially decays over time. The so-called "decay heat" of an SNF assembly is very high immediately after reactor shutdown and decays exponentially. Decay heat continues to decrease over time, eventually to very low values according to the half-lives of each individual isotope in the fuel assembly but will never be zero. The half-lives of the hundreds of isotopes created due to fission in a spent fuel pellet vary dramatically, from a few seconds for some to 24,000 years for plutonium-239. Thus, even after decades of cooling, SNF assemblies remain highly radioactive and emit some level of decay heat. Figure 1-2 shows a typical decay heat progression for the major long-lived elements in a uranium-oxide SNF assembly.

Figure 1-2: Typical decay heat curve for an SNF assembly[6]



[6] Source: www.radioactivity.eu.com.

Lastly, after removal from reactor operation, the fuel pellets in the SNF assemblies still contain fissionable material in the form of uranium and plutonium isotopes (created by the fission process). Thus, the position of SNF assemblies with respect to one another, especially in water, must be managed carefully to prevent inadvertent criticality. The combination of radiation shielding, decay heat removal, and criticality prevention form the technical basis for designing safe SNF wet and dry storage systems, transportation packages, and disposal systems discussed later in this course.

2.2 Spent Nuclear Fuel Regulation

As discussed above, civilian use of radioactive material is authorized by the AEA. The NRC implements and enforces the AEA by the establishment of a set of rules (also known as regulations). The NRC's rules are found in Title 10 of the Code of Federal Regulations (10 CFR), which contains 87 different parts that address administrative requirements and licensing requirements for the various civilian uses of nuclear material. For example, different parts of the NRC's regulations address power plant operating licenses (Part 50), fuel fabrication facility licenses (Part 70), transportation of radioactive material (Part 71), and independent spent fuel storage installations (ISFSIs) (Part72).

10 CFR 50 governs nuclear fuel storage inside the nuclear power plant facility as just one part of the requirements for overall nuclear plant operation. Part 50 addresses storage of both new fuel before use in the reactor and SNF in the spent fuel pool after discharge from the reactor. Wet storage of SNF inside the power plant is discussed in Section 2.3 below.

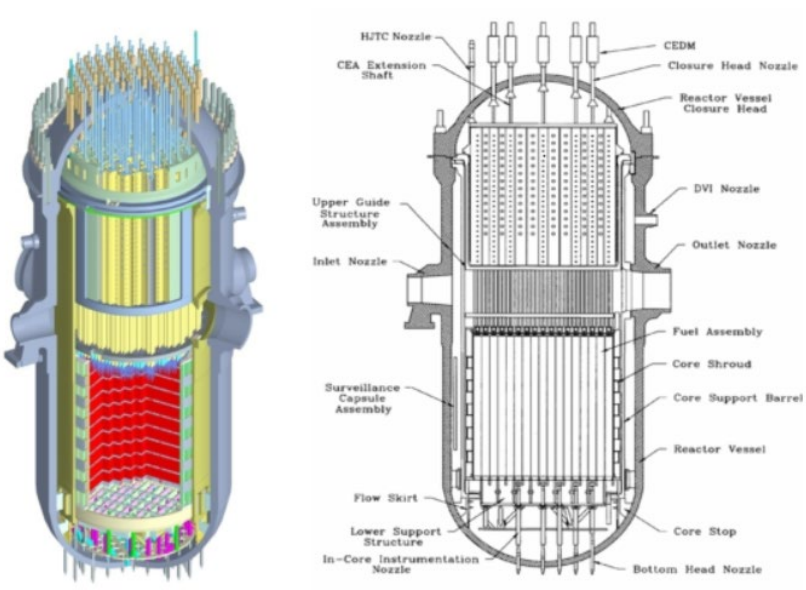
10 CFR 72 governs SNF storage outside the power plant facility, including facilities co-located on power plant sites and those located elsewhere. Part 72 also governs SNF dry storage system (DSS) design certification. Independent spent fuel storage is discussed in Sections 2.4 and 2.5 below.

SNF transportation under 10 CFR 71 is discussed in Section 3.0 below and the current status of SNF disposal in the United States (10 CFR 63) is briefly summarized in Section 4.0 below.

2.3 Nuclear Fuel Storage in the Power Plant

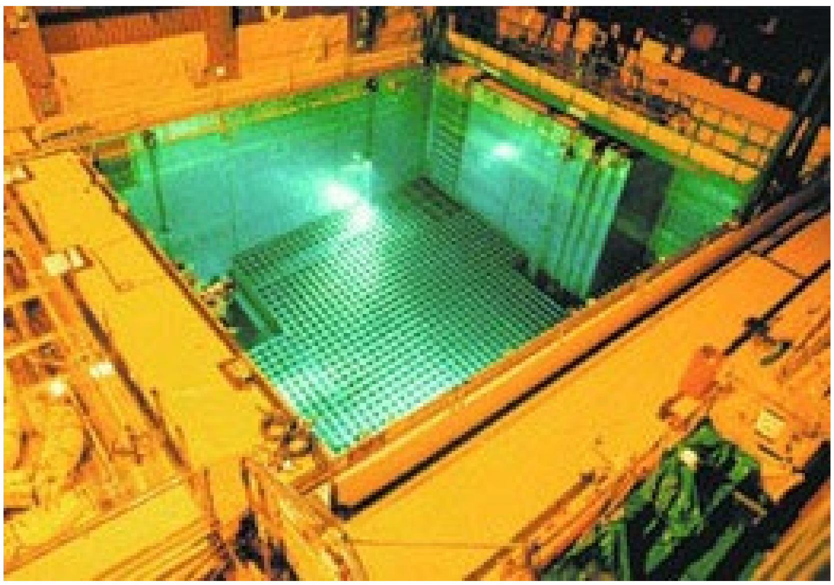
An operating nuclear power plant must have provisions for safely handling and storing both fresh nuclear fuel and SNF to allow operation over decades. Fresh nuclear fuel is delivered to the power plants from the fabrication facilities and stored for a short period of time before being loaded into the reactor during a refueling outage. About one-third of the reactor core is replaced with fresh fuel during each refueling outage. Likewise, one-third of the SNF in a reactor core is permanently discharged in the same outage. A typical PWR reactor graphic is shown in Figure 2-1 with the fuel assemblies shown in red.

Figure 2-1: Typical PWR Reactor



To make room for the fresh fuel assemblies, the SNF assemblies to be permanently discharged are removed from the reactor core each refueling outage and moved into the plant’s spent fuel pool (SFP). This is accomplished by removing the reactor vessel closure head, flooding the cavity area above the reactor, and opening tubes connecting the reactor cavity with the adjacent SFP. SNF assemblies cannot be moved above the water due to the high radiation, So, this arrangement creates a contiguous body of water through which the SNF assembly may be moved from the reactor into the spent fuel pool while maintaining the cooling and shielding provided by water. Each SNF assembly removed from the reactor is placed into a designated location in the storage racks located in the SFP. The SFP provides the necessary criticality control, decay heat removal, and radiation shielding for the SNF assemblies after discharge from the reactor. Plant SFP capacities vary widely plant to plant around the country. They allow for many years of reactor operation but, as discussed above, were never sized for the entire plant lifetime. Further, an SFP can never be completely filled because room in the storage racks must be maintained in the event all fuel must be removed from the reactor to conduct maintenance. Figure 2-2 shows a nuclear power plant spent fuel pool.

Figure 2-2: Power Plant Spent Fuel Pool[7]



A typical SFP is about 45 ft. (13.7 m.) deep and the approximately 15 ft. (4.6 m.) tall spent fuel storage racks rest on the bottom. The SFP is a thick concrete structure with a stainless steel liner and is designed for the worst seismic event for the power plant site. There are no large penetrations below the top of the storage racks to ensure the pool cannot inadvertently drain and uncover the SNF assemblies. About 23 ft. (7 m.) of water is always maintained over the storage racks to provide radiation shielding for personnel working in the area. Radiation levels in the SFP area are very low because of this water shielding.

[7] Source: www.nrc.gov.

The SFP water is continuously circulated through the SFP by a dedicated cooling system. The water is drawn from the SFP, directed through heat exchangers for cooling and through demineralizers to remove particulates to maintain water clarity and sent back to the SFP. The SFP is designed to maintain the desired level of water above the SNF and an alarm sounds in the control room if the level drops below a certain level setpoint. If the level drop is caused by evaporation due to loss of cooling, substantial time is available to repair the cooling system and, if necessary, provide make-up water to the pool.

The SFP storage racks are engineered to maintain the spacing required between adjacent SNF assemblies to prevent inadvertent criticality. Because space is finite in the SFP, the design of the spent fuel racks is vital to determining the overall storage capacity of the SFP. The storage rack walls between SNF storage locations are usually outfitted with a thin sheet of boron-infused material as part of the criticality control design. In PWR pools, the SFP water also contains dissolved boron. The boron in the fixed neutron absorbers and in the water, together, absorb neutrons effectively and allows the storage racks to be designed for higher capacity while maintaining safety margins. The SNF assembly spacing, the characteristics of the borated neutron absorber sheets, and the amount of dissolved boron in the water are precisely controlled and are based on the supporting criticality analysis. BWR plant SFPs use rack design and borated neutron absorbers for criticality control, but do not have boron in the spent fuel pool water.

Nuclear power plant SFPs were originally designed in the 1960s and 1970s. These designs were predicated on storing amounts of SNF that relied on the idea that the older fuel would periodically be removed from the SFP by the federal government to maintain adequate storage capacity indefinitely. When the federal government failed to begin removing that SNF from the sites, the capacities of the SFPs around the country became a concern for continued power plant operation. The first step to address the capacity issue was for the plants to "re-rack" the spent fuel pools with densified rack designs that significantly increased pool capacity. Re-racking involved optimization of rack geometry, neutron absorbers, and criticality analysis techniques and was successful in creating substantial additional storage space in the SFPs.

With re-racking, the SFPs had larger, but still limited capacities due to the physical size of the pools. The power plants would not be able to continue to operate beyond the time where the SFPs were predicted to be full. Further complicating matters was that nearly every nuclear power plant in the United States was planning to renew its 40-year operating license for an additional 20 years, substantially increasing the amount of SNF to be discharged from the reactor over its lifetime. Increasing the physical size of the SFPs was prohibitively expensive given their design requirements, size, and interconnections to other plant systems, structures, and components. There was no other facility to which the SNF could be transferred inside the power plant. Thus, SNF storage outside the power plant, but still on site, became vital to the survival of most operating nuclear power plants.

2.4 Spent Nuclear Fuel Storage Outside the Power Plant

Nuclear power plants began to plan for running out of SFP storage space in the early 1980s, despite the 1982 passage of the NWPA, which mandated the federal government to begin removing SNF from commercial plant sites by January 1998. January 1998 was also just the starting point for the government to begin taking fuel, on an "oldest-fuel-first" basis, as described in the Standard Contract. For several older plants and plants with smaller SFPs (often both), their place in the removal queue would not arrive soon enough to maintain power plant operation.

Nuclear power plants began designing constructing and operating on-site ISFSIs for augmented storage of SNF. ISFSIs consisted of concrete pads with rows of above-ground DSSs containing SNF. Periodically, the power plant would add some number of DSS to the ISFSI in "campaigns" that were scheduled with a frequency driven by SNF management strategy that was based on plant refueling outages and desired SFP available capacity. Figure 2-3 shows an example ISFSI at a U.S. nuclear power plant.

Figure 2-3: Example ISFSI at a Nuclear Power Plant[8]

2.4.1 Overview Spent Nuclear Fuel Storage at an ISFSI

The first commercial plant ISFSI began operation in 1986 at the Surry Nuclear Station in Virginia. Over time, with the federal government still not removing fuel in 2022, all but one nuclear plant site in the United States operates an ISFSI. In fact, 21 nuclear plant sites in the United States have no operating reactor but must continue to store SNF because of the government's failure to remove the SNF. Some of these decommissioned sites have no other facilities on the site except the ISFSI and associated security and support infrastructure. The one plant site in the United States without an ISFSI has sufficient SFP storage available because it has four SFPs with only one operating reactor.

An ISFSI may be of the wet type or the dry type as allowed by the NRC's regulations. Of the 75 operating ISFSIs in the United States in 2022, 74 are dry-storage facilities. This means the SNF is stored within DSSs placed on outdoor concrete pads on the plant site. As of June 2022, there were over 3,750 DSSs in service around the country storing about 169,000 SNF assemblies.[9]

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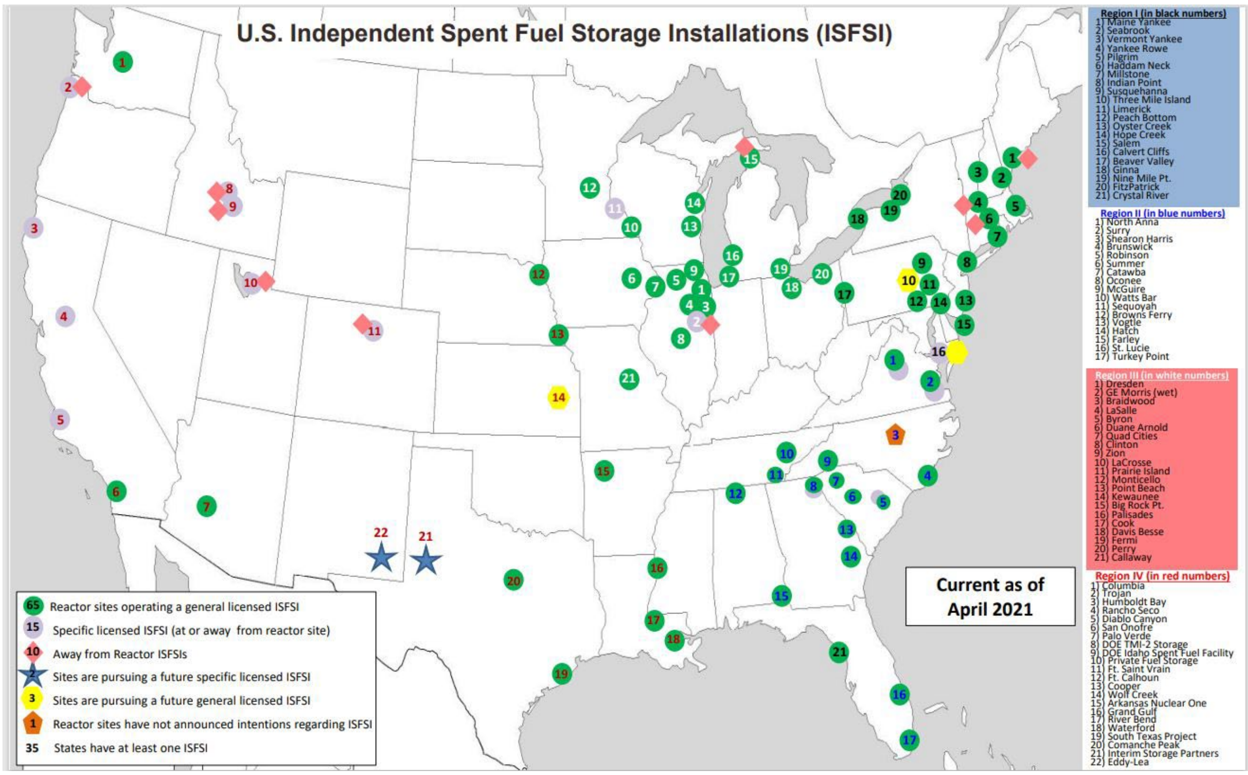
[8] Copyright © 2022 NAC International. All rights reserved.
[9] Source: Gutherman Technical Services, LLC.

Figure 2-4 depicts the ISFSIs around the United States. In the subsections below, the evolution of the different DSS designs and operation are described.

Figure 2-4: ISFSI Locations in the United States



2.4.1 Early Dry Storage System Designs

Research and development of the first DSS designs was performed in the early 1980s to test proposed design concepts. Using the NRC's regulations in 10 CFR 72, designs of vertical, bolted-lid, bare fuel casks (BFCs) were the first developed. One of the key regulations for DSS design required that cooling for the casks be completely passive, via natural conduction, convection, and radiative heat transfer. This eliminated the need for normal and emergency power supplies to cool the SNF.

Other design requirements included criticality prevention, radiation shielding, protection from environmental phenomena, and to have minimal (ideally, zero) radioactive releases to the environment. Thus, the design challenge was to meet all requirements in an optimized cask design. The cask design needed to be able to reject the heat emitted by the SNF without forced flow cooling through the SNF storage cavity, while also having thick walls for shielding and protection from tornado-borne missiles and was not too heavy given plant crane and floor capacities.

Given the above design challenges, the early BFC designs were of modest capacity and low decay heat duty with SNF having low enrichment and burnup to ensure robust safety margins were maintained. The first BFC designs accommodated 21-24 low-enrichment PWR SNF assemblies that had been cooled for long periods in the plant. It is also worth noting at this point that the early DSS designs were “storage-only” designs, which meant the SNF would need to be returned to the power plant SFP to be removed from the DSS and transferred to a transportation-certified shipping cask when the time arrived to ship the SNF to a repository. This becomes more relevant later in this course.

The DSS design that emerged from the early research was a thick-walled, metal BFC with a rack inside that emulated a spent fuel rack in the power plant. The BFC has a bolted lid with ports to allow draining, drying, and backfilling the cask cavity with helium. Helium protects the SNF assemblies from corrosion and is a good heat transfer medium. The BFC design required use of concentric, dual, metallic, O-ring seals in the space between the bolted lid and the cask body, with a pressurized helium monitoring system connected to the space between the seals. This arrangement ensured that if an O-ring seal leaked, clean helium from the overpressure system either escaped to the environment (outer seal leak) or into the cask cavity (inner seal leak). A leaking seal and loss of helium from the overpressure system would eventually cause an alarm, allowing the problem to be addressed without radioactive material escaping to the environment. Usually, this meant returning the BFC to the spent fuel pool so the lid could be removed and the O-ring seals replaced.

Figure 2-5 shows a typical BFC design and Figure 2-6 shows BFCs in service at an ISFSI. Note that there is no secondary barrier between the BFC lid and the SNF stored inside.

Figure 2-5: Bare Fuel Cask Cutaway[10]

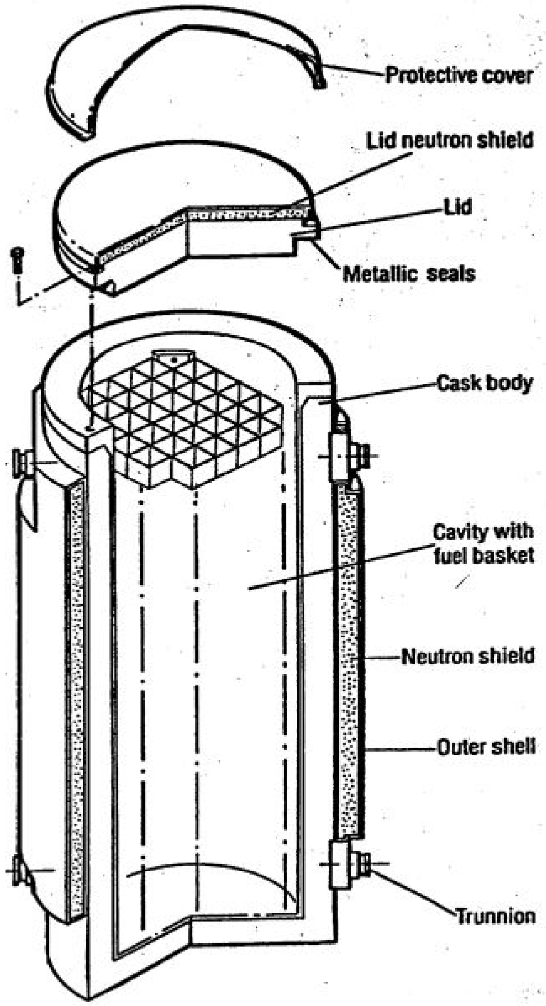


Figure 2-6: Bare Fuel Cask ISFSI

[10] Courtesy of Orano-TN Americas. Used with permission.

The BFC design concept evolved over the 1980s and 1990s to increase capacities up to 40 PWR SNF assemblies and 68 BWR SNF assemblies and to maximize heat rejection using the latest materials and analysis techniques. However, BFCs were costly and limited in the maximum heat loads they could ultimately accept. Nuclear plant owners began looking for more cost-effective DSS design options with increased capabilities and less maintenance. As of 2022, of the 3,750-plus DSSs in service at ISFSIs around the country only 235 are BFCs, and only one site continues to load a BFC design.

2.4.2 Canister-Based Dry Storage Systems

In the late 1980s, DSS designers began development of canister-based storage technology. This involved a seal-welded, cylindrical canister containing the SNF situated inside a concrete storage module or cask with ventilation ducts. The impetus for this technology was based on three main objectives, beyond cost:

1. To eliminate the maintenance involved with BFC lids and O-ring seals,
2. To increase DSS capacity without exceeding crane weight limitations, and
3. To increase the heat rejection capability of the DSS.

DSS capacities could be increased because the canisters were loaded inside relatively light-weight transfer casks (TCs) in the SFP, then moved into the heavy, outer storage modules or casks without having to use the plant crane. This capacity increase was also a tacit recognition that a facility to dispose of the SNF was well in the future and minimizing the number of DSS and the associated burden on plant resources was desirable. The first canister-based DSS designs remained storage-only and became available to the industry for use in the early 1990s. Initial capacities were 24 PWR or 52 BWR SNF assemblies.

Over the intervening years, DSS capacities have increased from 24 PWR and 52 BWR SNF assemblies to 37 PWR and 89 BWR SNF assemblies today. This is likely the highest possible capacity achievable due to crane and floor weight limitations in the power plant and dimensional limits from the railroads. The latter set of limits arises because today's canisters are also designed to be transportable in rail-compatible shipping packages without re-packaging the SNF. See Section 3.0 for additional information on SNF transportation.

2.4.2.1 Horizontal, Canister-Based Dry Storage Systems

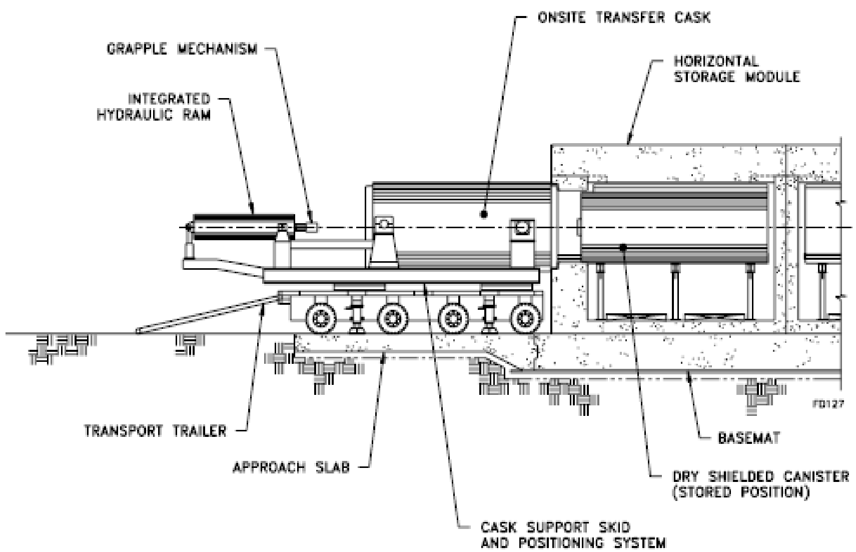
Along with the advent of the canister-based design came the introduction of a horizontal DSS design as an alternative to a vertical design. The horizontal design suited the plant facilities, particularly the truck bay floors and doorways, which were originally designed to accommodate small-capacity, relatively low-weight transportation casks leaving the plant via truck in the horizontal orientation.

The horizontal, canister-based DSS design includes a metal (usually stainless steel) canister with a fuel basket inside, and a shielded lid arrangement involving redundant lid welds. During storage operations, the canister rests on its side on support rails inside a reinforced concrete horizontal storage module (HSM). The HSM includes air inlet vents at the bottom and air outlet vents at the top. The hot canister shell creates a continuous natural convection process that introduces cooler ambient air into the HSM through the inlet vents where it gets heated and rises to exit from outlet air vents. This technology has the trade name NUHOMS. Figures 2-7 and 2-8 depict the design concept for the NUHOMS System during storage operations. Note that during normal storage operations, the NUHOMS transfer cask and trailer apparatus are removed and a door is installed on the HSM (see Figure 2-9 for a view of an NUHOMS ISFSI).

During NUHOMS loading operations in the nuclear power plant, a lid-less canister inside a TC is lowered into the SFP in a designated cask loading area. The SNF assemblies are moved individually from the storage racks into designated locations in the canister (which, like the SFP racks, are specially designed to prevent criticality). When fuel loading is complete, shield plug is inserted in the canister to provide radiation shielding for personnel as the TC housing the canister is lifted out of the SFP and moved to the canister preparation area. In the canister preparation area, an inner top cover is welded in place and the canister is drained, dried, and backfilled with helium before the outer top cover welded in place resulting in a ready-for-storage canister (see Figure 2-10).

The TC with the canister is moved to the truck bay and down-ended onto a transfer trailer or similar conveyance. The TC is moved to the ISFSI and aligned with the receiving NUHOMS module. A grapple is latched to a grapple ring on the bottom of the canister and a hydraulic ram system is used to push the canister along the rails into position inside the HSM. The TC is backed away and the HSM door is installed. The canister is now in dry storage and the only periodic checks required are to ensure air flow into the HSM is not obstructed. See Figures 2-11 through 2-14 for depiction of this process.

Figure 2-7: The NUHOMS System Showing Transfer Cask and Hydraulic Ram System [11]



[11] Courtesy of Orano-TN Americas. Used with permission.

Figure 2-8: NUHOMS Horizontal Storage Module with Canister[12]

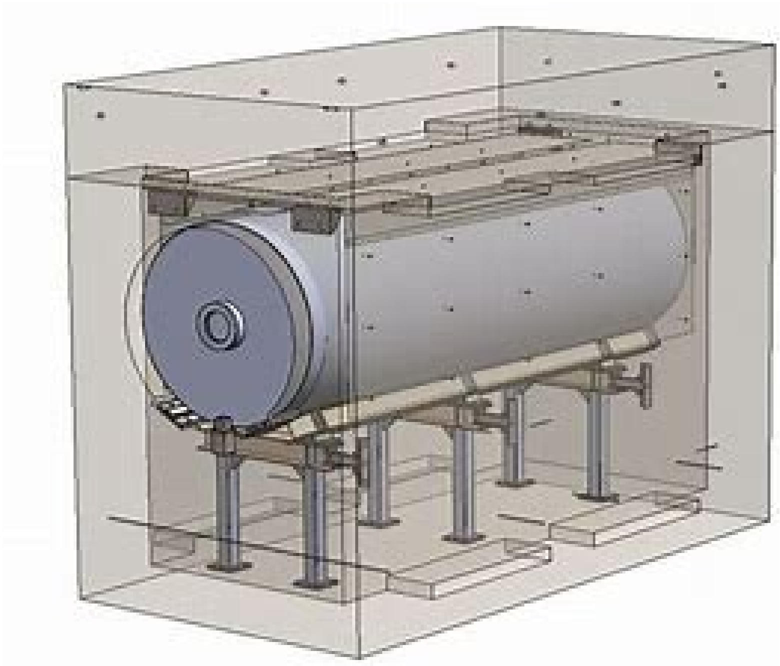


Figure 2-9: NUHOMS Modules at an ISFSI[13]

[12] Courtesy of Orano-TN Americas. Used with permission.
[13] Ibid.

Figure 2-10: NUHOMS Canister[14]

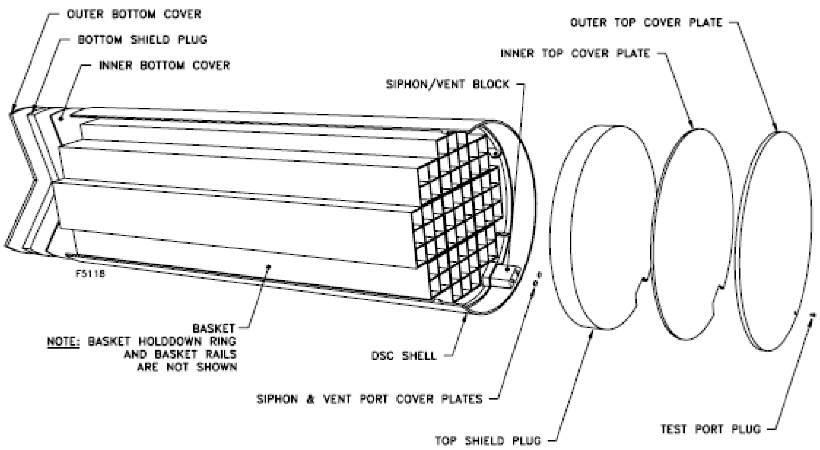


Figure 2-11: NUHOMS TC Being Downended onto Conveyance[15]

[14] Courtesy of Orano-TN Americas. Used with permission.
[15] Ibid.

Figure 2-12: NUHOMS Canister Insertion into HSM with Hydraulic Ram[16]

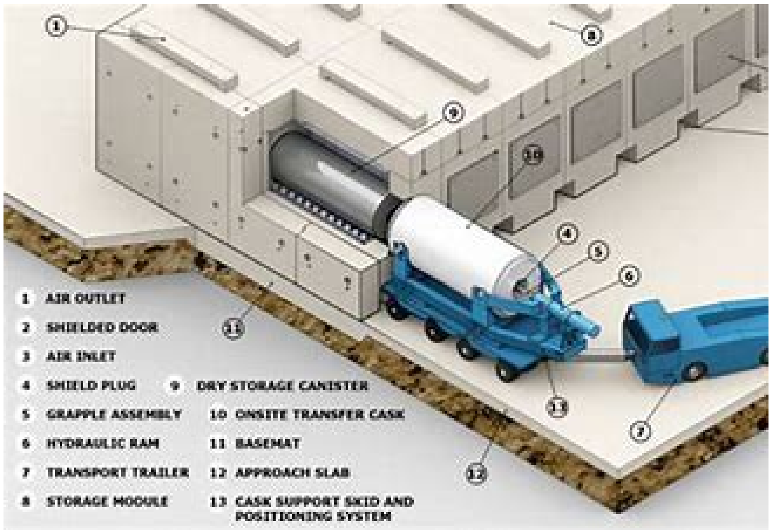


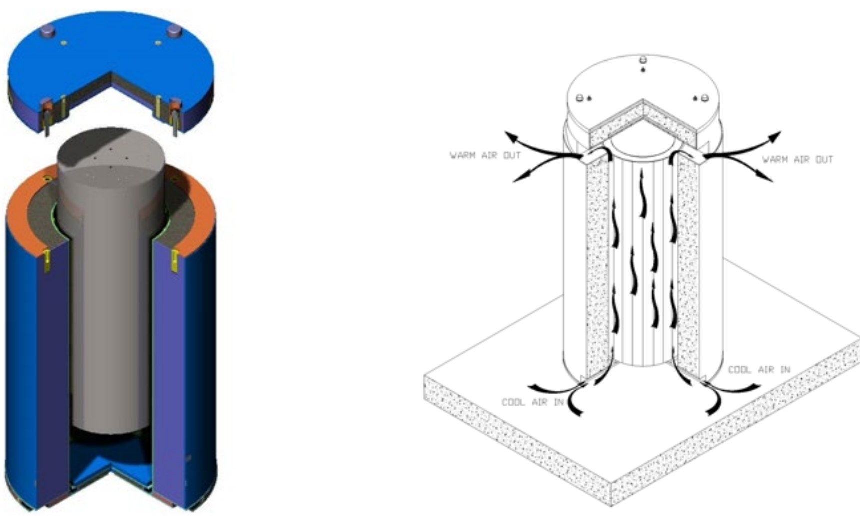
Figure 2-13: NUHOMS HSM Ready for Door Installation[17]

[16] Courtesy of Orano-TN Americas. Used with permission.
[17] Ibid.

2.4.2.2 Vertical, Canister-Based Dry Storage Systems

There are several different suppliers of vertical, canister-based DSS designs in the United States, each with unique trade names for its equipment. However, the loading and storage operations are all similar. In its storage configuration at the ISFSI, the vertical DSS includes a canister loaded with SNF inside a storage cask with air inlet vents at the bottom and outlet air vents at the top. Again, the canister heats the adjacent air, which rises to exit the upper air outlet vents, which draws in cooler ambient air at the lower air inlet vents. Figure 2-15 shows a cut-away of an example vertical, canister-based DSS and the cooling air flows.

Figure 2-15: Example Vertical, Canister-Based Dry Storage System[18]

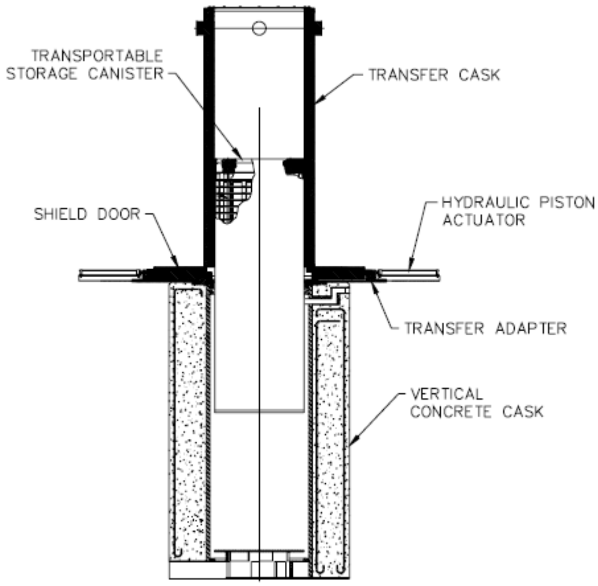


Loading of SNF assemblies into a vertical system canister and preparation of the canister for storage is essentially the same as that described for the horizontal system in Section 2.4.2.1, so that discussion will not be repeated. However, once the canister is ready for storage, the operations to place the canister into service at the ISFSI are quite different. The vertical storage casks must always be kept in the vertical position. Thus, the TC containing the canister must be stacked atop the storage cask (without its lid) and an intervening device to facilitate downloading

[18] Source: Holtec HI-STORM 100 Final Safety Analysis Report. Copyright © 2022 Holtec International. All rights reserved.

of the canister from the TC into the storage cask (see Figure 2-16). This usually occurs in the plant truck bay, but can take place outdoors at a specially designed canister transfer facility.

Figure 2-16: Vertical System Canister Transfer Cask Stack-up[19]



After the canister is lowered into the storage cask, the empty TC and intervening device are removed and the loaded storage cask is moved to a location where its lid may be installed. Sometimes this can be performed inside the power plant truck bay, but often the cask must be moved just outside the plant to install the lid due to low door clearance. Based on site-specific needs and capabilities, the cask may be moved out of the plant along embedded rails with a cart and airplane tugger, or other similar devices. The cask is then moved to the ISFSI using a crawler or other similar conveyance as shown in Figure 2-17.

[19] Copyright © 2022 NAC International. All rights reserved.

Figure 2-17: Vertical Cask Crawler[20]

2.4.2.3 Newer Variants of Canister-Based DSS Designs

Two recent variants of canister-based DSS designs are worth mentioning. These designs were intended to attract plant owners who saw value in the unique attributes of the respective designs. The first is a variant of the NUHOMS design, where an upper and lower level of storage locations are available as shown in Figure 2-18. This arrangement has the advantage of requiring less ISFSI pad space for a given number of canisters and HSMs and has high heat capacity.

[20] Source: spent fuel storage cask crawler - Bing images

Figure 2-18: NUHOMS EOS Matrix DSS Design[21]

The second variant of the canister-based DSS is where the canister is lowered into a below-grade vault that is designed to use the heat of the canister to force natural convection. In this case, hot air is exhausted out the top of the vault, which draws ambient air into an outer annulus. The ambient air travels downward to the bottom of the vault and turns 180 degrees under a divider and then travels past the canister shell where it removes the heat. This DSS design is known as the Holtec HI-STORM "UMAX" System. See Figure 2-19.

Figure 2-19: Holtec HI-STORM UMAX DSS Design[22]

[21] Source: Orano-Transnuclear Americas. Used with permission.
[22] Source: callaway spent nuclear fuel storage - Bing images. Copyright © 2022 Holtec International. All rights reserved

2.5 Consolidated Interim Storage of Spent Nuclear Fuel

As discussed previously, 21 former nuclear plant sites continue to store SNF while no operating reactor remain s on the site. Envisioning a commercial opportunity, two private companies submitted applications to the NRC for Part 72 licenses to construct and operate Consolidated Interim Storage Facilities (CISFs) away from any reactor site. While the storage technologies differ between the two, the concept is the same: move SNF stored at multiple locations around the country to one location to await federal government removal and final disposition. The primary targets for these enterprises is the shutdown plant sites. If the SNF could be moved away from those sites, the land could be sold and/or re-purposed for other uses by the current or successor owners. The operational concept for the two proposed facilities are summarized below.

2.5.1 Interim Storage Partners

A consortium called Interim Storage Partners (ISP) has received its NRC license to construct and operate a CISF adjacent to the Waste Control Specialists (WCS) low-level radioactive waste facility in West Texas. The operational concept is to ship the SNF canisters from various sites and return them to storage service is the same horizontal storage module or vertical storage cask design in which they are currently stored. Canisters in service at plant sites would be shipped to the CISF without re-packaging the SNF and returned to storage service in a newly built HSM or storage cask. The ISP CISF has not yet been constructed as of this writing in 2022. Figure 2-20 is an artist's rendering of the proposed ISP CISF.

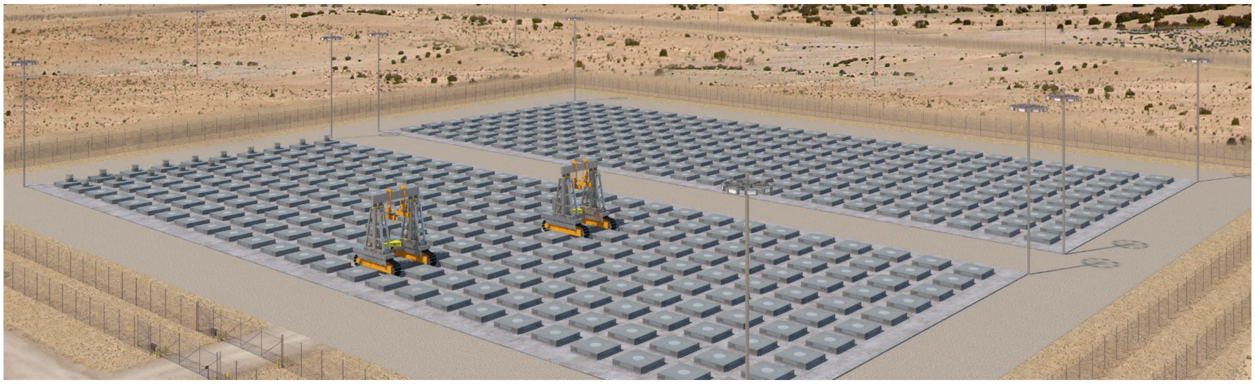
Figure 2-20: Artist's Rendering of Proposed ISP CISF[23]

2.5.2 Holtec International

Holtec International's CISF license application is under review as of this writing and is expected to be granted in 2023. The "HI-STORE" CISF site is in East New Mexico. Holtec's operational concept is to use its below-grade HI-STORM UMAX System to store canistered fuel. Like the ISP CISF, canisters in service at plant sites would be shipped to the CISF and returned to storage service. Canisters formerly in service in above-grade storage casks would be placed in below-grade UMAX vaults. Construction of the HI-STORE CISF awaits final issuance of the NRC license. Figure 2-21 provides an artist's rendering of the proposed HI-STORE CISF.

[23] Source: www.interimstoragepartners.com.

Figure 2-21: Artist's Rendering of Proposed Holtec HI-STORE CISF[24]



In summary, all operating nuclear power plants in the U.S. except one have run out of in-plant SNF storage space. These plants operate ISFSIs on site and will continue to add to the over 3,750 DSSs in service for as long as the reactors continue to operate and until the federal government begins removing the SNF. Approximately 200 new DSSs are placed into service at ISFSIs across the country every year. Twenty-one sites have no operating reactor but still manage the SNF and, as time goes on that number will increase as the plants reaching the end of their operating licenses. A federal repository is decades away. The federal government is currently contemplating development of its own CISF to begin removing SNF from the sites, but Congressional approval will be needed to modify the NWPA to bring such an idea to fruition.

[24] Source: www.holecinternational.com. Copyright © 2022 Holtec International. All rights reserved.

3.0 Spent Nuclear Fuel Transportation

This section summarizes the requirements and execution of SNF shipments and looks at the response to potential shipping accidents. It is worth noting that, notwithstanding the lack of SNF shipments from commercial nuclear sites under the NWPA, many SNF shipments are made around the world and in the United States on a regular basis. This includes shipments of research reactor SNF, Navy SNF, DOE SNF, and foreign reactor SNF.[25]

Since about 2000, spent fuel storage DSSs have been designed to be transported away from the ISFSI without having to re-package the fuel in the power plant. This has allowed the shutdown sites to dismantle all of the plant facilities that would have been needed for such re-packaging. For BFCs, the same cask design licensed for storage under 10 CFR 72 is licensed for transportation under 10 CFR 71. The cask is prepared for transportation and loaded onto the conveyance at the site for direct shipment.

For canister-based DSS, only the canister is designed for transportation, when loaded into a separate, sealed metal shipping cask. In this case, the canister is transferred directly from its HSM into a shipping cask or from the vertical storage cask into a TC and then from the TC into a shipping cask. The shipping casks with the loaded canister inside are then prepared for transportation and loaded onto the conveyance at the site for shipment. This canister-based approach allows the shipping casks to be re-used to ship additional canisters after the canister is received at the CISF or repository and the canister paced back into storage or into a disposal package.

[25] Many of these shipments are made by the Department of Energy under its own authority and orders, rather than NRC authority.

3.1 Spent Nuclear Fuel Transportation Regulation

Under the NRC's 10 CFR 71 regulations, every entity holding a license to receive and possess radioactive material, including SNF, is authorized to ship that material to another facility licensed to receive and possess it. Licensees shipping radioactive material must use an NRC-approved transportation package authorized for the material being shipped and comply with all other applicable NRC requirements. They must also comply with applicable U.S. Department of Transportation (DOT) regulations for hazardous material transportation and any State or Tribal requirements for movement of radioactive material shipments through those jurisdictions.

In general, the NRC's 10 CFR 71 regulations focus on two main areas discussed in the section below:

1. Design requirements for radioactive material packaging and the process for seeking NRC approval of a package design, and
2. The requirements for executing a shipment with respect to route approval, security of the shipment, notification of shipments to jurisdictions, and emergency response.

The NRC's regulations also cite specific DOT regulations for hazardous material transportation that also must be complied with. The NRC and DOT maintain a memorandum of understanding regarding their respective roles in regulating and inspecting radioactive material shipments.

3.2 Spent Nuclear Fuel Transportation Package Design

This section summarizes the various design requirements for SNF transportation packages without delving into how such requirements are met. Each package designer may use its own design concepts to meet the regulatory requirements. The package design features, allowed contents, and supporting safety analyses, as well as the operation, maintenance, and testing of the package are described in the Safety Analysis Report (SAR) and drawings submitted to the NRC for approval. The NRC reviews SAR and drawings and if they find the package design meets its regulations, they issue a Certificate of Compliance (CoC) to the package designer. This CoC is the document required for a licensee to use the package under its license to ship the SNF, as explained above. Two definitions within 10 CFR 71 are of particular importance because they are similar and often get confused (10 CFR 71.4):

> ***Package:*** the packaging together with its radioactive contents as presented for transport.

Type A and Type B packages are further defined in the regulations. SNF is transported in Type B(F) packages, the “F” indicative of a fissile material.

> ***Packaging:*** the assembly of components necessary to ensure compliance with the packaging requirements of this part. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle, tie-down system, and auxiliary equipment may be designated as part of the packaging

Simply put, a “packaging” becomes a “package” when the radioactive material is inside and the assemblage has been properly prepared for shipment on a conveyance (i.e., railcar, truck, ship, or aircraft). The packages contemplated in this course are rail casks, which may also be transported heavy-haul truck or by sea (i.e., barge or freighter) if properly configured. One key element of an SNF packaging is impact limiters, which are fitted to both ends of the shipping cask and serve to absorb the mechanical impact shock in cases of drop or collision.

3.2.1 General Standards

10 CFR 71 establishes the design requirements for all radioactive material package designs, beginning with general standards that apply to all packages (10 CFR 71.43):

(a) The smallest overall dimension of a package may not be less than 4 in. (10 cm).

(b) The outside of a package must incorporate a feature, such as a seal, that is not readily breakable and that, while intact, would be evidence that the package has not been opened by unauthorized persons.

(c) Each package must include a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by a pressure that may arise within the package.

(d) A package must be made of materials and construction that assure that there will be no significant chemical, galvanic, or other reaction among the packaging components, among package contents, or between the packaging components and the package contents, including possible reaction resulting from inleakage of water, to the maximum credible extent. Account must be taken of the behavior of materials under irradiation.

(e) A package valve or other device, the failure of which would allow radioactive contents to escape, must be protected against unauthorized operation and, except for a pressure relief device, must be provided with an enclosure to retain any leakage.

(f) A package must be designed, constructed, and prepared for shipment so that under the tests specified in § 71.71 ("Normal conditions of transport") there would be no loss or dispersal of radioactive contents, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the packaging.

(g) A package must be designed, constructed, and prepared for transport so that in still air at 100°F (38°C) and in the shade, no accessible surface of a package would have a temperature exceeding 122°F (50°C) in a nonexclusive use shipment, or 185°F (85°C) in an exclusive use shipment.

(h) A package may not incorporate a feature intended to allow continuous venting during transport.

10 CFR 71.45 and 10 CFR 71.47 establish requirements for tie-downs and package radiation levels, which are not repeated here. Applicants for a Part CoC must describe in their SARs for the package how these requirements will be met.

3.2.2 Fissile Material Packages

Type B packages intended to be used to ship fissile material, including SNF, have additional requirements due to the potential for inadvertent criticality and significant radiation exposure to the public, if not designed properly. Thus, the NRC establishes Type B package design requirements for prevention of criticality (see §71.55 and related regulations) and both normal conditions of transport (10 CFR 71.71) and hypothetical accident conditions (10 CFR 71.73). Irrespective of normal conditions and accident conditions, the package must be demonstrated by analysis to remain sub-critical if fresh (unborated) water were to leak into the package cavity. The package designer demonstrates compliance with these requirements to the NRC through a combinations of analysis and testing (either full scale or reduced scale). For this course, only the normal and accident condition design requirements are listed.

3.2.2.1 Normal Conditions of Transport

Because not every possible service condition of normal transportation can be defined, the NRC has established requirements involving the types of bounding conditions to cover the range of what the package could reasonably see during an uneventful shipment. 10 CFR 71.43(f) requires that there would be no loss or dispersal of radioactive contents, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the packaging under the following conditions, which are expected to bound all actual normal conditions of transport:

1. **Heat:** An ambient temperature of 100ºF (38ºC) in still air with solar insolation.

2. **Cold:** An ambient temperature of -40ºF (-40ºC) in still air and shade.

3. **Reduced External Pressure:** 3.5 psia (25 kPa).

4. **Increased External Pressure:** 20 psia (140 kPa).

5. **Vibration:** Vibration normally incident to transport.

6. **Water Spray:** A water spray that simulates exposure to rainfall of a approximately 2 in/hr (5 cm/hr) for at least 1 hour.

7. **Free Drop:** Between 1.5 and 2.5 hours after the conclusion of the water spray test, a free drop through the distance specified below [based on package weight, with lighter packages dropped from higher distances] onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected (ranges from 1 ft to 4 ft (0.3 m to 1.2 m)).

8. **Corner Drop:** A free drop onto each corner of the package in succession, or in the case of a cylindrical package onto each quarter of each rim, from a height of 1 ft (0.3 m) onto a flat, essentially unyielding, horizontal surface. This test applies only to fiberboard, wood, or fissile material rectangular packages not exceeding 110 lbs (50 kg) and fiberboard, wood, or fissile material cylindrical packages not exceeding 220 lbs (100 kg).

9. **Compression:** For packages weighing up to 11,000 lbs (5000 kg), the package must be subjected, for a period of 24 hours, to a compressive load applied uniformly to the top and bottom of the package in the position in which the package would normally be transported. The compressive load must be the greater of the following:

    a. The equivalent of 5 times the weight of the package; or

    b. The equivalent of 2 psi (13kPa) multiplied by the vertically projected area of the package.

10. **Penetration:** Impact of the hemispherical end of a vertical steel cylinder of 1.25 in (3.2 cm) diameter and 13 lbs (6 kg) mass, dropped from a height of 40 in (1 m) onto the exposed surface of the package that is expected to be most vulnerable to puncture. The long axis of the cylinder must be perpendicular to the package surface.

3.2.2.2 Hypothetical Accident Conditions

Similar to normal conditions, not every possible characteristic of an accident condition that could occur during transportation can be defined, so the NRC has established requirements involving the types of bounding conditions to cover the range of what the package could reasonably see during a hypothetical accident. 10 CFR 71.55 requires that the package contents remain sub-critical during and after all hypothetical accidents, among other requirements set down to protect public health and safety and the safety of first responders and recovery personnel. The SNF transportation package must be designed to withstand the following conditions, which are expected to bound any reasonably foreseeable accident:

1. **Free Drop:** A free drop of the specimen through a distance of 30 ft (9 m) onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected.[26]

2. **Crush:** Subjection of the specimen to a dynamic crush test by positioning the specimen on a flat, essentially unyielding horizontal surface so as to suffer maximum damage by the drop of an 1100 lbs (500 kg) mass from 30 ft (9 m) onto the specimen.

3. **Puncture:** A free drop of the specimen through a distance of 40 in (1 m) in a position for which maximum damage is expected, onto the upper end of a solid, 6 in (15 cm) diameter, vertical, cylindrical, mild steel bar mounted on an essentially unyielding horizontal surface.

4. **Thermal:** Exposure of the specimen fully engulfed in a fire with an average flame temperature of 1475ºF (800ºC) for a period of 30 minutes.

5. **Immersion:** Water pressure equivalent to immersion under a head of water of at least 50 ft (15 m).

Provided a SNF transportation package, including all associated auxiliary equipment, such as impact limiters, is determined to meet all applicable 10 CFR 71 requirements, the NRC will issue a CoC for the package design. Figure 3-1 shows a typical large-capacity SNF transportation package outfitted with impact limiters and protective hardware that would be mounted on a rail car for shipment.

[26] See Free-drop Test #2 (German Federal Institute for Materials Research and Testing) - Bing video for an example of transportation cask drop testing in Germany.

Figure 3-1: SNF Transportation Package with Impact Limiters[27]

3.3 Spent Nuclear Fuel Transportation Execution

While SNF is transported regularly in the United States and has been for decades, the large scale program for transporting SNF such as that contemplated by the NWPA has not been executed. Significant planning and nuclear plant site infrastructure upgrades will be required. This is because the plants were originally designed and built for the removal of SNF in small shipping casks that were certified for transport on the highway via legal weight trucks (40 tons or less). Today's large-capacity (125-130 ton) SNF packages are designed for shipment primarily by rail. It is expected that these packages will need to be moved off the sites to the nearest rail head either by rail spurs that connect to the sites, by barge, or on specially designed heavy haul trucks. Which technique will be used at any particular site will be based on the site location and cost.

Preparation for SNF transportation of commercial SNF from the nuclear plant sites is estimated to take up to ten years to allow for infrastructure upgrades, fabrication of shipping casks and rail cars, and organizational readiness both on site and in the states, counties, and Indian reservations

[27] Copyright © 2022 NAC International. All rights reserved.

through which the shipments may travel.[28] However, much of the detailed planning must await the identification of a receipt facility so that potential transport routes may be identified.

Offsite planning includes detailed interactions with the States and Tribes to ensure personnel are trained and ready to accommodate the SNF shipments. This includes normal conditions that may simply require notification of the State or Tribal designee and, in some jurisdictions, escorts between the jurisdictional boundaries. Along the route, preparations for accident response with procedures, equipment, and first-responder training will be needed. Because SNF is already transported regularly, many affected jurisdictions already have these plans and trained personnel in place.

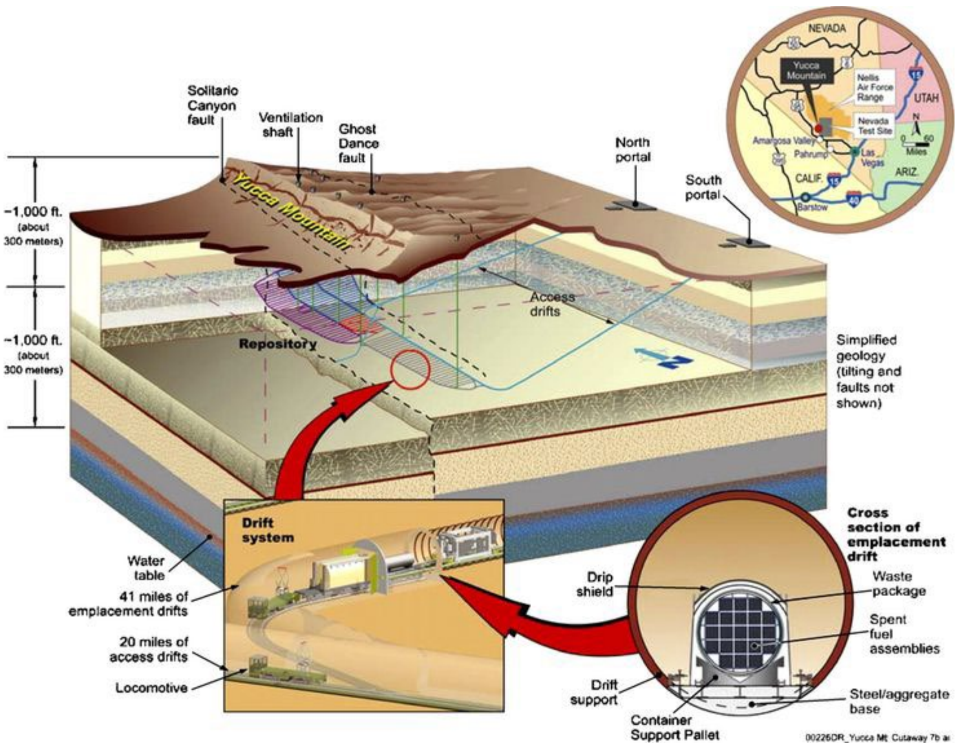
Nuclear power plant owners (or the federal government if they begin removal of the SNF from the sites) will be responsible for developing the shipping routes for approval by the NRC and acquiring NRC approval of the security arrangements from the starting point of the shipment to the destination. Efficient and cost-effect use of resources will drive the planning process for a large-scale transportation program, considering all of the on-site and off-site variables involved, especially with the railroad system and essential nature of the movement of commercial freight around the country.

[28] Source: "Conceptual Transportation Plan for the Relocation of SONGS Spent Nuclear Fuel to an Offsite Storage Facility or Repository," North Wind, 2021, www.songscommunity.com.

4.0 Spent Nuclear Fuel Disposal

The status of SNF disposal in the United States is unknown as of this writing. While federal law still designates Yucca Mountain as the sole location for the disposal of commercial SNF and government SNF and HLW, the DOE project to construct and operate a repository at Yuca Mountain is not active. Thus, it is currently unclear where an SNF/HLW repository will be located or when it will be available. In the meantime, SNF will continue to be stored at the nuclear power plant sites or, perhaps, be transferred to one or more CISFs awaiting final disposition. Figure 4-1 depicts the concept of SNF disposal at Yucca Mountain.

Figure 4-1: Yucca Mountain Repository Concept



LIST OF ACRONYMS

AEA – Atomic Energy Act

AEC – Atomic Energy Commission

BFC – Bare Fuel Cask

BWR – Boiling Water Reactor

CISF – Consolidated Interim Storage Facility

DOE – Department of Energy

ERDA – Energy Research and Development Administration

ISFSI – Independent Spent Fuel Storage Installation

ISP – Interim Storage Partners

HLW – High-Level Radioactive Waste

NNPP – Naval Nuclear Propulsion Program

NRC – Nuclear Regulatory Commission

NWF – Nuclear Waste Fund

NWPA – Nuclear Waste Policy Act

OCRWM – Office of Civilian Radioactive Waste Management

PWR – Pressurized Water Reactor

SFP – Spent Fuel Pool

SSCs – Systems, Structures, and Components

WCS – Waste Control Specialists

APPENDIX A

Department of Energy Standard Contract (10 CFR 961.11)

ELECTRONIC CODE OF FEDERAL REGULATIONS

e-CFR data is current as of July 10, 2015

Title 10 → Chapter III → Part 961 → Subpart B

Title 10: Energy
PART 961—STANDARD CONTRACT FOR DISPOSAL OF SPENT NUCLEAR FUEL AND/OR HIGH-LEVEL RADIOACTIVE WASTE

Subpart B—Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste

Contents

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§961.11 Text of the contract.

The text of the standard contract for disposal of spent nuclear fuel and/or high/level radioactive waste follows:

U.S. DEPARTMENT OF ENERGY CONTRACT NO. __

Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste

THIS CONTRACT, entered into this _______ day of ______ 19__, by and between the UNITED STATES OF AMERICA (hereinafter referred to as the “Government”), represented by the UNITED STATES DEPARTMENT OF ENERGY (hereafter referred to as “DOE”) and ______, (hereinafter referred to as the “Purchaser”), a corporation organized and existing under the laws of the State of ______ [add as applicable: “acting on behalf of itself and ___.”].

Witnesseth that:

Whereas, the DOE has the responsibility for the disposal of spent nuclear fuel and high-level radioactive waste of domestic origin from civilian nuclear power reactors in order to protect the public health and safety, and the environment; and

Whereas, the DOE has the responsibility, following commencement of operation of a repository, to take title to the spent nuclear fuel or high-level radioactive waste involved as expeditiously as practicable upon the request of the generator or owner of such waste or spent nuclear fuel; and

Whereas, all costs associated with the preparation, transportation, and the disposal of spent nuclear fuel and high-level radioactive waste from civilian nuclear power reactors shall be borne by the owners and generators of such fuel and waste; and

Whereas, the DOE is required to collect a full cost recovery fee from owners and generators delivering to the DOE such spent nuclear fuel and/or high level radioactive waste; and

Whereas, the DOE is authorized to enter into contracts for the permanent disposal of spent nuclear fuel and/or high-level radioactive waste of domestic origin in DOE facilities; and

Whereas, the Purchaser desires to obtain disposal services from DOE; and

Whereas, DOE is obligated and willing to provide such disposal services, under the terms and conditions hereinafter set forth; and

Whereas, this contract is made and entered into under the authority of the DOE Organization Act (Pub. L. 95-91, 42 U.S.C. 7101 *et seq.*) and the Nuclear Waste Policy Act of 1982 (Pub. L. 97-425, 42 U.S.C. 10101 *et seq.*)

Now, therefore, the parties hereto do hereby agree as follows:

ARTICLE I—DEFINITIONS

As used throughout this contract, the following terms shall have the meanings set forth below:

1. The term *assigned three-month period* means the period that each Purchaser will be assigned by DOE, giving due consideration to the Purchaser's assignment preference, for purposes of reporting kilowatt hours generated by the Purchaser's nuclear power reactor and for establishing fees due and payable to DOE.

2. The term *cask* means a container for shipping spent nuclear fuel and/or high-level radioactive waste which meets all applicable regulatory requirements.

3. The term *civilian nuclear power reactor* means a civilian nuclear powerplant required to be licensed under sections 103 or 104(b) of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2133, 2134(b)).

4. The term *Commission* means the United states Nuclear Regulatory Commission.

5. The term *contract* means this agreement and any duly executed amendment or modification thereto.

6. The term *Contracting Officer* means the person executing this contract on behalf of the Government, and any other officer or civilian employee who is a properly disignated Contracting Officer of the DOE; and the term includes, except as otherwise provided in this contract, the authorized representative of a Contracting Officer acting within the limits of his authority.

7. The term *delivery* means the transfer of custody, f.o.b. carrier, of spent nuclear fuel or high-level radioactive waste from Purchaser to DOE at the Purchaser's civilian nuclear power reactor or such other domestic site as may be designated by the Purchaser and approved by DOE.

8. The term *disposal* means the emplacement in a repository of high-level radioactive waste, spent nuclear fuel, or other highly radioactive waste with no foreseeable intent of recovery, whether or not such emplacement permits recovery of such waste.

9. The term *DOE* means the United States Department of Energy or any duly authorized representative thereof, including the Contracting Officer.

10. The term *DOE facility* means a facility operated by or on behalf of DOE for the purpose of disposing of spent nuclear fuel and/or high-level radioactive waste, or such other facility(ies) to which spent nuclear fuel and/or high-level radioactive waste may be shipped by DOE prior to its transportation to a disposal facility.

11. The term *full cost recovery,* means the recoupment by DOE, through Purchaser fees and any interest earned, of all direct costs, indirect costs, and all allocable overhead, consistent with generally accepted accounting principles consistently applied, of providing disposal services and conducting activities authorized by the Nuclear Waste Policy Act of 1982 (Pub. L. 97-425). As used herein, the term *cost* includes the application of Nuclear Waste Fund moneys for those uses expressly set forth in section 302 (d) and (e) of the said Act and all other uses specified in the Act.

12. The term *high-level radioactive waste* (HLW) means—

(a) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and

(b) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation.

13. The term *electricity (kilowatt hours) generated and sold* means gross electrical output produced by a civilian nuclear power reactor measured at the output terminals of the turbine generator minus the normal onsite nuclear station service loads during the time electricity is being generated multiplied by the total energy adjustment factor. For purposes of this provision, the following definition shall apply:

a. The term *Total Energy Adjustment Factor (TEAF)* means the sum of individual owners' weighted energy adjustment factors.

b. The term *Weighted Energy Adjustment Factor (WEAF)* means the product of an owner's energy adjustment factor times the owner's share of the plant.

c. The term *Owner's Energy Adjustment Factor (OEAF)* means the sum of the individual owner's adjustment for sales to ultimate consumers and adjustment for sales for resale.

d. The term *Owner's Share of the plant (OS)* means the owner's fraction of metered electricity sales, the owner's fraction of plant ownership, or the sponsor company's fixed entitlement percentage of the plant's output. This definition includes joint owners of generating companies or participants in a generation and transmission cooperative.

e. The term *Adjustment for Sales to ultimate Consumer (ASC)* means the owner's fraction of sales to the ultimate consumer multiplied by the owner's sales to ultimate consumer adjustment factor.

f. The term *Fraction of Sales to ultimate Consumer (FSC)* means the owner's fractional quantity of electricity sold to the ultimate consumer relative to the total of electricity sales (sales to ultimate consumers plus the sales for resale).

g. The term *Sales to ultimate Consumer Adjustment Factor (SCAF)* means one minus the quotient of all electricity lost or otherwise not sold for each owner divided by the total electricity available for disposition to ultimate consumers. Electricity lost or otherwise not sold includes:

(1) Energy furnished without charge;

(2) Energy used by the company;

(3) Transmission losses;

(4) Distribution losses; and

(5) Other unaccounted losses as reported to the Federal Government "Annual Report of Major Electric Utilities, Licensees and Others," Federal Energy Regulatory Commission (FERC) Form No.1; Rural Electrification Administration (REA) Forms 7 and 11 if appropriate; or the "Annual Electric Utility Report," Energy Information Administration (EIA) Form EIA-861.

h. The term *Total Electricity Available for Disposition to Ultimate Consumers* means the reporting year's total of all of a utility's electricity supply which is available for disposition, expressed in kilowatt hours, and is equal to the sum of the energy sources minus the electricity sold for resale by the utility.

i. The term *Adjustment for Sales for Resale (ASR)* means the owner's fraction of sales for resale multiplied by the national average adjustment factor.

j. The term *Fraction of Sales for Resale (FSR)* means the owner's fractional quantity of electricity sold for resale by the utility relative to the total of electricity sales.

k. The term *National Average Adjustment Factor (NAF)* means the ratio of the national total of electricity sold to the national total of electricity available for disposition, based on the most recent 3 years of national data provided to the Federal Government, and will be set by the Contracting Officer. This term will be evaluated annually and revised in increments of .005.

l. Pumped storage losses. If the proportion of nuclear generated electricity consumed by a pumped-storage hydro facility can be measured or estimated and if the electricity losses associated with pumped storage facilities can be documented (e.g. based on routine and uniform records of district power data on contributions from different electricity sources), a prorated nuclear share shall be allowed as an offset to gross electricity generation reported on the annex A of appendix G, NWPA-830G form. Specific methodologies for calculating these offsets must be approved by the Contracting Officer in advance.

Instructions to annex A of appendix G, NWPA-830G provide the necessary information to calculate the energy adjustment factors.

14. The term *metric tons uranium* means that measure of weight, equivalent to 2,204.6 pounds of uranium and other fissile and fertile material that are loaded into a reactor core as fresh fuel.

15. The term *Purchaser's site* means the location of Purchaser's civilian nuclear power reactor or such other location as the Purchaser may designate.

16. The term *quarterly Treasury rate* means the current value of funds rate as specified by the Treasury Fiscal Requirements Manual, Volume 1, Part 6, section 8020.20. This rate is published quarterly in the Federal Register prior to the beginning of the affected quarter.

17. The term *shipping lot* means a specified quantity of spent nuclear fuel or high-level radioactive waste designated by Purchaser for delivery to DOE beginning on a specified date.

18. The term *spent nuclear fuel* (SNF) means fuel that has been withdrawn from a nuclear reactor following irradiation, the consistituent elements of which have not been separated by reprocessing.

19. The term *spent nuclear fuel and high-level radioactive waste of domestic origin* means irradiated fuel material used, and radioactive wastes resulting from such use, in nuclear power reactors located only in the United States.

20. The term *year* means the period which begins on October 1 and ends on September 30.

Article II—Scope

This contract applies to the delivery by Purchaser to DOE of SNF and/or HLW of domestic origin from civilian nuclear power reactors, acceptance of title by DOE to such SNF and/or HLW, subsequent transportation, and disposal of such SNF and/or HLW and, with respect to such material, establishes the fees to be paid by the Purchaser for the services to be rendered hereunder by DOE. The SNF and/or HLW shall be specified in a delivery commitment schedule as provided in Article V below. The services to be provided by DOE under this contract shall begin, after commencement of facility operations, not later than January 31, 1998 and shall continue until such time as all SNF and/or HLW from the civilian nuclear power reactors specified in appendix A, annexed hereto and made a part hereof, has been disposed of.

Article III—Term

The term of this contract shall be from the date of execution until such time as DOE has accepted, transported from the Purchaser's site(s) and disposed of all SNF and/or HLW of domestic origin from the civilian nuclear power reactor(s) specified in appendix A.

Article IV—Responsibilities of the Parties

A. Purchaser's Responsibilities

1. *Discharge Information.*

(a) On an annual basis, commencing October 1, 1983, the Purchaser shall provide DOE with information on actual discharges to date and projected discharges for the next ten (10) years in the form and content set forth in appendix B, annexed hereto and made a part hereof. The information to be provided will include estimates and projections and will not be Purchaser's firm commitment with respect to discharges or deliveries.

(b) No later than October 1, 1983, the Purchaser shall provide DOE with specific information on:

(1) Total spent nuclear fuel inventory as of April 7, 1983;

(2) Total number of fuel assemblies removed from the particular reactor core prior to 12:00 a.m. April 7, 1983 for which there are plans for reinsertion in the core, indicating the current planned dates for reinsertion in the core. Estimates of the burned and unburned portion of each individual assembly are to be provided.

(c) In the event that the Purchaser fails to provide the annual forecast in the form and content required by DOE, DOE may, in its sole discretion, require a rescheduling of any delivery commitment schedule then in effect.

2. *Preparation for Transportation.*

(a) The Purchaser shall arrange for, and provide, all preparation, packaging, required inspections, and loading activities necessary for the transportation of SNF and/or HLW to the DOE facility. The Purchaser shall notify DOE of such activities sixty (60) days prior to the commencement of such activities. The preparatory activities by the Purchaser shall be made in accordance with all applicable laws and regulations relating to the Purchaser's responsibilities hereunder. DOE may designate a representative to observe the preparatory activities conducted by the Purchaser at the Purchaser's site, and the Purchaser shall afford access to such representative.

(b) Except as otherwise agreed to by DOE, the Purchaser shall advise DOE, in writing as specified in appendix F, annexed hereto and made a part hereof, as to the description of the material in each shipping lot sixty (60) days prior to scheduled DOE transportation of that shipping lot.

(c) The Purchaser shall be responsible for incidental maintenance, protection and preservation of any and all shipping casks furnished to the Purchaser by DOE for the performance of this contract. The Purchaser shall be liable for any loss of or damage to such DOE-furnished property, and for expenses incidental to such loss or damage while such casks are in the possession and control of the Purchaser except as otherwise provided for hereunder. Routine cask maintenance, such as scheduled overhauls, shall not be the responsibility of the Purchaser.

B. DOE Responsibilities

1. DOE shall accept title to all SNF and/or HLW, of domestic origin, generated by the civilian nuclear power reactor(s) specified in appendix A, provide subsequent transportation for such material to the DOE facility, and dispose of such material in accordance with the terms of this contract.

2. DOE shall arrange for, and provide, a cask(s) and all necessary transportation of the SNF and/or HLW from the Purchaser's site to the DOE facility. Such cask(s) shall be furnished sufficiently in advance to accommodate scheduled deliveries. Such cask(s) shall be suitable for use at the Purchaser's site, meet applicable regulatory requirements, and be accompanied by pertinent information including, but not limited to, the following:

(a) Written procedures for cask handling and loading, including specifications on Purchaser-furnished cannisters for containment of failed fuel;

(b) Training for Purchaser's personnel in cask handling and loading, as may be necessary;

(c) Technical information, special tools, equipment, lifting trunnions, spare parts and consumables needed to use and perform incidental maintenance on the cask(s); and

(d) Sufficient documentation on the equipment supplied by DOE.

3. DOE may fulfill any of its obligations, or take any action, under this contract either directly or through contractors.

4. DOE shall annually provide to the Purchaser pertinent information on the waste disposal program including information on cost projections, project plans and progress reports.

5. (a) Beginning on April 1, 1991, DOE shall issue an annual acceptance priority ranking for receipt of SNF and/or HLW at the DOE repository. This priority ranking shall be based on the age of SNF and/or HLW as calculated from the date of discharge of such material from the civilian nuclear power reactor. The oldest fuel or waste will have the highest priority for acceptance, except as provided in paragraphs B and D of Article V and paragraph B.3 of Article VI hereof.

(b) Beginning not later than July 1, 1987, DOE shall issue an annual capacity report for planning purposes. This report shall set forth the projected annual receiving capacity for the DOE facility(ies) and the annual acceptance ranking relating to DOE contracts for the disposal of SNF and/or HLW including, to the extent available, capacity information for ten (10) years following the projected commencement of operation of the initial DOE facility.

Article V—Delivery of SNF and/or HLW

A. Description of SNF and HLW

The Purchaser shall deliver to DOE and DOE shall, as provided in this contract, accept the SNF and/or HLW which is described in accordance with Article VI.A. of this contract, for disposal thereof.

B. Delivery Commitment Schedule

1. Delivery commitment schedule(s), in the form set forth in appendix C annexed hereto and made a part hereof, for delivery of SNF and/or HLW shall be furnished to DOE by Purchaser. After DOE has issued its proposed acceptance priority ranking, as described in paragraph B.5 of Article IV hereof, beginning January 1, 1992 the Purchaser shall submit to DOE the delivery commitment schedule(s) which shall identify all SNF and/or HLW the Purchaser wishes to deliver to DOE beginning sixty-three (63) months thereafter. DOE shall approve or disapprove such schedules within three (3) months after receipt. In the event of disapproval, DOE shall advise the Purchaser in writing of the reasons for such disapproval and request a revised schedule from the Purchaser, to be submitted to DOE within thirty (30) days after receipt of DOE's notice of disapproval.

2. DOE shall approve or disapprove such revised schedule(s) within sixty (60) days after receipt. In the event of disapproval, DOE shall advise the Purchaser in writing of the reasons for such disapproval and shall submit its proposed schedule(s). If these are not acceptable to the Purchaser, the parties shall promptly seek to negotiate mutually acceptable schedule(s). Purchaser shall have the right to adjust the quantities of SNF and/or HLW plus or minus (±) twenty percent (20%), and the delivery schedule up to two (2) months, until the submission of the final delivery schedule.

C. Final Delivery Schedule

Final delivery schedule(s), in the form set forth in appendix D, annexed hereto and made a part hereof, for delivery of SNF and/or HLW covered by an approved delivery commitment schedule(s) shall be furnished to DOE by Purchaser. The Purchaser shall submit to DOE final delivery schedules not less than twelve (12) months prior to the delivery date specified therein. DOE shall approve or disapprove a final delivery schedule within forty-five (45) days after receipt. In the event of disapproval, DOE shall advise the Purchaser in writing of the reasons for such disapproval and shall request a revised schedule from the Purchaser, to be submitted to DOE within thirty (30) days after receipt of DOE's notice of disapproval. DOE shall approve or disapprove such revised schedule (s) within sixty (60) days after receipt. In the event of disapproval, DOE shall advise the Purchaser in writing of the reasons for such disapproval and shall submit its proposed schedule(s). If these are not acceptable to the Purchaser, the parties shall promptly seek to negotiate mutually acceptable schedule(s).

D. Emergency Deliveries

Emergency deliveries of SNF and/or HLW may be accepted by DOE before the date provided in the delivery commitment schedule upon prior written approval by DOE.

E. Exchanges

Purchaser shall have the right to determine which SNF and/or HLW is delivered to DOE; *provided, however,* that Purchaser shall comply with the requirements of this contract. Purchaser shall have the right to exchange approved delivery commitment schedules with parties to other contracts with DOE for disposal of SNF and/or HLW; *provided, however,* that DOE shall, in advance, have the right to approve or disapprove, in its sole discretion, any such exchanges. Not less than six (6) months prior to the delivery date specified in the Purchaser's approved delivery commitment schedule, the Purchaser shall submit to DOE an exchange request, which states the priority rankings of both the Purchaser hereunder and any other Purchaser with whom the exchange of approved delivery commitment schedules is proposed. DOE shall approve or disapprove the proposed exchange within thirty (30) days after receipt. In the event of disapproval, DOE shall advise the Purchaser in writing of the reasons for such disapproval.

ARTICLE VI—CRITERIA FOR DISPOSAL

A. General Requirements

1. *Criteria.*

(a) Except as otherwise provided in this contract, DOE shall accept hereunder only such SNF and/or HLW which meets the General Specifications for such fuel and waste as set forth in appendix E, annexed hereto and made a part hereof.

(b) Purchaser shall accurately classify SNF and/or HLW prior to delivery in accordance with paragraphs B and D of appendix E.

2. *Procedures.*

(a) Purchaser shall provide to DOE a detailed description of the SNF and/or HLW to be delivered hereunder in the form and content as set forth in appendix F, annexed hereto and made a part hereof. Purchaser shall promptly advise DOE of nay changes in said SNF and/or HLW as soon as they become known to the purchaser.

(b) DOE's obligation for disposing of SNF under this contract also extends to other than standard fuel; however, for any SNF which has been designated by the Purchaser as other than standard fuel, as that term is defined in appendix E, the Purchaser shall obtain delivery and procedure confirmation from DOE prior to delivery. DOE shall advise Purchaser within sixty (60) days after receipt of such confirmation request as to the technical feasibility of disposing of such fuel on the currently agreed to schedule and any schedule adjustment for such services.

B. Acceptance Procedures

1. *Acceptance Priority Ranking.*

Delivery commitment schedules for SNF and/or HLW may require the disposal or more material than the annual capacity of the DOE disposal facility (or facilities) can accommodate. The following acceptance priority ranking will be utilized:

(a) Except as may be provided for in subparagraph (b) below and Article V.D. of this contract, acceptance priority shall be based upon the age of the SNF and/or HLW as calculated from the date of discharge of such material from the civilian nuclear power reactor. DOE will first accept from Purchaser the oldest SNF and/or HLW for disposal in the DOE facility, except as otherwise provided for in paragraphs B and D of Article V.

(b) Notwithstanding the age of the SNF and/or HLW, priority may be accorded any SNF and/or HLW removed from a civilian nuclear power reactor that has reached the end of its useful life or has been shut down permanently for whatever reason.

2. *Verification of SNF and/or HLW.*

During cask loading and prior to acceptance by DOE for transportation to the DOE facility, the SNF and/or HLW description of the shipping lot shall be subject to verification by DOE. To the extent the SNF and/or HLW is consistent with the description submitted and approved, in accordance with appendices E and F, DOE agrees to accept such SNF and/or HLW for disposal when DOE has verified the SNF and/or HLW description, determined the material is properly loaded, packaged, marked, labeled and ready for transportation, and has taken custody, as evidenced in writing, of the material at the Purchaser's site, f.o.b. carrier. A properly executed off-site radioactive shipment record describing cask contents must be prepared by the Purchaser along with a signed certification which states: “This is to certify that the above-named materials are properly described, classified, packaged, marked and labeled and are in proper condition for transfer according to the applicable regulations of the U. S. Department of Transportation.”

3. *Improperly described SNF and/or HLW.*

(a) *Prior to Acceptance*— If SNF and/or HLW is determined by DOE to be improperly described prior to acceptance by DOE at the Purchaser's site, DOE shall promptly notify the Purchaser in writing of such determination. DOE reserves the right, in its sole discretion, to refuse to accept such SNF and/or HLW until the SNF and/or HLW has been properly described. The Purchaser shall not transfer such SNF and/or HLW to DOE unless DOE agrees to accept such SNF and/or HLW under such other arrangements as may be agreed to, in writing, by the parties.

(b) *After Acceptance*— If subsequent to its acceptance DOE finds that such SNF and/or HLW is improperly described, DOE shall promptly notify the Purchaser, in writing, of such finding. In the event of such notification, Purchaser shall provide DOE with a proper designation within thirty (30) days. In the event of a failure by the Purchaser to provide such proper designation, DOE may hold in abeyance any and all deliveries scheduled hereunder.

Article VII—Title

Title to all SNF and/or HLW accepted by DOE for disposal shall pass to DOE at the Purchaser's site as provided for in Article VI hereof. DOE shall be solely repsonsible for control of all material upon passage of title. DOE shall have the right to dispose as it sees fit of any SNF and/or HLW to which it has taken title. The Purchaser shall have no claim against DOE or the Government with respect to such SNF or HLW nor shall DOE or the Government be obligated to compensate the Purchaser for such material.

Article VIII—Fees and Terms of Payment

A. Fees

1. Effective April 7, 1983, Purchaser shall be charged a fee in the amount of 1.0 mill per kilowatt hour (1M/kWh) electricity generated and sold.

2. For SNF, or solidified high-level radioactive waste derived from SNF, which fuel was used to generate electricity in a civilian nuclear power reactor prior to April 7, 1983, a one-time fee will be assessed by applying industry-wide average dollar per kilogram charges to four (4) distinct ranges of fuel burnup so that the integrated cost across all discharged (i.e. spent) fuel is equivalent to an industry-wide average charge of 1.0 mill per kilowatt-hour. For purposes of this contract, discharged nuclear fuel is that fuel removed from the reactor core with no plans for reinsertion. In the event that any such fuel withdrawn with plans for reinsertion is not reinserted, then the applicable fee for such fuel shall be calculated as set forth in this paragraph 2. The categories of spent nuclear fuel burnup and the fee schedule are listed below:

[In 1982 dollars]

Nuclear spent fuel burnup range	Dollars per kilogram
0 to 5,000 MWDT/MTU	$80.00
5,000 to 10,000 MWDT/MTU	142.00
10,000 to 20,000 MWDT/MTU	162.00
Over 20,000 MWDT/MTU	184.00

This fee shall not be subject to adjustment, and the payment thereof by the Purchaser shall be made to DOE as specified in paragraph B of this Article VIII.

3. For in-core fuel as of April 7, 1983, that portion of the fuel burned through April 6, 1983 shall be subject to the one-time fee as calculated in accordance with the following methodology: [a] determine the total weight in kilograms of unranium loaded initially in the particular core; [b] determine the total megawatt-days (thermal) which have been generated by all of the fuel assemblies in the said core as of 12:00 A.M. April 7, 1983; [c] divide the megawatt-days (thermal) generated in the said core by the total metric tons of initially loaded uranium in that core and multiply the quotient by the conversion factor 0.0078 to obtain a value in dollars per kilogram; and [d] multiply the dollars per kilogram value by the kilograms determined in [a] above to derive the dollar charge for the one-time fee to be paid for the specified in-core fuel as of 12:00 A.M. April 7, 1983. For purposes of this contract, in-core fuel is that fuel in the reactor core as of the date specified, plus any fuel removed from the reactor with plans for reinsertion. That portion of such fuel unburned as of 12:00 A.M. April 7, 1983 shall be subject to the 1.0 mill per kilowatt-hour charge.

4. DOE will annually review the adequacy of the fees and adjust the 1M/KWH fee, if necessary, in order to assure full cost recovery by the Government. Any proposed adjustment to the said fee will be transmitted to Congress and shall be effective after a period of ninety (90) days of continuous session has elapsed following receipt of such transmittal unless either House of Congress adopts a resolution disapproving the proposed adjustment. Any adjustment to the 1M/KWH fee under paragraph A.1. of this Article VIII shall be prospective.

B. Payment

1. For electricity generated and sold by the Purchaser's civilian nuclear power reactor(s) on or after April 7, 1983, fees shall be paid quarterly by the Purchaser and must be received by DOE not later than the close of the last business day of the month following the end of each assigned 3-month period. The first payment shall be due on July 31, 1983, for the period April 7, 1983, to June 30, 1983. (Add as applicable: A one-time adjustment period payment shall be due on _____, for the period _____ to _____.) The assigned 3-month period, for purposes of payment and reporting of electricity generated and sold shall begin _____.

2. For SNF discharged prior to April 7, 1983, and for in-core burned fuel as of 12:00 A.M. April 7, 1983, the Purchaser shall, within two (2) years of contract execution, select one of the following fee payment options:

(a) *Option 1*— The Purchaser's financial obligation for said fuel shall be prorated evenly over forty (40) quarters and will consist of the fee plus interest on the outstanding fee balance. The interest from April 7, 1983, to date of the first payment is to be calculated based upon the 13-week Treasury bill rate, as reported on the first such issuance following April 7, 1983, and compounded quarterly thereafter by the 13-week Treasury bill rates as reported on the first such issuance of each succeeding assigned three-month period. Beginning with the first payment, interest is to be calculated on Purchaser's financial obligation plus accrued interest, at the ten-year Treasury note rate in effect on the date of the first payment. In no event shall the end of the forty (40) quarters extend beyond the first scheduled delivery date as reflected in the DOE-approved delivery commitment schedule. All payments shall be made concurrently with the assigned three month period payments. At any time prior to the end of the forty (40) quarters, Purchaser may, without penalty, make a full or partial lump sum payment at any of the assigned three month period payment dates. Subsequent quarterly payments will be appropriately reduced to reflect the reduction in the remaining balance in the fee due and payable. The remaining financial obligation, if any, will be subject to interest at the same ten-year Treasury note rate over the remainder of the ten year period.

(b) *Option 2*— The Purchaser's financial obligation shall be paid in the form of a single payment anytime prior to the first delivery, as reflected in the DOE approved delivery commitment schedule, and shall consist of the fee plus interest on the outstanding fee balance. Interest is to be calculated from April 7, 1983, to the date of the payment based upon the 13-week Treasury bill rate, as reported on the first such issuance following April 7, 1983, and compounded quarterly thereafter by the 13-week Treasury bill rates as reported on the first such issuance of each succeeding assigned three-month period until payment.

(c) *Option 3*— The Purchaser's financial obligation shall be paid prior to June 30, 1985, or prior to two (2) years after contract execution, whichever comes later, in the form of a single payment and shall consist of all outstanding fees for SNF and in-core fuel burned prior to April 7, 1983. Under this option, no interest shall be due to DOE from April 7, 1983, to the date of full payment on the outstanding fee balance.

3. *Method of Payment:*

(a) Payments shall be made by wire transfer, in accordance with instructions specified by DOE in appendix G, annexed hereto and made a part hereof, and must be received within the time periods specified in paragraph B.1. of this Article VIII.

(b) The Purchaser will complete a Standard Remittance Advice, as set forth in appendix G, for each assigned three month period payment, and mail it postmarked no later than the last business day of the month following each assigned three month period to Department of Energy, Office of Controller, Cash Management Division, Box 500, Room D-208, Germantown, Maryland 20874.

4. Any fees not paid on a timely basis or underpaid because of miscalculation will be subject to interest as specified in paragraph C of this Article VIII.

C. Interest on Late Fees

1. DOE will notify the Purchaser of amounts due only when unpaid or underpaid by the dates specified in paragraph B above. Interest will be levied according to the following formula:

Interest=Unpaid balance due to DOE for assigned three month period × Quarterly Treasury rate plus six percent (6%) × Number of months late including month of payment (fractions rounded up to whole months) ÷ 12

2. Interest is payable at any time prior to the due date for the subsequent assigned three month period fee payment. Nonpayment by the end of the subsequent assigned three month period will result in compounding of interest due. Purchaser shall complete a Standard Remittance Advice of interest payments.

3. Following the assessment of a late fee by DOE, payments will be applied against accrued interest first and the principal thereafter.

D. Effect of Payment

Upon payment of all applicable fees, interest and penalties on upaid or underpaid amounts, the Purchaser shall have no further financial obligation to DOE for the disposal of the accepted SNF and/or HLW.

E. Audit

1. The DOE or its representative shall have the right to perform any audits or inspections necessary to determine whether Purchaser is paying the correct amount under the fee schedule and interest provisions set forth in paragraphs A, B and C above.

2. Nothing in this contract shall be deemed to preclude an audit by the General Accounting Office of any transaction under this contract.

3. The Purchaser shall furnish DOE with such records, reports and data as may be necessary for the determination of quantities delivered hereunder and for final settlement of amounts due under this contract and shall retain and make available to DOE and its authorized representative examination at all reasonable times such records, reports and data for a period of three (3) years from the completion of delivery of all material under this contract.

ARTICLE IX—DELAYS

A. Unavoidable Delays by Purchaser or DOE

Neither the Government nor the Purchaser shall be liable under this contract for damages caused by failure to perform its obligations hereunder, if such failure arises out of causes beyond the control and without the fault or negligence of the party failing to perform. In the event circumstances beyond the reasonable control of the Purchaser or DOE—such as acts of God, or of the public enemy, acts of Government in either its sovereign or contractual capacity, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes and unusually severe weather—cause delay in scheduled delivery, acceptance or transport of SNF and/or HLW, the party experiencing the delay will notify the other party as soon as possible after such delay is ascertained and the parties will readjust their schedules, as appropriate, to accommodate such delay.

B. Avoidable Delays by Purchaser or DOE

In the event of any delay in the delivery, acceptance or transport of SNF and/or HLW to or by DOE caused by circumstances within the reasonable control of either the Purchaser or DOE or their respective contractors or suppliers, the charges and schedules specified by this contract will be equitably adjusted to reflect any estimated additional costs incurred by the party not responsible for or contributing to the delay.

ARTICLE X—SUSPENSION

A. In addition to any other rights DOE may have hereunder, DOE reserves the right, at no cost to the Government, to suspend this contract or any portion thereof upon written notice to the Purchaser within ninety (90) days of the Purchaser's failure to perform its obligations hereunder, and the Purchaser's failure to take corrective action within thirty (30) days after written notice of such failure to perform as provided above, unless such failure shall arise from causes beyond the control and without the fault or negligence of the Purchaser, its contractors or agents. However, the Purchaser's obligation to pay fees required hereunder shall continue unaffected by any suspension. Any such suspension shall be rescinded if and when DOE determines that Purchaser has completed corrective action.

B. The DOE reserves the right to suspend any scheduled deliveries in the event that a national emergency requires that priority be given to Government programs to the exclusion of the work under this contract. In the event of such a suspension by the Government, the DOE shall refund that portion of payments representing services not delivered as determined by the Contracting Officer to be an equitable adjustment. Any disagreement arising from the refund payment, if any, shall be resolved as provided in the clause of this contract, entitled “DISPUTES.”

ARTICLE XI—REMEDIES

Nothing in this contract shall be construed to preclude either party from asserting its rights and remedies under the contract or at law.

ARTICLE XII—NOTICES

All notices and communications between the parties under this contract (except notices published in the FEDERAL REGISTER) shall be in writing and shall be sent to the following addressees:

To DOE: ____________________

____

____

To the Purchaser: ____________________

____

____

However, the parties may change the addresses or addressees for such notices or communications without formal modification to this contract; *provided, however,* that notice of such changes shall be given by registered mail.

ARTICLE XIII—REPRESENTATION CONCERNING NUCLEAR HAZARDS INDEMNITY

A. DOE represents that it will include in its contract(s) for the operation of any DOE facility an indemnity agreement based upon Section 170(d) of the Atomic Energy Act of 1954, as amended, a copy of which agreement shall be furnished to the Purchaser; that under said agreement, DOE shall have agreed to indemnify the contractor and other persons indemnified against claims for public liability (as defined in said Act) arising out of or in connection with contractual activities; that the indemnity shall apply to covered nuclear incidents which (1) take place at a contract location; or (2) arise out of or in the course of transportation of source, special nuclear or by-product material to or from a contract location. The obligation of DOE to indemnify shall be subject to the conditions stated in the indemnity agreement.

B. The provisions of this Article XIII shall continue beyond the term of this contract.

Article XIV—Assignment

The rights and duties of the Purchaser may be assignable with transfer of title to the SNF and/or HLW involved; *provided, however,* that notice of any such transfer shall be made to DOE within ninety (90) days of transfer.

Article XV—Amendments

The provisions of this contract has been developed in the light of uncertainties necessarily attendant upon long-term contracts. Accordingly, at the request of either DOE or Purchaser, the parties will negotiate and, to the extent mutually agreed, amend this contract as the parties may deem to be necessary or proper to reflect their respective interests; *provided, however,* that any such amendment shall be consistent with the DOE final rule published in the Federal Register on April 18, 1983 entitled, “Standard Contract for Disposal or SNF and/or HLW”, as the same may be amended from time to time.

Article XVI—Disputes

A. Except as otherwise provided in this contract, any dispute concerning a question of fact arising under this contract which is not disposed of by agreement shall be decided by the Contracting Officer, who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the Purchaser. The decision of the Contracting Officer shall be final and conclusive unless within ninety (90) days from the date of receipt of such copy, the Purchaser mails or otherwise furnishes to the Contracting Officer a written appeal addressed to the DOE Board of Contract Appeals (Board). The decision of the Board shall be final and conclusive unless determined by a court of competent jursidiction to have been fraudulent, or capricious, or arbitrary, or so grossly erroneous as necessarily to imply bad faith or not supported by substantial evidence. In connection with any appeal proceeding under this clause, the Purchaser shall proceed diligently with the performance of the contract and in accordance with the Contracting Officer's decision.

B. For Purchaser claims of more than $50,000, the Purchaser shall submit with the claim a certification that the claim is made in good faith; the supporting data are accurate and complete to the best of the Purchaser's knowledge and belief; and the amount requested accurately reflects the contract adjustment for which the Purchaser believes the Government is liable. The certification shall be executed by the Purchaser if an individual. When the Purchaser is not an individual, the certification shall be executed by a senior company official in charge at the Purchaser's plant or location involved, or by an officer or general partner of the Purchaser having overall responsibility for the conduct of the Purchaser's affairs.

C. For Purchaser claims of $50,000 or less, the Contracting Officer must render a decision within sixty (60) days. For Purchaser claims in excess of $50,000, the Contracting Officer must decide the claim within sixty (60) days or notify the Purchaser of the date when the decision will be made.

D. This “Disputes” clause does not preclude consideration of law questions in connection with decisions provided for in paragraph A above; *provided, however,* that nothing in this contract shall be construed as making final the decision of any administrative official, representative, or board on a question of law.

Article XVII—Officials Not To Benefit

No member of or delegate to Congress or resident commissioner shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

Article XVIII—Covenant Against Contingent Fees

The Purchaser warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Purchaser for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability or in its discretion to increase the contract price or consideration, or otherwise recover, the full amount of such commission, brokerage, or contingent fee.

Article XIX—Examination of Records

The Purchaser agrees that the Comptroller General of the United States or any of his duly authorized representatives shall have access to and the right to examine any directly pertinent books, documents, papers and records of the Purchaser involving transactions related to this contract until the expiration of three years after final payment under this contract.

Article XX—Permits

The Government and the Purchaser shall procure all necessary permits or licenses (including any special nuclear material licenses) and comply with all applicable laws and regulations of the United States, States and municipalities necessary to execute their respective responsibilities and obligations under this contract.

Article XXI—Rights in Technical Data

A. Definitions.

1. *Technical data* means recorded information regardless of form or characteristic, of a specific or technical nature. It may, for example, document research, experimental, developmental, or demonstration, or engineering work, or be usable or used to define a design or process, or to procure, produce, support, maintain or operate material. The data may be graphic or pictorial delineations in media such as drawings or photographs, text in specifications or related performance or design-type documents or computer software (including computer programs, computer software data bases, and computer software documentation). Examples of technical data include research and engineering data, engineering drawings and associated lists, specifications, standards, process sheets, manuals, technical reports, catalog item identification, and related information. Technical data as used herein do not include financial reports, cost analyses, and other information incidental to contract administration.

2. *Proprietary data* means technical data which embody trade secrets developed at private expense, such as design procedures or techniques, chemical composition of materials, or manufacturing methods, processes, or treatments, including minor modifications thereof, provided that such data:

(a) Are not generally known or available from other sources without obligation concerning their confidentiality;

(b) Have not been made available by the owner to others without obligation concerning its confidentiality; and

(c) Are not already available to the Government without obligation concerning their confidentiality.

3. *Contract data* means technical data first produced in the performance of the contract, technical data which are specified to be delivered under the contract, or technical data actually delivered in connection with the contract.

4. *Unlimited rights* means rights to use, duplicate, or disclose technical data, in whole or in part, in any manner and for any purpose whatsoever, and to permit others to do so.

B. Allocation of Rights.

1. The Government shall have:

(a) Unlimited rights in contract data except as otherwise provided below with respect to proprietary data properly marked as authorized by this clause;

(b) The right to remove, cancel, correct or ignore any marking not authorized by the terms of this contract on any technical data furnished hereunder, if in response to a written inquiry by DOE concerning the proprietary nature of the markings, the Purchaser fails to respond thereto within 60 days or fails to substantiate the proprietary nature of the markings. In either case, DOE will notify the Purchaser of the action taken;

(c) No rights under this contract in any technical data which are not contract data.

2. Subject to the foregoing provisions of this rights in technical data clause, the Purchaser shall have the right to mark proprietary data it furnishes under the contract with the following legend and no other, the terms of which shall be binding on the Government:

Limited Rights Legend

This “proprietary data,” furnished under “Contract No. __” with the U.S. Department of Energy may be duplicated and used by the Government with the express limitations that the “proprietary data” may not be disclosed outside the Government or be used for purposes of manufacture without prior permission of the Purchaser, except that further disclosure or use may be made solely for the following purposes:

(a) This “proprietary data” may be disclosed for evaluation purposes under the restriction that the “proprietary data” be retained in confidence and not be further disclosed;

(b) This “proprietary data” may be disclosed to contractors participating in the Government's program of which this contract is a part, for information or use in connection with the work performed under their contracts and under the restriction that the “proprietary data” be retained in confidence and not be further disclosed; or

(c) This “proprietary data” may be used by the Government or others on its behalf for emergency work under the restriction that the “proprietary data” be retained in confidence and not be further disclosed. This legend shall be marked on any reproduction of this data in whole or in part.

3. In the event that proprietary data of a third party, with respect to which the Purchaser is subject to restrictions on use or disclosure, is furnished with the Limited Rights Legend above, Purchaser shall secure the agreement of such third party to the rights of the Government as set forth in the Limited Rights Legend. DOE shall upon request furnish the names of those contractors to which proprietary data has been disclosed.

Article XXII—Entire Contract

A. This contract, which consists of Articles I through XXII and appendices A through G, annexed hereto and made a part hereof, contains the entire agreement between the parties with respect to the subject matter hereof. Any representation, promise, or condition not incorporated in this contract shall not be binding on either party. No course of dealing or usage of trade or course of performance shall be relevant to explain or supplement any provision contained in this contract.

B. Nothing in this contract is intended to affect in any way the contractual obligation of any other persons with whom the Purchaser may have contracted with respect to assuming some or all disposal costs or to accept title to SNF and/or HLW.

C. Appendices

A. Nuclear Power Reactor(s) or Other Facilities Covered

B. Discharge Information (Ten Year; Annual)

C. Delivery Commitment Schedule

D. Final Delivery Schedule

E. General Specifications

F. Detailed Description of Purchaser's Fuel

G. Standard Remittance Advice For Payment of Fees

In witness whereof, the parties hereto have executed this contract as of the day and year first above written.

United States of America

United States Department of Energy

By: ____________________

(Contracting Officer)

Witnesses as to Execution on Behalf of Purchaser

(Name) ____________________

(Address) ____________________

(Name) ____________________

(Address) ____________________

(Purchaser's Company Name)

By: ____________________

Title: ____________________

I, (*Name*), certify that I am the (*Title*) of the corporation named as Purchaser herein; that (*Name*) who signed this document on behalf of the Purchaser was then (*Title*) of said corporation; that said document was duly signed for and on behalf of said corporation by authority of its governing body and is within the scope of its corporate powers.

In Witness Whereof, I have hereunto affixed my hand and the seal of said corporation this __ day of __, 1983

(Corporate Seal)

(Signature) ____________________

APPENDIX A

Nuclear Power Reactor(s) or Other Facilities Covered

Purchaser ____________________

Contract Number/Date __/__ ____________________

Reactor/Facility Name ____________________

Location:

Street ____________________

City ____________________

County/State ____/ ____________________

Zip Code ____________________

Capacity (MWE)_Gross ____________________

Reactor Type:

BWR □

PWR □

Other (Identify) ____________________

Facility Description ____________________

Date of Commencement of Operation ____________________

(actual or estimated)

NRC License #: ____________________

By Purchaser:

Signature ____________________

Title ____________________

Date ____________________

APPENDIX B

Ten Year Discharge Forecast

To be used for DOE planning purposes only and does not represent a firm commitment by Purchaser.

Purchaser ____________________

Contract Number/Date ____/ ____________________

Reactor/Facility Name ____________________

Location:

Street ____________________

City ____________________

County/State ____/ ____________________

Zip Code

Type: BWR □

PWR □

Other (Identify)

	1	2	3	4	5	6	7	8	9	10	10 yr total
Discharge date—mo/yr (or refueling shut down date)											
Metric tons:											
—initial											
—discharged											
Number of assemblies discharged (per cycle)											

By Purchaser:

Signature ______

Title ______

Date ______

APPENDIX B (ENCLOSURE 1)

Actual Discharges

Purchaser ______

Contract Number/Date ______

Reactor/Facility Name ______

Location:

Street ______

City ______

County/State ______

Zip Code ______

Type:

BWR □

PWR □

Other (Identify) ______

Refueling Shutdown Date ______

Metric Tons Uranium (Initial/Discharged);

Initial ______

Discharged ______

Number of Assemblies Discharged: ______

Any false, fictitious or fraudulent statement may be punishable by fine or imprisonment (U.S. Code, Title 18, Section 1001).

By Purchaser:

Signature ______

Title ______

Date ______

APPENDIX C

Delivery Commitment Schedule

This delivery commitment schedule shall be submitted by Purchaser to DOE as specified in Article V.B. of this contract.

Purchaser ______

Contract Number/Date ______

Reactor/Facility Name ______

Location:

Street ______

City ______

County/State ______

Zip Code ______

Type Cask Required: ______

Shipping Lot Number ______

(Assigned by DOE)

Proposed Shipping Mode:

Truck □

Rail ☐

Barge ☐

DOE Assigned Delivery Commitment Date

Range of Discharge Date(s) (Earliest to Latest)

Mo__ Day__ Yr__ to Mo__ Day__ Yr__

Metric Tons Uranium:

(Initial)

(Discharged)

Number of Assemblies:

BWR

PWR

Other

Unless otherwise agreed to in writing by DOE, the Purchaser shall furnish herewith to DOE suitable proof of ownership of the SNF and/or HLW to be delivered hereunder. The Purchaser shall notify DOE in writing at the earliest practicable date of any change in said ownership.

Any false, fictitious or fraudulent statement may be punishable by fine or imprisonment (U.S. Code, Title 18, Section 1001).

By Purchaser:

Signature

Title

Date

Approved by DOE:

Technical Representative

Title

Date

Contracting Officer

Date

Appendix D

Final Delivery Schedule

(To be submitted to DOE by Purchaser for each designated Purchaser Delivery site not later than twelve (12) months prior to estimated date of first delivery)

Purchaser:

Contract Number/Date

Reactor/Facility Name

Location:

Street

City

County/State

Zip Code

Type(s) cask(s) required:

No. Assemblies per cask

Shipping Lot Number

Shipping Mode:

(Assigned by DOE)

Truck

Rail

Barge

Metric Tons Uranium:

(Discharged) __________

Range of Discharge Date(s) (Earliest to Latest)

(From approved commitment schedule)

Mo__ Day__ Yr__ to Mo__ Day__ Yr__

Number of Assemblies:

BWR __________

PWR __________

Other __________

Purchaser's Delivery First Estimate

Mo__ Day__ Yr__ last Mo__ Day__ Mo__

Unless otherwise agreed to in writing by DOE, the Purchaser shall furnish herewith to DOE suitable proof of ownership of the SNF and/or HLW to be delivered hereunder. The Purchaser shall notify DOE in writing at the earliest practicable date of any change in said ownership.

To confirm acceptability of delivery date(s):

Purchaser Contact __________

Phone __________

Title __________

DOE Contact __________

Phone __________

Title __________

Any false, fictitious or fraudulent statement may be punishable by fine or imprisonment (U.S. Code, Title 18, Section 1001).

By Purchaser:

Signature __________

Title __________

Date __________

Approved by DOE:

Technical Representative __________

Title __________

Date __________

Contracting Officer __________

Date __________

Appendix E

General Specifications

A. Fuel Category Identification

1. Categories—Purchaser shall use reasonable efforts, utilizing technology equivalent to and consistent with the commercial practice, to properly classify Spent Nuclear Fuel (SNF) prior to delivery to DOE, as follows:

a. *Standard Fuel* means SNF that meets all the General Specifications therefor set forth in paragraph B below.

b. *Nonstandard Fuel* means SNF that does not meet one or more of the General Specifications set forth in subparagraphs 1 through 5 of paragraph B below, and which is classified as Nonstandard Fuel Classes NS-1 through NS-5, pursuant to paragraph B below.

c. *Failed Fuel* means SNF that meets the specifications set forth in subparagraphs 1 through 3 of paragraph B below, and which is classified as Failed Fuel Class F-1 through F-3 pursuant to subparagraph 6 of paragraph B below.

d. Fuel may have “Failed Fuel” and/or several “Nonstandard Fuel” classifications

B. Fuel Description and Subclassification—General Specifications

1. *Maximum Nominal Physical Dimensions.*

	Boiling water reactor (BWR)	Pressurized water reactor (PWR)
Overall Length	14 feet, 11 inches	14 feet, 10 inches.
Active Fuel Length	12 feet, 6 inches	12 feet, 0 inches.
Cross Section[1]	6 inches × 6 inches	9 inches × 9 inches.

[1]The cross section of the fuel assembly shall not include the channel.

NOTE: Fuel that does not meet these specifications shall be classified as Nonstandard Fuel—Class NS-1.

2. *Nonfuel Components.* Nonfuel components including, but not limited to, control spiders, burnable poison rod assemblies, control rod elements, thimble plugs, fission chambers, and primary and secondary neutron sources, that are contained within the fuel assembly, or BWR channels that are an integral part of the fuel assembly, which do not require special handling, may be included as part of the spent nuclear fuel delivered for disposal pursuant to this contract.

NOTE: Fuel that does not meet these specifications shall be classified as Nonstandard Fuel—Class NS-2.

3. *Cooling.* The minimum cooling time for fuel is five (5) years.

NOTE: Fuel that does not meet this specification shall be classified as Nonstandard Fuel—Class NS-3.

4. *Non-LWR Fuel.* Fuel from other than LWR power facilities shall be classified as Nonstandard Fuel—Class NS-4. Such fuel may be unique and require special handling, storage, and disposal facilities.

5. *Consolidated Fuel Rods.* Fuel which has been disassembled and stored with the fuel rods in a consolidated manner shall be classified as Nonstandard Fuel Class NS-5.

6. *Failed Fuel.*

a. Visual Inspection.

Assemblies shall be visually inspected for evidence of structural deformity or damage to cladding or spacers which may require special handling. Assemblies which [i] are structurally deformed or have damaged cladding to the extent that special handling may be required or [ii] for any reason cannot be handled with normal fuel handling equipment shall be classified as Failed Fuel—Class F-1.

b. Previously Encapsulated Assemblies.

Assemblies encapsulated by Purchaser prior to classification hereunder shall be classified as Failed Fuel—Class F-3. Purchaser shall advise DOE of the reason for the prior encapsulation of assemblies in sufficient detail so that DOE may plan for appropriate subsequent handling.

c. Regulatory Requirements.

Spent fuel assemblies shall be packaged and placed in casks so that all applicable regulatory requirements are met.

C. Summary of Fuel Classifications

1. *Standard Fuel:*

a. Class S-1: PWR

b. Class S-2: BWR

2. *Nonstandard Fuel:*

a. Class NS-1: Physical Dimensions

b. Class NS-2: Non Fuel Components

c. Class NS-3: Short Cooled

d. Class NS-4: Non-LWR

e. Class NS-5: Consolidated Fuel Rods.

3. *Failed Fuel:*

a. Class F-1: Visual Failure or Damage

b. Class F-2: Radioactive “Leakage”

c. Class F-3: Encapsulated

D. High-Level Radioactive Waste

The DOE shall accept high-level radioactive waste. Detailed acceptance criteria and general specifications for such waste will be issued by the DOE no later than the date on which DOE submits its license application to the Nuclear Regulatory Commission for the first disposal facility.

APPENDIX F

Detailed Description of Purchaser's Fuel

This information shall be provided by Purchaser for each distinct fuel type within a Shipping Lot not later than sixty (60) days prior to the schedule transportation date.

Purchaser ______________________________

Contract Number/Date __/____

Reactor/Facility Name_ ______________________________

____

____

I. Drawings included in generic dossier: ____

1. Fuel Assembly DWG# __

2. Upper & Lower end fittings DWG# __

Dossier Number: __

DOE Shipping Lot #: __

Assemblies Described:

___BWR

___PWR

___Other

II. *Design Material Descriptions.*

Fuel Element:

1. Element type __ (rod, plate, etc.)

2. Total length) __/(in.)

3. Active length __ (in.)

4. Cladding material __ (Zr, s.s., etc.)

Assembly Description:

1. Number of Elements __

2. Overall dimensions (length __ (cross section) __ (in.)

3. Overall weight __

III. Describe any distortions, cladding damage or other damage to the spent fuel, or nonfuel components within this Shipping Lot which will require special handling procedures. (Attach additional pages if needed.)

IV. Assembly Number __

Shipping Lot #__

	Irradiation history cycle No.				
	1	2	3	4	5
1. Startup date (mo/day/yr)					
2. Shutdown date (mo/day/yr)					
3. Cumulative fuel exposure (mwd/mtu)					
4. Avg. reactor power (mwth)					
5. Total heat output/assembly in watts, using an approved calculational method: ____ as of Date ____					

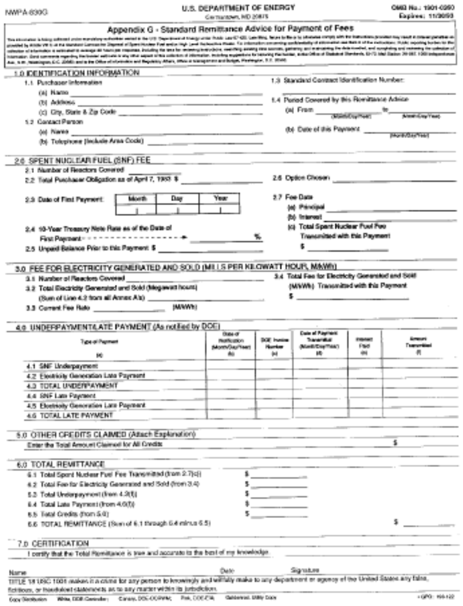
Any false, fictitious or fradulent statement may be punishable by fine or imprisonment (U.S. Code, Title 18, Section 1001).

By Purchaser:

Signature ____________________

Title ____________________

Date ____________________



NWPA-830G

U.S. DEPARTMENT OF ENERGY
Germantown, MD 20875

OMB No.: 1901-0260
Expires: 11/30/93

Appendix G - Standard Remittance Advice for Payment of Fees

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1.0 IDENTIFICATION INFORMATION

1.1 Purchaser Information
(a) Name
(b) Address
(c) City, State & Zip Code
1.2 Contact Person
(a) Name
(b) Telephone (Include Area Code)

1.3 Standard Contract Identification Number:
1.4 Period Covered by this Remittance Advice
(a) From (Month/Day/Year) to (Month/Day/Year)
(b) Date of this Payment (Month/Day/Year)

2.0 SPENT NUCLEAR FUEL (SNF) FEE

2.1 Number of Reactors Covered
2.2 Total Purchaser Obligation as of April 7, 1983 $
2.3 Date of First Payment: Month Day Year
2.4 10-Year Treasury Note Rate as of the Date of First Payment %
2.5 Unpaid Balance Prior to this Payment $
2.6 Option Chosen
2.7 Fee Date
(a) Principal
(b) Interest
(c) Total Spent Nuclear Fuel Fee Transmitted with this Payment $

3.0 FEE FOR ELECTRICITY GENERATED AND SOLD (MILLS PER KILOWATT HOUR, M/kWh)

3.1 Number of Reactors Covered
3.2 Total Electricity Generated and Sold (Megawatt hours) (Sum of Line 4.2 from all Annex A's)
3.3 Current Fee Rate (M/kWh)
3.4 Total Fee for Electricity Generated and Sold (M/kWh) Transmitted with this Payment $

4.0 UNDERPAYMENT/LATE PAYMENT (As notified by DOE)

Type of Payment (a)	Date of Notification (Month/Day/Year) (b)	DOE Invoice Number (c)	Date of Payment Transmitted (Month/Day/Year) (d)	Interest Paid (e)	Amount Transmitted (f)
4.1 SNF Underpayment					
4.2 Electricity Generation Late Payment					
4.3 TOTAL UNDERPAYMENT					
4.4 SNF Late Payment					
4.5 Electricity Generation Late Payment					
4.6 TOTAL LATE PAYMENT					

5.0 OTHER CREDITS CLAIMED (Attach Explanation)

Enter the Total Amount Claimed for All Credits $

6.0 TOTAL REMITTANCE

6.1 Total Spent Nuclear Fuel Fee Transmitted (from 2.7(c)) $
6.2 Total Fee for Electricity Generated and Sold (from 3.4) $
6.3 Total Underpayment (from 4.3(f)) $
6.4 Total Late Payment (from 4.6(f)) $
6.5 Total Credits (from 5.0) $
6.6 TOTAL REMITTANCE (Sum of 6.1 through 6.4 minus 6.5) $

7.0 CERTIFICATION

I certify that the Total Remittance is true and accurate to the best of my knowledge.

Name Date Signature

TITLE 18 USC 1001 makes it a crime for any person to knowingly and willfully make to any department or agency of the United States any false, fictitious, or fraudulent statements as to any matter within its jurisdiction.

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DEPARTMENT OF ENERGY
Germantown, MD 20875

APPENDIX G - STANDARD REMITTANCE ADVICE FOR PAYMENT OF FEES

General Information

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INSTRUCTIONS FOR COMPLETING STANDARD REMITTANCE ADVICE FOR PAYMENT OF FEES

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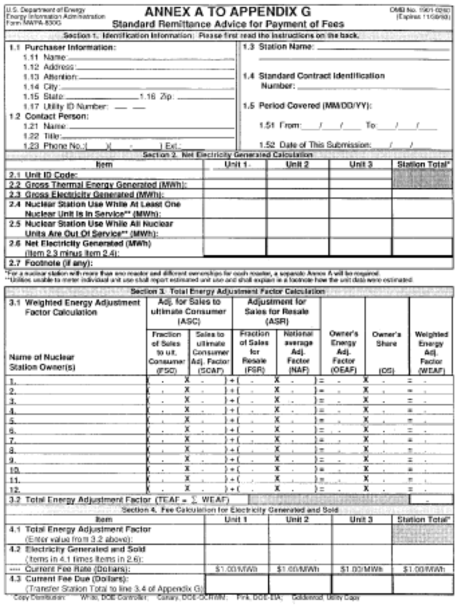

U.S. Department of Energy
Energy Information Administration
Form NWPA-830G

ANNEX A TO APPENDIX G

Standard Remittance Advice for Payment of Fees

OMB No. 1901-0260 (Expires 11/30/93)

Section 1. Identification Information: Please first read the instructions on the back.

1.1 Purchaser Information:
1.11 Name:
1.12 Address:
1.13 Attention:
1.14 City:
1.15 State: 1.16 Zip:
1.17 Utility ID Number:
1.2 Contact Person:
1.21 Name:
1.22 Title:
1.23 Phone No.:( )(-) Ext.:

1.3 Station Name:
1.4 Standard Contract Identification Number:
1.5 Period Covered (MM/DD/YY):
1.51 From: / / To: / /
1.52 Date of This Submission: / /

Section 2. Net Electricity Generated Calculation

Item	Unit 1	Unit 2	Unit 3	Station Total*
2.1 Unit ID Code:				
2.2 Gross Thermal Energy Generated (MWh):				
2.3 Gross Electricity Generated (MWh):				
2.4 Nuclear Station Use While At Least One Nuclear Unit Is In Service** (MWh):				
2.5 Nuclear Station Use While All Nuclear Units Are Out Of Service** (MWh):				
2.6 Net Electricity Generated (MWh) (Item 2.3 minus Item 2.4):				
2.7 Footnote (if any):				

*For a nuclear station with more than one reactor and different ownerships for each reactor, a separate Annex A will be required.
**Utilities unable to meter individual unit use shall report estimated unit use and shall explain in a footnote how the unit data were estimated.

Section 3. Total Energy Adjustment Factor Calculation

3.1 Weighted Energy Adjustment Factor Calculation	Adj. for Sales to ultimate Consumer (ASC)		Adjustment for Sales for Resale (ASR)				
Name of Nuclear Station Owner(s)	Fraction of Sales to ult. Consumer (FSC)	Sales to ultimate Consumer Adj. Factor (SCAF)	Fraction of Sales for Resale (FSR)	National average Adj. Factor (NAF)	Owner's Energy Adj. Factor (OEAF)	Owner's Share (OS)	Weighted Energy Adj. Factor (WEAF)
1.	(.	X .) +	(.	X .) =	.	X .	= .
2.	(.	X .) +	(.	X .) =	.	X .	= .
3.	(.	X .) +	(.	X .) =	.	X .	= .
4.	(.	X .) +	(.	X .) =	.	X .	= .
5.	(.	X .) +	(.	X .) =	.	X .	= .
6.	(.	X .) +	(.	X .) =	.	X .	= .
7.	(.	X .) +	(.	X .) =	.	X .	= .
8.	(.	X .) +	(.	X .) =	.	X .	= .
9.	(.	X .) +	(.	X .) =	.	X .	= .
10.	(.	X .) +	(.	X .) =	.	X .	= .
11.	(.	X .) +	(.	X .) =	.	X .	= .
12.	(.	X .) +	(.	X .) =	.	X .	= .
3.2 Total Energy Adjustment Factor (TEAF = ∑ WEAF)							.

Section 4. Fee Calculation for Electricity Generated and Sold

Item	Unit 1	Unit 2	Unit 3	Station Total*
4.1 Total Energy Adjustment Factor (Enter value from 3.2 above):				
4.2 Electricity Generated and Sold (Items in 4.1 times items in 2.6):				
---- Current Fee Rate (Dollars):	$1.00/MWh	$1.00/MWh	$1.00/MWh	$1.00/MWh
4.3 Current Fee Due (Dollars): (Transfer Station Total to line 3.4 of Appendix G)				

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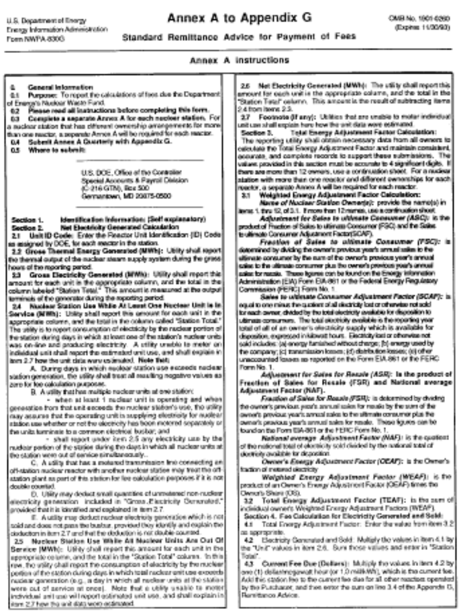

U.S. Department of Energy
Energy Information Administration
Form NWPA-830G

Annex A to Appendix G

Standard Remittance Advice for Payment of Fees

OMB No. 1901-0260 (Expires 11/30/93)

Annex A Instructions

0. General Information
0.1 **Purpose:** To report the calculations of fees due the Department of Energy's Nuclear Waste Fund.
0.2 **Please read all instructions before completing this form.**
0.3 **Complete a separate Annex A for each nuclear station.** For a nuclear station that has different ownership arrangements for more than one reactor, a separate Annex A will be required for each reactor.
0.4 **Submit Annex A Quarterly with Appendix G.**
0.5 **Where to submit:**

U.S. DOE, Office of the Controller
Special Accounts & Payroll Division
(C-216 GTN), Box 500
Germantown, MD 20875-0500

Section 1. Identification Information: (Self explanatory)
Section 2. Net Electricity Generated Calculation
2.1 **Unit ID Code:** Enter the Reactor Unit Identification (ID) Code as assigned by DOE, for each reactor in the station.
2.2 **Gross Thermal Energy Generated (MWh):** Utility shall report the thermal output of the nuclear steam supply system during the gross hours of the reporting period.
2.3 **Gross Electricity Generated (MWh):** Utility shall report this amount for each unit in the appropriate column, and the total in the column labeled "Station Total." This amount is measured at the output terminals of the generator during the reporting period.
2.4 **Nuclear Station Use While At Least One Nuclear Unit Is In Service (MWh):** Utility shall report this amount for each unit in the appropriate column, and the total in the column called "Station Total." The utility is to report consumption of electricity by the nuclear portion of the station during days in which at least one of the station's nuclear units was on-line and producing electricity. A utility unable to meter on individual unit shall report the estimated unit use, and shall explain in item 2.7 how the unit data were estimated. **Note that:**

A. During days in which nuclear station use exceeds nuclear station generation, the utility shall treat all resulting negative values as zero for fee calculation purposes.

B. A utility that has multiple nuclear units at one station:

- when at least 1 nuclear unit is operating and when generation from that unit exceeds the nuclear station's use, the utility may assume that the operating unit is supplying electricity for nuclear station use whether or not the electricity has been metered separately or the units terminate to a common electrical busbar; and
- shall report under item 2.5 any electricity use by the nuclear portion of the station during the days in which all nuclear units at the station were out of service simultaneously.

C. A utility that has a metered transmission line connecting an off-station nuclear reactor with another nuclear station may treat the off-station plant as part of this station for fee calculation purposes if it is not double counted.

D. Utility may deduct small quantities of unmetered non-nuclear electricity generation included in "Gross Electricity Generated," provided that it is identified and explained in item 2.7.

E. A utility may deduct nuclear electricity generation which is not sold and does not pass the busbar, provided they identify and explain the deduction in item 2.7 and that the deduction is not double-counted.

2.5 **Nuclear Station Use While All Nuclear Units Are Out Of Service (MWh):** Utility shall report this amount for each unit in the appropriate column, and the total in the "Station Total" column. In this row, the utility shall report the consumption of electricity by the nuclear portion of the station during days in which total nuclear unit use exceeds nuclear generation (e.g., a day in which all nuclear units at the station were out of service at once). Note that a utility unable to meter individual unit use will report estimated unit use, and shall explain in item 2.7 how the unit data were estimated.

2.6 **Net Electricity Generated (MWh):** The utility shall report this amount for each unit in the appropriate column, and the total in the "Station Total" column. This amount is the result of subtracting items 2.4 from items 2.3.
2.7 **Footnote (If any):** Utilities that are unable to meter individual unit use shall explain here how the unit data were estimated.
Section 3. Total Energy Adjustment Factor Calculation:
The reporting utility shall obtain necessary data from all owners to calculate the Total Energy Adjustment Factor and maintain consistent, accurate, and complete records to support these submissions. The values provided in this section must be accurate to 4 significant digits. If there are more than 12 owners, use a continuation sheet. For a nuclear station with more than one reactor and different ownerships for each reactor, a separate Annex A will be required for each reactor.
3.1 **Weighted Energy Adjustment Factor Calculation:**
Name of Nuclear Station Owner(s): provide the name(s) in items 1. thru 12. of 3.1. If more than 12 names, use a continuation sheet.
Adjustment for Sales to ultimate Consumer (ASC): is the product of Fraction of Sales to ultimate Consumer (FSC) and the Sales to ultimate Consumer Adjustment Factor(SCAF).
Fraction of Sales to ultimate Consumer (FSC): is determined by dividing the owner's previous year's annual sales to the ultimate consumer by the sum of the owner's previous year's annual sales to the ultimate consumer plus the owner's previous year's annual sales for resale. These figures can be found on the Energy Information Administration (EIA) Form EIA-861 or the Federal Energy Regulatory Commission (FERC) Form No. 1.
Sales to ultimate Consumer Adjustment Factor (SCAF): is equal to one minus the quotient of all electricity lost or otherwise not sold for each owner, divided by the total electricity available for disposition to ultimate consumers. The total electricity available is the reporting year total of all of an owner's electricity supply which is available for disposition, expressed in kilowatt hours. Electricity lost or otherwise not sold includes: (a) energy furnished without charge; (b) energy used by the company; (c) transmission losses; (d) distribution losses; (e) other unaccounted losses as reported on the Form EIA-861 or the FERC Form No. 1.
Adjustment for Sales for Resale (ASR): **is the product of Fraction of Sales for Resale (FSR) and National average Adjustment Factor (NAF).**
Fraction of Sales for Resale (FSR): is determined by dividing the owner's previous year's annual sales for resale by the sum of the owner's previous year's annual sales to the ultimate consumer plus the owner's previous year's annual sales for resale. These figures can be found on the Form EIA-861 or the FERC Form No. 1.
National average Adjustment Factor (NAF): is the quotient of the national total of electricity sold divided by the national total of electricity available for disposition.
Owner's Energy Adjustment Factor (OEAF): is the Owner's fraction of metered electricity.
Weighted Energy Adjustment Factor (WEAF): is the product of an Owner's Energy Adjustment Factor (OEAF) times the Owner's Share (OS).
3.2 **Total Energy Adjustment Factor (TEAF):** is the sum of individual owner's Weighted Energy Adjustment Factors (WEAF).
Section 4. Fee Calculation for Electricity Generated and Sold:
4.1 Total Energy Adjustment Factor: Enter the value from item 3.2 as appropriate.
4.2 Electricity Generated and Sold: Multiply the values in item 4.1 by the "Unit" values in item 2.6. Sum those values and enter in "Station Total".
4.3 Current Fee Due (Dollars): Multiply the values in item 4.2 by one (1) dollar/megawatt hour (or 1.0 mill/kWh), which is the current fee. Add this station fee to the current fee due for all other reactors operated by the Purchaser, and then enter the sum on line 3.4 of the Appendix G, Remittance Advice.

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Annex B to Appendix G

Standard Remittance of Advice (RA) for Payment of Fees

This Annex should be completed only for SNF burned before midnight between April 6/7, 1983.

I. *Identification*

A. Purchaser:______

B. Unit identification (Only one unit may be covered in each report.)

1. Reactor/Facility Name: ______

2. Location: ______

3. Type: ______

4. Capacity: ______

5. Date of Commencement of Operations: ______

II. *Fee Calculation*

A. *Discharged nuclear fuel*

1. Burnup[1] (MWDT/MTU)	0–	5,000–	10,000	20,000
	5,000	10,000	20,000	up
2. Initial loading (KgU) (with indicated burnup)				
3. Fee rate ($/KgU)	80.00	142.00	162.00	184.00
4. Fee ($)				
5. Total fee (4)				

B. Nuclear fuel in the reactor core as of midnight of 6/7 April 1983.

Assembly identification	Initial loading (KgU)	Burnup[1] as of midnight 6/7 April 1983 (MWDT/MTU)	Fee
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			
25.			

[1]Please provide (as an attachment) a clear reference to the methodology used to derive the burnup figures (computer codes, etc.) and a clear reference to all data used in the derivation of those figures.

C. Total fee.

(Approved by the Office of Management and Budget under control number 1091-0260)

[48 FR 16599, Apr. 18, 1983; 48 FR 23160, May 24, 1983, as amended at 52 FR 35359, Sept. 18, 1987; 56 FR 67659, Dec. 31, 1991]

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Need assistance?

Spent Nuclear Fuel Management- Quiz

Updated: 11/1/2022

1. What federal law requires the Department of Energy to remove spent nuclear fuel from all commercial nuclear power plant sites?

    a. The Standard Contract
    b. The Nuclear Materials Act
    c. The Atomic Energy Act
    d. The Nuclear Waste Policy Act

2. What United States federal government agency currently performs all licensing and oversight of the civilian use of nuclear materials?

    a. The Department of Energy
    b. The Nuclear Regulatory Commission
    c. The Atomic Energy Commission
    d. The Energy Research and Development Administration

3. Which of the following are required by the Standard Contract?

    a. The federal government would remove and dispose of commercial SNF in exchange for a fee
    b. Plant owners would ship the SNF to the repository
    c. The federal government would pay for additional on-site storage
    d. Plant owners could re-process the SNF and sell it to any willing buyer

4. Which of the following are provisions of the 1987 amendments to the NWPA?

    a. Designated Yucca Mountain as the only SNF repository
    b. Created Yucca Mountain licensing milestones
    c. Canceled the second repository
    d. All of the above

5. Spent nuclear fuel just discharged from the reactor is stored…

    a. In a dry storage cask inside the power plant
    b. Either in wet or dry storage at the discretion of the plant owner
    c. In a wet storage pool inside the power plant
    d. Is immediately transported to an offsite repository

6. About 23 feet of water is always maintained over the racks in the spent fuel pool primarily to…:

    a. Cool the SNF without forced circulation
    b. Provide radiation shielding for personnel
    c. Allow visual inspection of the SNF assemblies
    d. Provide protection from tornado missiles

7. Spent nuclear fuel takes what form?

    a. Solid, with liquid inside the fuel rods
    b. Liquid
    c. It begins as a solid and melts during dry storage due to decay heat
    d. Completely solid, inside and out, and remains that way

8. Decay heat emitted from spent nuclear fuel after removal from the reactor…

    a. Decreases over time to low levels according to the half-lives of the isotopes in the fuel assembly, but never reaches zero
    b. Never decreases
    c. Decreases to zero over time
    d. Is zero immediately when fission stops

9. The types of dry spent fuel storage systems used in the United States include:

    a. Bare fuel casks
    b. Canister-based horizontal storage systems
    c. Canister-based vertical storage systems
    d. All of the above

10. The capacity of dry storage systems for PWR fuel have increased from 24 SNF assemblies in the early years to _______ SNF assemblies today.

    a. 89
    b. 37
    c. 32
    d. 52

11. One common element of loading of a horizontal or vertical, canister-based dry storage system with SNF in the spent fuel pool is…

    a. The horizontal storage module or vertical storage cask is loaded in the spent fuel pool
    b. Both systems are loaded horizontally
    c. Both require the use of a transfer cask
    d. There are no common elements

12. Which of the following was a main objective providing the impetus for canister-based dry storage technology?

    a. To eliminate the maintenance involved with BFC lids and O-ring seals
    b. To allow direct transportation of the ventilated storage module or cask
    c. To allow disposal of the canister on the reactor site
    d. All of the above

13. Decay heat removal in a canister-based dry storage system is primarily by

    a. Forced convection cooling by fans
    b. Natural convection cooling created by the hot canister
    c. Conduction
    d. The SNF is naturally cool enough to not require heat removal

14. 10 CFR 71 governs…

    a. Storage of nuclear fuel inside the nuclear power plant
    b. Storage of nuclear fuel outside the nuclear power plant
    c. Transportation of all radioactive material regulated by the NRC
    d. Only transportation of spent nuclear fuel regulated by the NRC

15. One difference between a transportation “package” and “packaging” is…

    a. The packaging includes the radioactive contents and a package does not
    b. A package includes the radioactive contents and the packaging does not
    c. The packaging absorbent materials are not part of the package
    d. “Package” and “packaging” are unrelated terms

16. For normal conditions of transport, an SNF package design must withstand heat, based on which set of ambient conditions?

    a. 100°F without consideration of solar isolation
    b. 80°F with consideration of wind
    c. 80°F in still air
    d. 100°F with consideration of solar isolation

17. Transportation of an SNF package must comply with…

    a. Only NRC regulations
    b. Only State and Tribal regulations in jurisdictions through which the shipment passes
    c. All federal regulations and those of any States and Tribal jurisdictions through which the shipment passes
    d. Only DOT regulations

18. The drop test requirement for a hypothetical accident is to drop the package from what height onto a flat, essentially unyielding, horizontal surface?

    a. 30 feet
    b. From 1 to 4 feet depending on package weight
    c. 1 foot
    d. 50 feet

19. Canister-based, large-capacity spent nuclear fuel transportation packages are designed to primarily be shipped by…?

    a. Ocean-going barge
    b. Air
    c. Truck
    d. Rail

20. The status of SNF disposal in the United States today is…

    a. Under the active management of OCWRM
    b. Unknown
    c. Awaiting the completion of construction of the Yucca Mountain repository
    d. Awaiting the issuance of a final Environmental Impact Statement