CANISTER CONSIDERATIONS FOR COMMERCIAL SPENT NUCLEAR FUEL

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ABSTRACT

The Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) entered into contracts with spent nuclear fuel (SNF) owners and generators for the disposal of the SNF. These contracts are modeled on the Standard Contract for the Disposal of Spent Fuel Nuclear Fuel and/or High Level Waste (Standard Contract), which was promulgated in 10 CFR 961 and established specific requirements for the SNF. At the time the Standard Contract was established, the widespread use of single and dual purpose casks and canisters was not envisioned; hence, provisions for them were not included in the Standard Contract. In recognition of this growing trend in the industry and the need to establish standards to assure compatibility of the numerous single and dual purpose systems with the various system interfaces, OCRWM has initiated the development of cask and canister acceptance standards in context of the Standard Contract. This paper describes these efforts.

NOMENCLATURE

CFR – Code of Federal Regulations
CoC – Certificate of Compliance issued by the NRC
DOE/Department – Department of Energy
DPC – Dual Purpose Canister or Cask
HLW - High Level Waste
ISFSI – Independent Spent Fuel Storage Installation
NRC – Nuclear Regulatory Commission
NWPA – Nuclear Waste Policy Act of 1982, as amended
OCRWM – Office of Commercial Radioactive Waste Management
Purchasers – SNF owners and generators, i.e.,Utilities
QA – Quality Assurance
SNF – Spent Nuclear Fuel
Standard Contract – Standard Contract For Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (10 CFR 961)
Standard Fuel – SNF that meets the requirements of 10 CFR 961 Appendix E.A.1.a.

INTRODUCTION

As part of its responsibility under the NWPA, the Department of Energy is in the process of making scientific determinations regarding the suitability of the Yucca Mountain site located in Nye County

Nevada, as a possible Federal repository for the permanent disposal of Spent Fuel and High Level Waste. The SNF and HLW is derived from the operation of domestic commercial nuclear power reactors, and similar government owned material is derived from the nuclear weapons development and Naval reactor programs.

To support this effort, the Department must identify specific waste forms and the characteristics of those wastes that will be placed in the repository so that appropriate radiological, thermal, waste package design and performance analysis can be accomplished. For the commercial nuclear industry the waste form is essentially spent nuclear fuel of various types, configurations, and radiological and thermal properties. Since the NWPA was promulgated in 1982 and the resulting Standard Contracts were established, a significant evolution of the spent fuel waste form has, and is continuing to occur. Changes have taken place in both the fuel cycle and the potential form that a portion the waste that may be delivered to the repository. Additionally, there is a steadily increasing deployment of ISFSIs by utilities as traditional in-plant spent fuel storage pools reach design capacity. Many of these new ISFSI systems are based on the use of dual-purpose canisters/casks (DPCs). DPCs are those systems certified by the Nuclear Regulatory Commission (NRC) for use for storage under 10 CFR Part 72 and transport under 10 CFR Part 71. The use of DPC's allows utilities to load cask/canisters for storage and later, when the Federal repository begins operations, to transport these cask/canisters directly to the repository. It is anticipated that the canister can be shipped without further handling of the individual spent fuel assemblies until they arrive at the Federal repository.

Fuel cycle changes are resulting in increasing fuel burn-ups and the potential for higher thermal output from the fuel assemblies, depending on the length of temporary storage before shipment to the Federal repository. Additionally, many plants are now seeking license extensions to allow up to twenty additional years of operation. These changes will likely affect the repository design parameters, waste-handling infrastructure designs, and many of the activities associated with waste acceptance including transportation. Many of these factors are being considered in developing longer range waste acceptance and repository operating strategies.

STANDARD CONTRACT

The Department has entered into contracts with utilities for the disposal of their SNF. At the time of development of these contracts various obligations were placed on the parties and specific requirements, definitions and other technical details were incorporated in the contract.

However, during the 19 years since the development of these contracts, a number of factors as noted above have occurred that may justify a review of some of the technical components of the contracts. Changes are required to better reflect the present realities of utility operations and fuel management practices, and to address the evolving Federal repository program. One key area of interest is incorporation of dual-purpose canisters now being widely used by the nuclear industry. The definitions in the Standard Contract only considered bare SNF as an acceptable waste form. Canistered SNF is not currently considered an acceptable waste form under the existing Standard Contract. DOE has previously stated that it will initiate appropriate actions to include such systems as an acceptable waste form under the terms of the disposal contracts.

Appendix E of the Standard Contract identifies the general specifications for SNF. DOE has stated that all bare SNF is considered to be acceptable under the contract. The contract categorizes SNF as standard, nonstandard and failed. The differentiating criteria between standard and nonstandard are age and physical dimensions. The effects of the standard and nonstandard fuel categories will be seen in the timing of acceptance of specific spent fuel assemblies. Spent fuel that is classified or qualifies as standard under the contract specifications would be eligible for acceptance by DOE on the schedule proposed by the utility, as long as it is based on an allocation earned under the terms and conditions of the contract. However, spent fuel classified as non-standard may be subject to delayed acceptance. That is DOE can delay the acceptance of a specific nonstandard SNF assembly until technical issues associated with its handling have been resolved.. It should be emphasized that all utility spent fuel will ultimately be accepted for disposal under the contract. The utility would not lose the allocation, but simply may need to offer other utility spent fuel for acceptance under that allocation. Under the disposal Contract, failed fuel is currently treated as nonstandard fuel.

CURRENT STATUS

In recognition of this evolving scenario the Department is initiating its efforts to establish standards that accommodate new waste forms while striving to achieve compatibility of the incoming waste with the emerging repository requirements. Additionally, DOE hopes to provide the utilities and cask industry vendors with information to formulate spent fuel management strategies and for future acquisition and deployment of additional dual-purpose cask/canister storage systems. It is DOE's current expectation that after receipt at the repository all dual-purpose canisters will be opened and individual SNF assemblies will be removed for subsequent placement into the waste disposal package.

In order to accomplish these goals DOE has begun the process of developing information for expanding the "standard fuel" definition to encompass spent fuel housed in dual purpose systems that are consistent with the current repository operational and inventory management strategies and the expected fuel handling capabilities. The focus of this effort is to reflect current industry SNF management practices and to assure that the site performance characteristics can be achieved.

DOE is cognizant of the features of current dual-purpose systems and notes that in some cases system features are evolving in such a manner that could create difficulties in future transport and handling operations. DOE hopes that identifying various interface considerations that must be addressed during repository design and licensing will be helpful in mitigating the potential for future problems.

It should be recognized that the repository design has not been advanced beyond that which is required to support site characterization efforts. Consequently guidance will be continually refined as a result of further site characterization efforts or subsequent facility design and licensing efforts that will be undertaken if the site is approved. However, DOE has tried to identify those types of features or performance parameters that it believes can be helpful for the utilities and vendors while providing the repository designers with necessary design latitudes.

The Department recognizes that the definitions of failed fuel also need further development. Efforts in that area are also underway, but are not yet ready for discussion.

DOE is considering how to proceed with updating these canister definitions and descriptions and other clarifications to accommodate current fuel management practices while still being responsive to future repository waste acceptance needs.

GENERAL CANISTER CHARACTERISTICS

DOE will endeavor to make the repository system compatible with existing and pending transport/storage systems. DOE has surveyed components and features of the population of existing and pending canister and cask transport/storage systems for commercial spent fuel and concluded that generally the system features and characteristics that meet NRC requirements for storage and transport should be compatible with the current repository design. DOE currently believes that the component characteristics shown below will not require additional restrictions beyond the applicable requirements of 10 CFR Part 71 and/or Part 72, which ever governs, if shown to be compliant at the time of acceptance and shipment to the repository by DOE.

- Cladding temperature limits and cladding condition
- Residual water
- Criticality potential
- Solid waste form
- Organic materials
- Canister fill materials
- External surface contamination
- Closure seal
- Internal pressure
- Physical condition
- Materials of construction

PHYSICAL CHARACTERISTICS

Physical characteristics, those that interface directly with the repository handling systems, will be considered in establishing the classification of the waste form.

Multi-element Canisters

Physical envelope considerations for dual-purpose multi element canisters that will be important to sizing of critical waste handling interfaces and establishing compatibility with future disposal requirements include:

- Maximum diameter
- Minimum and maximum length
- Maximum loaded lifting weight
- Handling interfaces including installation of removable handling devices
- Structural capability (as described below)
- Physical access to, and visibility of the canister lid closure welds
- Handling interfaces for empty canisters
- Ability to stand upright without support on a horizontal surface
- Access and visibility of identification marking or labeling.

DOE is seeking to enhance the potential for compatibility of future dual-purpose canisters so that incoming waste and waste canisters will likely be compatible with repository handling systems, support repository inventory management needs, and facilitate other on-site waste storage, preparation, or disposal activities.

It is important to note that DOE will also consider the physical limits for the Transport System, as shown in Table 1, when actions to include dual-purpose cask/canister systems as waste forms under the Standard Contract are initiated.

Multi-element single purpose casks and /or canisters (i.e., those certified by the NRC for storage only) if subsequently certified by the NRC for one-time shipment will be considered for acceptance. DOE will consider these systems on a case by case basis. The Purchaser should ensure that these systems or components satisfactorily demonstrate that once certified for a single use shipment, they can be shipped without imposing special operating conditions or restrictions, or requiring special movement considerations that are significantly beyond those associated with other dual purpose systems. These canisters must also be suitable for use at the Federal repository as noted below. As with dual purpose systems, it is DOE's current expectation that after receipt at the repository any single purpose system will be opened and individual SNF assemblies, or individually canned fuel assemblies housed in a multi-element canister removed for subsequent placement, into the waste disposal package.

Single-element Disposable Canisters

DOE would like to be able to disposes of single element canisters without subsequent reopening and repackaging. They may be considered disposable if certain requirements are met when it arrives at the Federal repository. Physical characteristics that are important for single element non-sealed (screened-end) canisters are similar to those shown for multi-element canisters. It is again assumed that several of the characteristics that are suitable for the transport environment at the time of shipment would be satisfactory as noted. Additionally, since the canister would become part of the waste package, additional features such as materials of construction may need to be considered. It should be noted that the canister-handling interface should mirror that of an equivalent bare undamaged fuel element.

For single element sealed canisters, additional characteristics may also be considered beyond the physical characteristics noted above. Since any additional materials included in the sealed environment of the single element canister are expected to interact directly with the disposal packaging, other characteristics may be important to satisfactorily assure performance in the disposal mode. These additional areas of consideration may include:

- Limits on free and chemically bound water
- Sealing method and seal integrity verification
- Backfill pressure and gas
- Presence of RCRA Subtitle C wastes
- Presence of fill other than spacers or non-fuel components
- Presence of combustible, explosive or chemically reactive materials and H_2 vol %

It is expected that the single element canisters would be shipped to the repository along with other bare spent fuel or housed in a dual-purpose multi-element canister or cask system. Since this type of canister would be used for failed fuel, it may be subject to other NRC requirements not specifically identified herein.

CANISTER STRUCTURAL CAPABILITIES

As part of the site characterization and qualification efforts the NRC has established in 10 CFR 63 a maximum radiation dose allowable at the site boundary of 5 rem. In order to meet this limit, DOE must develop handling requirements that provide assurance that even in the most severe case of handling mishap this exposure limit will not be exceeded. For commercial spent fuel, DOE currently expects that a canister drop during handling would represent the worse credible accident scenario. With the current facility design, the accident scenario may include a canister drop of 23 ft. onto its bottom surface and a 2 ft. drop in any orientation on an unyielding surface. The specifics of the drop scenario and dose assessment models are still being developed. As this area progresses, further information will be made available. The radiological consequences of the drop scenario will be considered when classifying a canister system. It should be noted that these scenarios are expected to evolve consistent with the maturity of the facility designs.

SPENT FUEL RETRIEVABILITY

It is essential that the spent fuel assemblies and single element canisters, sealed and screened end, retain sufficient structural integrity after storage and transport to allow retrieval with normal fuel handling grapples for subsequent loading into the waste disposal package. DOE would prefer that reasonable efforts be made to preclude further degradation of the cladding during storage and transport. Again, it should be noted that these considerations are expected to evolve consistent with the maturity of the facility designs.

CANISTERS SUITABLE FOR USE AT THE FEDERAL REPOSITORY

The DOE anticipates the need to provide adequate dry storage of spent fuel at the Federal repository that would support inventory management needs. These needs can include thermal management where some SNF may require aging to reduce it's thermal signature consistent with disposal temperature strategies. Also storage may be required to provide sufficient surge capacity when acceptance and emplacement rates differ, or to deal with unanticipated off-normal operations in the repository surface or sub-surface facilities. Therefore, for DPC, canisters or casks, or specially certified SPC canisters, to be considered standard they must also be certified under 10 CFR Part 72 for use at the Federal repository site. This assumes that adequate site preparation has been completed, and the appropriate storage over-packs, if applicable, and compatible site handling equipment are available.

Cask Physical Characteristics		"Standard Cask" Envelope Limits	
		LWT – Truck	**Rail**
With Trunnions, and Impact limiters	Length (inches)	268	340
	Diameter (inches)	96	128
	Length (inches)	224	233
	Diameter (inches)	48	103
Suitable for in-pool operations Cask must be provided with suitable Drains/vents to allow cask cool down Prior to opening the outer closure , and Draining/drying after removal from the handling pool.		Bare/SEC	Bare/SEC/DPC/SPC
Cask and Transport Vehicle		Length < 60'-0" Height < 13'-6" Width < 8'-0"	AAR (1992) Plate B or C
Surface Contamination		49 CFR 173.443	
Maximum Internal Presure		Maximum operating pressure permitted by the CoC	
Lifting and Handling		• Trunnion sets shall permit lifting in Vertical and horizontal orientaions • Lifting devices meet NUREG-0612 And ANSI N14.6 • Lifting features compatible with remote attachment and removal • Fasting bolts shall be captured with Spring-return and crossthread-prevention	
Loaded lifting weight (tons) Note that weights include impact limiters for truck and rail systems and inter-modal handling skids for rail systems.		27	200

Table 1 – Transportation system physical envelopes that will be considered "Standard"