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United States Department of Energy

National Spent Nuclear Fuel Program

Guidelines for Meeting Repository Requirements for Disposal of U.S. Department of Energy Spent Nuclear Fuel (Draft)

September 1998

U.S. Department of Energy
Assistant Secretary for Environmental Management
Office of Spent Fuel Management and Special Projects

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Prepared for the
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DOE Idaho Operations Office

ABSTRACT

This document provides the process and guidelines by which custodians of the Department of Energy (DOE) spent nuclear fuel (SNF) can prepare that fuel for shipment to a national repository. The process and guidelines presented herein are derived from requirements of the Code of Federal Regulations, preliminary requirements developed by the Office of Civilian Radioactive Waste Management (OCRWM), and operational requirements of the Savannah River Site (SRS) and the Idaho National Engineering and Environmental Laboratory (INEEL) Chemical Processing Plant (CPP).

EXECUTIVE SUMMARY

The United States Department of Energy (DOE) has a legal obligation to dispose spent nuclear fuel (SNF) generated by commercial reactors of the United States. The DOE is actively pursuing development of a national repository at Yucca Mountain (YM) in Nevada to meet this obligation. By agreement between various parties, SNF generated by the DOE in research and development (R&D) and defense-related activities will also be placed in YM at the same time as commercial SNF.

The organization within DOE responsible for developing YM and defining the requirements for SNF to be placed in YM is the Office of Civilian Radioactive Waste Management (OCRWM). The Nuclear Regulatory Commission (NRC) will be the agency to license operation of YM and will be the ultimate decisionmaker on the adequacy and completeness of the requirements for SNF disposed in YM. This document has been developed by the National Spent Nuclear Fuel Program, a part of the DOE Environmental Management (EM), to identify these SNF disposal requirements, and to define a process by which DOE SNF custodians can prepare the SNF for disposal.

A number of requirements and regulations in the Code of Federal Regulations (CFR), (primarily 10CFR60) provide direction for preparing DOE SNF for disposal. However, the requirements are often too general and do not provide specific directions to a custodian preparing fuel for disposal. OCRWM is preparing a requirements document but has not made it specific to particular DOE fuels. They have not developed prescriptive requirements to implement the general requirements and regulations existing in the CFR. The objective of this document is to develop, working closely with OCRWM and NRC, a Guidance Document that is more prescriptive regarding particular regulations and particular DOE fuels.

The purpose of this document is to:

X Identify and present requirements of the OCRWM, DOE EM, and the NRC regarding acceptance of DOE-owned SNF into a national repository.

X Identify a process by which present custodians of DOE SNF can prepare it for transport and acceptance into a national repository.

X Define the form and contents of the package transferred to a national repository. This package, the “Repository Package,” shall consist of the physical canister where the SNF resides and the documentation package accompanying the SNF.

This document attempts to very prescriptively define one process by which SNF can be satisfactorily prepared for disposal. The suggested processes for characterization of individual fuel parameters are not meant to be restrictive. SNF custodians are free to prepare SNF for disposal in a more effective manner, and are encouraged to pass on that process to others within the DOE complex. This document also attempts to focus on characterization requirements that are presently unclear, in order to concentrate the effort of the DOE and the scientific/engineering community toward standard characterization procedures.

This document also identifies the DOE-owned spent nuclear fuels requiring preparation for disposal, the location and custodians of those fuels, and an initial evaluation of the processes required to prepare those fuels for disposal. This document is expected to be a living and transitional document for some period of time since many of the requirements and regulations governing the disposal preparation process are still being developed. The operating procedures for YM are still being formulated as well as many of the legal issues associated with its operation. Thus, a number of places in the document are labeled "To Be Determined (**TBD**)."

ACKNOWLEDGMENTS

This document represents a collection of expert advice and comment on a number of subjects pertinent to the preparation, storage, transportation, and disposal of spent nuclear fuel. The author is thankful for the effort exerted by the following people in the preparation and review of this document.

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ACRONYMS

ALARA	as low as reasonably achievable
CPP	Chemical Processing Plant
CRD	Civilian Radioactive Waste Management System Requirements Document
DIS	Mined Geologic Disposal System Draft Disposability Interface Specification
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
EM	DOE Environmental Management
EOL	end of life
FRR	foreign research reactor
HEU	highly-enriched uranium
HLW	high-level waste
HR	Hanford Reservation
INTEC FAC	Idaho Nuclear Technology and Engineering Center Fuel Acceptance Criteria
INEEL	Idaho National Engineering and Environmental Laboratory
LLNL	Lawrence Livermore National Laboratory
LOFT	Loss of Fluid Test
NDA	nondestructive assay
NDE	nondestructive examination
NRC	Nuclear Regulatory Commission
NSNFP	National Spent Nuclear Fuel Program
NWPA	Nuclear Waste Project Act
OCRWM, RW	Office of Civilian Radioactive Waste Management
ORNL	Oak Ridge National Laboratory
PA	performance assessment
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
QARD	Quality Assurance Requirements and Description
R&D	research and development
RW	Office of Civilian Radioactive Waste Management
SNF	spent nuclear fuel
SRS	Savannah River Site
TBD	to be determined
TBV	to be verified
YM	Yucca Mountain

Guidelines for Meeting Repository Requirements for Disposal of U.S. Department of Energy Spent Nuclear Fuel

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to:

- X Identify and present requirements of the Office of Civilian Radioactive Waste Management (RW), DOE Environmental Management (EM), and the Nuclear Regulatory Commission (NRC) regarding acceptance of United States Department of Energy Spent Nuclear Fuel (DOE SNF) into a national repository.

- X Identify a process by which present custodians of DOE SNF can prepare it for transport and acceptance into a national repository.

- X Define the form and contents of the package transferred to a national repository. This package, the "Repository Package," shall consist of the physical canister where the SNF resides and the documentation package accompanying the SNF.

Processes identified herein are not meant to be the only acceptable ones for preparation, storage, transportation, and acceptance of SNF to a national repository. This document was developed to provide information and guidance on the waste acceptance criteria for a national repository and provide at least one acceptable fuel characterization path for DOE SNF custodians.

1.2 Scope

This document addresses requirements associated with all SNF in the DOE inventory and specific requirements associated with particular SNF in DOE laboratories or SNF storage locations for which DOE has some type of financial, contractual, or policy-directed interest. Appendix A is a list of the SNF covered, its present location, and the planned location for short-term storage under the Record of Decision "Alternative 4(A), Regionalization by Fuel Type," as modified by the court order (Settlement Agreement, Civil No. 91-0054-S-EJL, October 17, 1995), and the Modified Record of Decision for the Programmatic SNF Management and INEEL Environmental and Restoration and Waste Management Programs issued March 1996. This document does not address Navy fuel.

1.3 Drivers and Justification

The Department of Energy is required, by various legal and policy directives, to minimize risk associated with storing DOE-owned SNF. The DOE SNF is to be emplaced in a national repository (at which time and place, it is implemented) along with the commercial SNF and high-level waste which the DOE must also dispose.

This document is designed to set forth a clear set of requirements and procedures based on the CRD for preparing DOE SNF for acceptable disposal in a national repository, since DOE SNF is so different from commercial SNF. The regulations and requirements for compliance are presented in the tables and appendices of this document.

1.4 Characterization and Certification

Procedures outlined in this document are focused on two primary activitiesXcharacterization and certificationXsince they constitute the bulk of the work to be performed.

Characterization is the activity associated with gathering or producing data that define the fuel. These characterization parameters include physical data such as pedigree, weight, dimensions, material content, etc.

Certification of the fuel is the process of documenting and verifying that the fuel, as determined through the characterization process, meets requirements for disposition into a national repository.

Sections 3 and 4 describe particular data need areas, regulatory requirements that influence that data, and a brief description of how requirements are to be satisfied. Specific processes employed to comply with the regulations are described in the associated sections of the Appendices. Discussion and justification of various regulations and requirements are also found in the associated Appendices.

1.5 Organizational Interfaces

The DOE-EM is responsible for safely, effectively, and efficiently storing the current and future inventory of DOE SNF and returned foreign research reactor (FRR) SNF, and preparing them for disposal. Through EM, the Idaho National Engineering and Environmental Laboratory (INEEL) has been designated as the lead laboratory for the National SNF Program (NSNFP), receiving direction from the DOE Idaho Operations Office (DOE-ID) and the DOE Office of Spent Nuclear Fuel Management (EM-67). In this role the NSNFP is challenged to determine the necessary long range solutions for emplacement of DOE SNF in a the geologic repository. The NSNFP is leading an aggressive effort to coordinate with RW and Yucca Mountain site characterization on requirements, schedules, and characterization needs. NSNFP coordinates and integrates activities between major DOE sites (INEEL, Hanford, SRS, and ORNL), RW, and the NRC. The NRC is the ultimate regulator of Yucca Mountain. NSNFP interaction with the NRC is worked in conjunction with RW. The NSNFP is working with RW to develop the minimum set of repository data requirements and acceptance criteria for DOE SNF. The relationship between EM and RW technical baseline documents for DOE-SNF are depicted in Figure 1-1.

SitesXThe major SNF sites are responsible for managing SNF program activities at their various locations to ensure safe existing storage, to achieve secure interim storage, and to prepare SNF for disposal in a geologic repository or interim storage facility. The sites are responsible for gathering data and

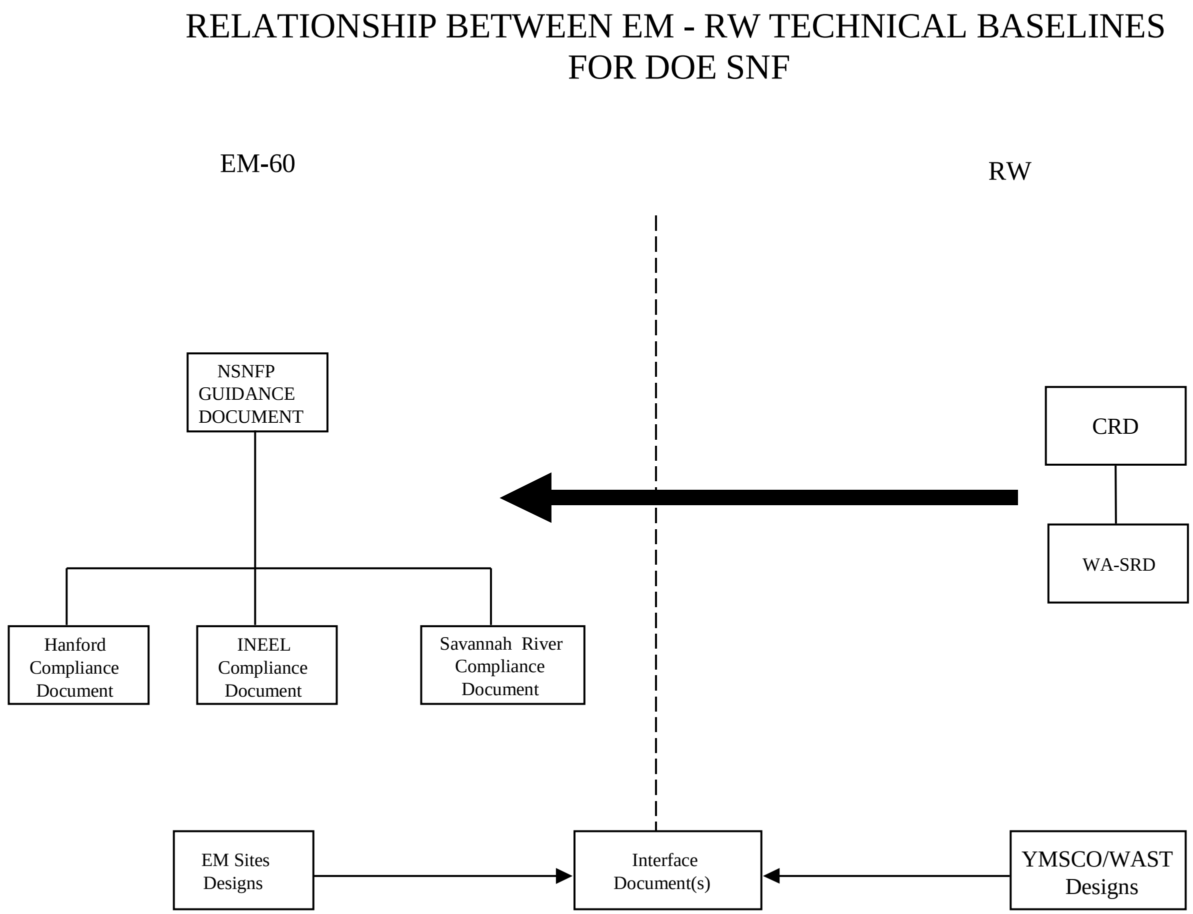

Figure 1-1. Relationship between EM-RW technical baselines for DOE-SNF.

performing characterization on their fuels to ensure that they meet the quality requirements necessary for final disposal. In this role the sites will work with the NSNFP to ensure that the data collected in these activities meets applicable acceptance criteria and quality requirements, is presented in a timely and consistent manner, and is acceptable by RW and the NRC.

Quality AssuranceXThe National Spent Nuclear Fuel Quality Assurance (QA) Program is responsible for the method by which DOE sites will qualify to RW-0333P QA requirements. Further QA roles are discussed in Appendix E.

RWXRW is responsible for the construction, operation, and, through the NRC, licensing of Yucca Mountain. RW will, in conjunction with the NSNFP, develop data needs and requirements necessary for incorporation of DOE SNF into applicable repository documentation, qualification of DOE SNF for repository disposal, and acceptance of this fuel for disposal into a geologic repository. RW will work with the NSNFP to develop the approaches for resolving DOE SNF disposal licensing issues.

2. FUEL CERTIFICATION PROCESS CHECKLIST

The ultimate goal of this document is to define the steps required to prepare DOE SNF for shipment to and acceptance into a national repository by providing guidance in carrying out the processes required to implement the aforementioned steps. This section provides a sample checklist of suggested steps and provides direction toward other portions of the document that define and elaborate on completing those steps. DOE SNF sites should use or modify this list to match their individual needs.

Section 3, 4, and the Appendices contain details on the characterization and certification process, regulations and requirements controlling the process, and definitions of terms associated with the process. This document does not provide specific guidance for transportation or interim storage. Therefore, it is recommended that the latest guidelines for interim storage and transportation be obtained and reviewed for any possible conflict with the process and procedures presented in the document (due to some change in the interim storage or transportation requirements since the completion of this document). ***Section 3, 4, and the Appendices should be read before starting on the following process checklist. If the guidance or procedures presented in this document are not applicable to a particular fuel, contact the National Spent Nuclear Fuel Program.***

1. Compile fuel identification records and certification documentation.
   [See Section 3 for requirements, Appendix B for data form, and Appendix E for data collection]

2. Compile fuel operational history (for use in various certification calculations).
   [Use Table in Appendix B]

3. Determine size of standard canister needed to physically store fuel.
   [See Appendix C for options. Check for updates in amount of fissile material allowed per canister and changes in transportation requirements that might impact canister loading weights or materials]

4. Select a packing configuration that makes most efficient use of canister volume.
   [See Appendix C for guidelines in efficient and criticality-related packing]
   [See Section 4.2.1.1 for maximum weights]

5. Perform criticality evaluation of selected packing configuration.
   [See Section 4.2.2.3 for evaluation guidelines]

6. Perform thermal analysis of packing configuration.
   [See Section 4.2.2.2 for thermal limits on individual canisters and evaluation process]

7. If criticality evaluation or thermal analysis is outside bounds, modify packing and return to step 3.

8. With ORIGEN (or equivalent) code, calculate isotope inventory of fuel contained in canister.

   8.1 Document QA pedigree of code per applicability of code to analysis of particular fuel under evaluation. (Section 5 and Appendix E).

   8.2 Verify that isotope inventory is within acceptable bounds. [Section 4.2.2.4]

9. Review Table 3.2 for compliance with all criteria and requirements.

10. Load SNF in canister per final calculated configuration. [photograph and video tape packaging processXone photo per additional SNF unit]

11. Place temporary seal cap on canister (if necessary to move prior to seal welding).

12. Verify radiation level of canister at surface and at 3 feet.
    [See Section 4.2.2.1] If out of bounds, return to step 4.

13. Verify thermal output of canister.
    [See Thermal Output Evaluation Procedure in Section 4.2.2.2] If out of bounds, return to step 4.

14. a) Remove temporary seal, b) replace with permanent seal, and c) weld.
    [See Appendix C for sealing directions)

15. Verify identification number on canister and matching number in data package.
    [See Table 3.5 for references and directions for identification]

16. Store canister and file data package. [see QA Section 5 for storage requirements]

17. Consult transportation authorities at National Spent Nuclear Fuel Program or the RW transportation coordinator for latest information on transportation requirements and schedule.

3. CHARACTERIZATION AND CERTIFICATION PROCESS

The characterization and certification process described in this document addresses only those RW requirements for which additional guidance may be required, over and above that in the Civilian Radioactive Waste Management System Requirements Document (CRD, Reference 1).

Specific and general requirements for SNF to be accepted into a national repository are still being formulated. Data needed to satisfy these requirements are identified in Table 3.1, along with the regulations setting the requirement. These data are defined in the draft Disposability Interface Specification (DIS, Reference 26), the OCRWM Data needs document (Reference 11) and various sections of the Code of Federal Regulations (CFR).

In addition to information required for the data package, requirements exist for the physical package/canister structure in which the SNF is transported for disposition. Guidelines for providing an NRC-approved canister for the SNF are provided in Section 3.3. Guidance for transportation of the canister must be obtained from <**TBD**>.

3.1 Data Package

The data package portion of the qualified fuel package has the forms in Appendix B filled out to the appropriate level for each fuel. The process by which the fuel is characterized, and data obtained for the data forms, is illustrated in Figure 3.1.

Table 3.1. Data needs for SNF acceptance.

SNF Data		Requirement Source
1.	**Description**	
1.1	Source	10CFR961, CRD, DIS
1.2	Operating History	CRD, DIS
1.3	Drawings	CRD
1.4	Dimensions	CRD
1.5	Weights and Materials	CRD, DIS
1.6	Physical Condition	CRD, DIS
1.7	Identification Tags	10CFR60; CRD, DIS
2. Physical and Chemical Characteristics		
2.1	Particulate	10CFR60; CRD, DIS
2.2	Pyrophoric, Combustible, or Explosive	10CFR60; CRD, DIS
2.3	Criticality Evaluation	10CFR60, CRD, DIS
2.4	Free Liquids	10CFR60; CRD, DIS
2.5	Gas Generation	10CFR60; CRD, DIS
2.6	RCRA Materials	CRD, DIS
2.7	Material Compatibility	10CFR60; CRD, DIS
2.8	Organics	CRD, DIS

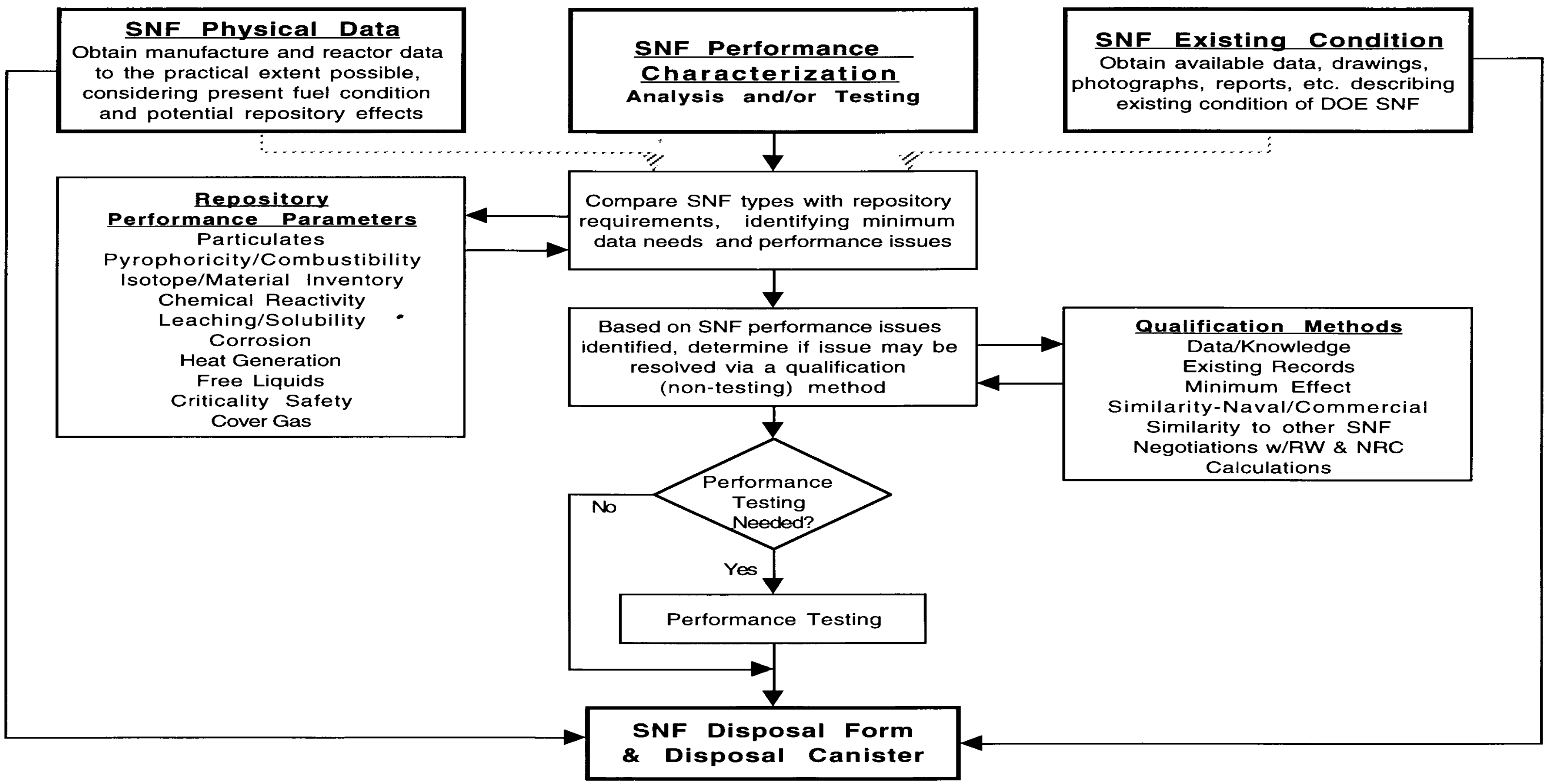

Figure 3.1. Characterization process.

Data needs shown in Table 3.1 are top level requirements. Specific data and methods needed to fulfill requirements of Table 3.1 are identified in Table 3.2, with description and justification for data given in Section 3.1.1.

Figure 3.1 illustrates the process by which the repository package preparation process is completed, both for the data package and the physical package (the Repository Package).

The first activity in preparation of the Repository Package is the collection and recording of basic descriptive data on the fuel, its material, history, composition, and physical state. The form for documenting this information is in Appendix B. The quality level and process for collecting these data are described in Appendix E.

The next major activity in the data package portion of the Repository Package is to provide information on particular fuel requirements unique to the repository, such as “No Free Liquids,” information on isotopes leaching, particulate fuel, etc. Information requirements for each fuel in the DOE inventory are supplied in Appendix A. Figure 3.1 is a visualization of the process by which this information is obtained.

Four different processes are available to qualify fuel for repository acceptance. The varied nature of DOE SNF impacts the need to collect physical and documentary information in a variety of methods. For example, if the fuel in question is reactive, the first process by which the fuel may be allowed into the repository is by showing that its being there, even if reactive, will have a minimal effect on the repository. This information would be gained by determining this fuel=s particular effect on the repository as part of the performance assessment (PA) of the repository. If it is impossible to calculate or deduce from the PA that this particular reactive fuel has a minimal effect on the repository, it may be possible to prove from existing scientific data or knowledge that it is not a threat to the repository. If data is unavailable, the next possible step is to compare the fuel in question to other characterized and acceptable fuels, such as commercial or Navy fuel. Appendix A includes a listing of different fuel groups (Table A.1) and each fuel in the DOE SNF inventory is referenced to one of these fuel groups (see Table A.2).

The last certification process listed is a physical test on the fuel, because it can potentially be costly and time consuming, but not necessarily the most expensive. A simple nondestructive assay/nondestructive evaluation (NDA/NDE) test or a simple physical test could be less costly than a long study and calculational procedure. Serious evaluation of alternatives should be made of all available processes prior to selecting any one (or a combination) for the certification process.

The above procedure is continued until a certification process is found to satisfy the particular repository requirements relating to that fuel. If no defined certification process is adequate, RW and the NRC must determine an acceptable process to satisfy the licensing requirements.

Following completion of the data portion of the repository package, the physical canister must be prepared. This preparation process consists of physically placing the fuel into appropriate canisters that satisfy transportation, storage, and repository requirements such as weight, thermal load, radiation levels, and criticality margins. These canisters will be inserted into waste packages at the repository for disposal. They are not designed to be emplaced into the repository “as is.”

Table 3.2. DOE SNF acceptance criteria, requirements, and compliance methods.

Criteria	Requirements/Limits	Compliance Method
1. Description		
1.1 Source 10CFR961.11 10CFR60.21(c)(5) CRD 3.3.E.3 CRD 3.6.1.3.C DIS 2.1.1	Provide information on production of SNF and the facility where it was irradiated.	Provide requested data on form provided in guidance document. (Appendix B)
1.2 Operating History 10CFR60.21(c)(5) 10CFR60.71(b) 10CFR72.72(a) CRD 3.3.E.3 CRD 3.6.1.3.C DIS 2.1.2	The operating history of the SNF is required in order to calculate burnup and isotopic inventory.	Provide validated operating history. Backup method is to supply validated total burnup of SNF.
1.3 Drawings 10CFR60.21(c)(5) CRD 3.3.E.3 CRD 3.6.1.3.C DIS 2.1.1	Provide drawings of SNF and shipping geometry sufficient to describe package and contents.	Provide information as described in guidance document (Appendix B)
1.4 Dimensions 10CFR60.21(c)(5) CRD 3.3.E.3 CRD 3.6.1.3.C DIS 2.2.20	Provide dimensions of SNF and shipping containers sufficient to describe package and contents.	1. Provide dimensions as requested per guidance document or 2. Indicate required dimensions on drawings . (Appendix B)
1.5 Weights & Materials 10CFR60.21(c)(5) CRD 3.3.E.3 CRD 3.6.1.3.7.2.C DIS 2.1.1 DIS 2.1.4	Provide weights of SNF and packaging sufficient to describe total weight and weight distribution of package. List materials contained within the SNF and SNF package. Identify materials making up at least **<TBD>** wt %, or **<TBD>** kg (which ever is greater), of total package. No RCRA materials should be present.	Provide requested data on indicated form in guidance document. Data can be from actual weighing or calculations. Provide list of materials on indicated forming guidance document. Reference to data satisfying RW-0333P shall be provided or, where qualified data is not available, a statement as to range of data provided. (Appendix B)
1.6 Physical Condition CRD 3.3.E.4 DIS 2.1.4.1 DIS 2.1.4.3 DIS 2.1.28	Provide a description of the physical state of the SNF, i.e., intact, breached clad, broken, corrosionXlight, severeXetc.	Provide the requested description on form in guidance document. (Appendix B)

Table 3.2. (continued).

Criteria	Requirements/Limits	Compliance Method
1.7 Identification Tags 10CFR60.135(b)(4) 10CFR70.51(e)(1)(i) CRD 3.6.1.3.5.E CRD 3.3.E.4 DIS 2.1.26	Provide a unique identification number or tag on each SNF container.	Provide a record in the data package which documents the type, format, and location of the identification tag on the SNF canister.

2. Physical and Chemical Characteristics

2.1 Particulate 10CFR60.135.c.1 10CFR60.135.c.2 CRD 3.6.1.3.5.A CRD 3.6.1.3.5.B.1 CRD 3.6.1.3.5.B.2 DIS 2.1.23 DIS 2.1.23.1 DIS 2.1.23.2	Particulate fuels of a size <(**TBD**) must be consolidated. SNF shall be in a solid form.	Indicate process by which particulate fuel has been stabilized. See Appendix D.1 for stabilization procedure. Provide documentation that SNF is not a liquid or gas. One option may be to seal material in a special high integrity container (HIC). The HIC is presently under development.
2.2 Pyrophoric, Combustible or Explosive 10CFR60.135.a.2 10CFR60.135.b.1 10CFR60.135.c.3 CRD 3.6.1.3.5.A CRD 3.6.1.3.5.B.3 CRD 3.6.1.3.5.D.1 DIS 2.1.24 DIS 2.1.25	Materials that can self-ignite under repository conditions (**TBD**) and cause loss of function (**TBD**) to the repository, may not be deposited. Materials that can explode or undergo rapid oxidation under repository conditions (**TBD**) and cause loss of function (**TBD**) to the repository, are forbidden.	Provide evidence that SNF is either a) nonpyrophoric by nature or b) has been treated to be nonpyrophoric, or will not adversely affect the repository. Provide evidence that SNF is either a) noncombustible by nature or b) will not burn in known repository conditions, or will not adversely affect the repository. See Appendix D.2 for procedure.
2.3 Criticality Evaluation 10CFR60.131.b.7 10CFR71.55 CRD 3.6.1.3.5.A CRD 3.6.1.3.5.C DIS 2.3.22	Canisters must be loaded such that k_{eff} is less than 0.95 for all conditions other than two unlikely, and concurrent or sequential, changes have occurred in the conditions essential to nuclear criticality safety.	Provide analyses to show that criticality requirements are met under (**TBD**) repository conditions.
2.4 Free Liquids 10CFR60.135.b.2 CRD 3.6.1.3.5.A CRD 3.6.1.3.5.D.2 DIS 2.1.21 DIS 2.1.22	Free liquids are not allowed in a container in an amount **(TBD)** that can cause loss of function (**TBD**) to the repository.	Subject SNF to a standard drying procedure (as described in Appendix D.4), or show by test or record that SNF contains no free liquid.

Table 3.2. (continued).

Criteria	Requirements/Limits	Compliance Method
Criteria	**Requirements/Limits**	**Compliance Method**
2.5 Gas Generation 10CFR60.135.a.2 CRD 3.6.1.3.5.A CRD 3.6.1.3.6.A DIS 2.4.23 DIS 2.4.24	Gas generation is not allowed in the repository to the point where function of the repository is degraded. (The level of this function is **TBD**.)	Provide data or calculations to indicate that SNF will not degrade repository function through gas generation.
2.6 RCRA Materials CRD 3.6.1.3.5.A CRD 3.6.1.3.6.B Memo: Dreyfus to O=Leary, 6/22/95 DIS 2.1.29	No RCRA materials are to be deposited in the repository.	Provide documentation that no RCRA material is contained in the SNF canisters or fuel elements.
2.7 Material Compatibility 10CFR60.135.a.2 CRD 3.6.1.3.6.C DIS 2.1.20	SNF shall be compatible with the planned environment of the repository (**TBD**) and not react with the containment structure or any other material contained within the waste package.	Provide data or calculations to indicate that SNF will be compatible with repository environment and not react with other materials within the waste package.
2.8 Organic Material CRD 3.6.1.3.6.A.3 DIS 2.3.23	No organics at levels that compromise the repository safety.	Provide documentation that any organics have been stabilized or contained to meet requirement.

3.1.1 Description of Data Needs

A brief description of each of the data needs of Table 3.1 follows:

SourceXThis data describes where the fuel was made and where it was irradiated.

Operating HistoryXThis describes the operating history of the fuel that modified the original materials in the fuel and produced new materials. The operating history should be of sufficient detail that an ORIGEN (or equivalent) computer evaluation can be made of the fuel and its operating history.

DrawingsXEngineering drawings of the fuel as it is to be submitted to the repository.

DimensionsXDimensions of the fuel. If this information is available from the drawings, refer to the drawings.

Weights and MaterialsXWeights of the primary components of the fuel. This information will be used to determine the total inventory of particular materials within the repository.

Physical ConditionXA brief description of the physical condition of the fuel is required by repository managers to assess correct packaging procedures. The description should include condition of cladding, geometric changes, corrosion level, etc.

Identification TagsXNRC requires identification of stored nuclear material such that its identity can be checked and verified at any point in the storage process. If any repackaging or rearrangement of packages/sub-packages occur as part of the path to the repository, identification of each movable canister will require identification traceable to the contents of that package.

3.1.2 Physical and Chemical Characteristics

This section presents data for repository managers to determine the total inventory of various materials as well as the existence of controlled materials.

ParticulateXParticulate fuels are not permitted in the repository. Fuels must be solid. The size at which fuel is classified as particulate is <**TBD**>. The information data package for a fuel submitted to the repository shall address the process by which the fuel is contained if that fuel has a (TBD) % by weight of material less than <**TBD**> in diameter.

Pyrophoric, Combustible or ExplosiveXAny fuel that has the propensity for or the possibility of self-igniting in the repository shall be identified and safeguards taken for dealing with this possibility. Any fuel that is combustible (such as the graphite fuels) shall be shown to not be in danger of combusting and compromising the effectiveness of the repository, given the conditions under which the repository is projected to operate. The process for characterizing reactive fuels is described in Section 4.1.2.2.

Criticality EvaluationXThe entity submitting an SNF package for deposition in the repository shall provide calculations validating the criticality safety and margin of safety of the submitted package. Guidelines for generating this validation calculation are given in Section 4.1.2.3.

Free LiquidsXFree liquids are limited to an amount "which will not adversely affect the behavior of the repository." This amount is presently being determined. Guidelines for dealing with free liquids are provided in Section 4.1.2.4.

Gas GenerationXThis information states whether there is any potential for the submitted SNF to generate gas over the confinement period. The conditions under which this gas generation would be expected, the amount expected, and possible consequences of the generation should be stated. Guidelines for characterizing a fuel relative to gas generation are provided in Section 4.1.2.5.

RCRA MaterialsXNo RCRA material is presently allowed in the repository. Discussions are in progress which might allow a minimum amount of some RCRA materials. No information is available at present on which elements or what the minimum quantity might be.

CompatibilityXIf there is some incompatibility between a fuel and its packaging material, the expected temperature or humidity level in the repository, or some condition expected to exist in several hundred years, it is important that repository managers have this information for planning and using in the performance analysis.

OrganicsXThis information describes the process by which any organic material has been stabilized to meet the requirements of not compromising the repository. This can be in the form of treatment (oxidation, removal) or containment in a separate container.

3.2 Process For Producing Certification Data

The next step is to determine if the data required is available and sufficient to the certification task. If it is available, this data is provided in the form presented in Appendix B.

If the data is unavailable, or insufficient for the repository acceptance requirements, an acquisition process to obtain it must be initiated. The data acquisition/certification process may be satisfied by one or more of the paths listed in Table 3.3.

The certification processes below are not meant to be mandatory or all-inclusive. If an individual SNF custodian can identify a process to certify compliance of their SNF to the requirements, the custodian will need to qualify that process with EM and NRC.

Table 3.3. Methods for Certification of Data.

1. Provide published data relative to the requirement in question.

2. Compare fuel with acceptable commercial fuel or with another fuel type.

3. Calculate required information

   (a) Calculations that generate required data or information

   (b) Show by calculation or comparison that fuel has a noncompromising effect on the repository,

   (c) Bounding calculation. or logic acceptable to RW and NRC, that fuel will not have an unacceptable effect on the repository

4. Test or physically treat fuel to satisfy requirement.

3.2.1 Certification Methods and Approach

The several methods, as listed in Table 3.3, by which a fuel can be certified for acceptance to a national repository, are described below. One or more of these methods may be used and the most applicable method(s) will depend on the individual fuel.

3.2.1.1 Provide Published Data Relative to the Requirement in Question. This method is suggested for use in satisfying requirements where there are relative data, studies, and documentation that may not be fuel or even nuclear related, but are relative to a particular requirement. Examples of this might be corrosion rates of stainless steel, or the combustibility of graphite. Unless some particular aspect of the fuel=s nuclear-related history changes a basic behavior, similar related data or documentation can be used.

3.2.1.2 Compare Fuel with Acceptable Commercial Fuel or with Another Fuel Type. This method is used when a particular DOE SNF element is expected to behave as if it were just another commercial fuel rod. Examples of this are fuel rods from various commercial reactor fuels that the DOE has taken and tested for different reasons, and which are now stored in DOE custody, the LOFT test assemblies, which are just shortened PWR design rods, as well as other fuels which, in their simplest forms, are just zircaloy-clad uranium oxide rods.

Fuel grouping, to identify one fuel as a member of a particular group, and then characterize that fuel, decreases the total number of fuels to be classified. An example of using this method would be in the case of **TBD**, where this fuel is very similar to **TBD** regarding leachability and would therefore be included in the same group as **TBD**, and not requiring separate testing to determine leaching characteristics.

A study has been made and a report issued on the different grouping of DOE SNF and the specific characteristics of each group (Henry Loo, et. al., EM/RW Repository Task Team Report: *Grouping Method to Minimize Testing for Repository Emplacement of Department of Energy (DOE) Spent Nuclear Fuel (SNF)*, National Spent Nuclear Fuel Program, Idaho National Engineering and Environmental Laboratory, DOE/SNF/REP-008, 1997).

3.2.1.3 Calculate Required Information. This method consists of performing calculations or studies which generate or show the data or information required. There are three ways in which this method can be implemented, depending on which is the most applicable to the parameter.

3.2.1.3.1 Calculations Generating Required DataXThis method is recommended where sufficient information and accepted calculational processes are available to produce, through analyses, data required to satisfy a particular repository requirement. Examples of this method would be using ORIGEN to calculate isotopic inventory of a fuel as a result of its burnup history and using nuclear criticality codes to determine criticality safety of the fuel.

3.2.1.3.2 Calculations or Comparisons Showing Fuel Has a Noncompromising Effect on RepositoryXThis method requires that it be shown, through calculation, comparison, or acceptable logic, that a particular fuel has a minimal negative effect on the behavior of the repository. A minimal negative effect is defined as an unfavorable change of more than **TBD** in any parameter on which the behavior of the repository is defined (temperature, humidity, radiation level, etc.). This effect may be calculated and reviewed (by an acceptable process) consistent with the tools used for the PA and by the cognizant PA personnel performing the analysis.

3.2.1.3.3 Bounding Calculations (or Logic Acceptable to RW and NRC) Showing Fuel Will Not Have an Unacceptable Effect on RepositoryXThis method is somewhat different from the previous one. The effect may not be minimal, but it is an acceptable effect on the repository. This method is used when the exact value of a fuel parameter is unknown, and when it can be shown that the maximum (or minimum) possible value of this parameter does not present a problem to the repository. An example of this method may be when the exact burnup of a fuel element is not known. A bounding calculation can be made with the maximum possible burnup relative to isotope and fission product inventory, while for the same fuel, a zero burnup could be used for criticality calculations.

3.2.1.4 Test Fuel to Obtain Required Data. This procedure should be considered the method of last resort because of cost and time requirements. While there might be instances where a simple test would be quicker and cheaper than an analysis (test for radiation level or heat generation rate), test programs are generally considered to be expensive and time consuming.

Testing can include nondestructive assay (NDA) and nondestructive evaluation (NDE) processes. Projects are underway to qualify DOE SNF by NDA and NDE methods. These projects include (**TBD**).

If it is determined that the fuel is not acceptable to the requirements of the repository, some treatment or conditioning of the fuel will be required, such as oxidizing a pyrophoric fuel or consolidating a particulate fuel.

3.3 Physical Package

The final step in the process is to place the SNF in an acceptable canister or transportation cask for shipment to the repository. This shippable form, along with the associated documentation, constitutes a Repository Package. The Repository Package consists of the metallic canister in which the SNF is sealed, transported, and deposited in the repository.

Several requirements for the physical package relate directly to fuel data needs (such as heat generation rate), while others apply only to the container and the repository environment. Table 3.4 is the list of items necessary to consider for the physical container as part of the Qualified Fuel Package. Table 3.5 details the requirements and the method for compliance with these requirements. Section 3.3.1 provides further detail and explanation of the requirements.

Table 3.4. SNF canister guideline items.

1. Canister	
1.1 Canister size	DOE Orders, CRD, DIS
1.2 Internals	10CFR60; CRD, DIS
1.3 Sealing process	10CFR60; CRD, DIS
1.4 Handling	NUREG, ANSI, CRD, DIS
1.5 Identification	10CFR70.5; CRD, DIS
2. Contents	
2.1 Radiation levels	10CFR60; CRD, DIS
2.2 Heat generation	10CFR60; CRD, DIS
2.3 Criticality	10CFR60; CRD, DIS
2.4 Isotope content & leachability	10CFR60; DIS

Table 3.5. Repository canister acceptance criteria, requirements/limits, and compliance method.

Criteria	Requirements/Limits	Compliance Method
1. Canister		
1.1 Canister Size CRD 3.6.1.3.7.2.C DIS 2.2.20 DIS 2.2.21	The canistered DOE SNF shall be sized to optimize system standardization. Unique standard dimensions and weights for bare DOE SNF assemblies and canistered DOE SNF have not been determined (**TBD**).	Use canisters that fit within the (**TBD**) size ranges of the repository requirements.
1.2 Internals 10 CFR 60.135(a) and (b) CRD 3.6.1.3.5.C CRD 3.6.1.3.7.2 DIS 2.1.20	The internals of a DOE SNF canister must be considered in the evaluation of any potential reaction with the SNF and of any potential criticality of the contents of the package. The internals shall be described, in both form and material against this requirement.	Include documentation of the canister internals, both of potential material reactivity and criticality effects, in the data package.
1.3 Sealing of Canister 10 CFR 60.135(b)(3) 10 CFR 60.135(c)(1) 10 CFR 60.135(a)(2) CRD 3.6.1.3.6.A DIS 2.1.21 DIS 2.4.23 DIS 2.4.24	The canister shall be capable of being sealed and shall have an inert cover gas leak rate of less than 10^{-4} atm/sec at the time of canister closure (if considered the outermost closure). After closure of the canister, canistered DOE SNF shall not contain or generate free gasesXof greater than 22 psia at 25ºC.	Document sealing process per standard recommended procedure if using standardized canister. If unique canister, submit process by which canister is sealed, along with RW-0333P verification documentation.
1.4 Handling 10 CFR 60.135(b)(3) CRD 3.6.1.3.7.2.H DIS 2.2.22	Handling equipment design shall be provided suitable for use in loading or unloading bare DOE SNF or canistered DOE SNF from a transportation cask or waste package.	Include design and operating procedures for handling requirements/equipment as part of data package, addressing specific requirements and regulations governing design.
1.5 Identification 10 CFR 60.135(b)(4) CRD 3.6.1.3.6.E CRD 3.6.1.3.7.2.I DIS 2.1.26 DIS 2.1.27	Canister shall be designed to permit use of an NRC tamper-safe seal and labeled for identification by repository personnel.	Include identification process in data package and the method used to read canister identification. If canister is welded, separate tamper indicating desire is not required.

Table 3.5. (continued).

Criteria	Requirements/Limits	Compliance Method

2. Contents

2.1 Radiation Level 10CFR60.21.c.1.ii.F.5 CRD 3.6.1.3.6.D CRD 3.6.1.3.7.2.D CRD 3.6.1.3.7.2.E 10CFR73.6.b DIS 2.4.22	SNF canister shall exhibit a gamma-ray dose rate less than 10^5 rem per hour and a neutron dose rate less than 10 rem/hr at a distance of 1 meter. Forms with a total external dose rate less than 100 rems per hour at 3 feet must be addressed on case by case basis.	Provide results of radiation survey per qualified measurement procedure.
2.2 Heat Generation Rate 10CFR60.135.a.2 CRD 3.6.1.3.7.2.F DIS 2.4.20	14.2 kW is the current (**TBD**) total heat output per waste package. Individual canisters shall be proportionally loaded with SNF and placed within a MPC (or **TBD**) such that total thermal load is < 14.2 kW.	Provide documentation from measurements or calculations that total container thermal loading is less than 14.2 kW. Small canisters must be proportioned to volume of MPC or DPC.
2.3 Criticality Evaluation 110CFR60.131.b.7 CRD 3.6.1.2.5.C 10CFR71.55 DIS 2.3.22	Canisters must be loaded such that k_{eff} is less than 0.95 for all conditions other than two unlikely, and concurrent or sequential, changes have occurred in the conditions essential to nuclear criticality safety.	Provide analyses to show that criticality requirements are met under (**TBD**) repository conditions.
2.4 Isotope Content and Leachability 10CFR60.113.a.ii.A 10CFR60.113.a.ii.B DIS 2.3.20 DIS 2.3.21	Isotopic inventory of SNF is required (total species and accuracy required is **TBD**). Each isotope of amount >**(TBD)** shall be calculated for its leachability and transport capability under repository migration rates **(TBD)**.	Output from validated ORIGEN run giving isotope name and quantity, or, assay results providing isotope quantity, or calculated maximum. Provide data on leach rate of particular isotope.

3.3.1 Description of Canister Parameters

Standard CanistersXA set of standard canisters is proposed for packaging DOE SNF. These standard packages are designed to fit together in various ways and be backfilled with borosilicate glass beads (TBV) in order to accommodate the many varieties of DOE fuels. These standard canisters will be licensed by the NRC for use with certain bounds on fuel loading and other parameters regarding the contents (see Section 3.3.2). Use of a standard canister will save individual SNF custodians from individual licensing and certification expenses regarding specialized canisters. The standard canister set is shown in Appendix C. Included in Appendix C are proposed specifications for the canisters.

InternalsXThis information, in drawing form, shall illustrate the internal configuration of the canister. If the canister is a standard canister backfilled with borosilicate glass, the drawings shall show how the SNF is placed in the canister prior to backfill. If the SNF is restrained by a special internal structure, this information shall describe the internals and the appropriate certification reports on those internals.

Sealing ProcessXThis information describes the process by which the individual canister is sealed (if different from the standard process on a standard canister).

HandlingXThis information describes how a canister is to be handled (lifted, moved, positioned, etc), if other than handling procedures for a standard canister.

IdentificationXRegulations require that each fuel canister have identification that can be easily readable during handling and storage of the canister. This identification shall be traceable to the documentation accompanying the fuel canister.

3.3.2 Contents

This information group describes requirements placed on an individual canister relative to contents of that canister.

Radiation LevelsXThe canistered DOE SNF shall not exceed a maximum gamma-ray dose rate of 10^5 rem per hour and a maximum neutron dose rate of 10 rem per hour at a distance of 1 meter from any accessible surface without intervening shielding at the time of acceptance. This information is needed by the repository facility personnel for the safe planning of their handling operation. The procedure for satisfying this requirement is discussed in Section 4.2.2.1.

The bare DOE SNF assemblies or canistered DOE SNF shall have a total external dose rate in excess of 100 rems per hour at a distance of 3 feet from any accessible surface without intervening shielding at the time of acceptance. This requirement is based on the need for self-protection of the nuclear material. Self-protection may be adequately supplied by the canister in which the SNF is packaged. Forms with a total external dose rate less than the above will be addressed on a case-by-case basis.

Heat GenerationXRepository requirement CRD 3.6.1.2.7.2.F limits total heat generation for a repository package to 14.2 kW per package. The generation rate of an individual canister shall be equal to or less than 14.2kW H (Volume of individual canister)/(Volume of repository package) if a waste package is completely filled with one type of canister. Individual canisters can be grouped with individual canisters containing more or less than the above limit as long as the total heat generation of the canister group is equal to or less than 14.2 H (Volume of canister group)/(Volume of repository package). All of the canisters defined as a group must be contained within the same repository package.

The heat generation rate of a canister can be qualified by the process described in Section 4.2.2.2.

Criticality ControlXAll systems shall be designed to ensure that together with the components of the CRWMS, a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in conditions essential to nuclear criticality safety during processing, transporting, handling, storage, retrieval, emplacement, and isolation. All system components (including DOE SNF and any canister) must be such that any system of which they are part, will comply with this requirement. The procedure for satisfying the criticality requirement is discussed in Section 4.2.2.3.

Isotope and Content LeachabilityXThis data should be the calculational result of the ORIGEN run on the SNF. The rate at which individual fuel materials and isotopes leach out of the containment package is needed for the repository performance assessment. The information is needed for each listed material constituting more than 1% by weight of the fuel. The list of materials and isotopes for which information is needed is provided in Section 4.1.2.10.

3.3.3 Loading and Storing Packaged Material

Packaging should be with standard canisters to take advantage of commonality within the DOE Complex.

Canisters RequiredXThe custodian determines the number of canisters required based on the total amount of SNF to be packaged and the loading limits of each fuel type on each package. These package loading limits are dictated by radiation limits (Section 4.2.2.1), thermal limits (Section 4.2.2.2), criticality limits (Section 4.2.2.3), and weight/fissile material limits (Section 4.2.1.4). The required number of canisters can be calculated with assistance from the NSNFP, and canisters can be procured as part of the standard canister procurement process. If other procurement paths are available and some advantage is realized, the custodian may wish to pursue those paths.

LoadingXCanisters may be loaded at the custodian=s facility, if room and equipment is available to handle the canisters. The SNF may need to be shipped to a large handling facility, such as is being built at SRS and INEEL. If the fuel must be dried (Appendix D.4), a DOE-owned drying fixture can be made available (TBV) at the custodian=s facility.

Loading includes backfilling the canister with glass beads (TBD) for structural strength and rigidity, followed by seal welding of the canister. A DOE-owned seal welder will be available (TBV) for sealing standard canisters. If nonstandard canisters are used, the custodian is responsible for obtaining the equipment to seal the canister as well as supplying the QA procedure for using the equipment.

Proper identification of the canister and photographic coverage of the loading process shall be maintained in the data package. Media and format for storage of this information is **(TBD)**.

StorageXStorage of the SNF canisters after loading will depend on capabilities of the local facility as well as time and legal constraints on major interim storage laboratories, namely SRS and INEEL.

Since SNF was stored at the custodians site prior to being loaded into the storage canister, the canistered SNF should remain at the original facility until it can (1) be taken to either SRS or INEEL, or (2) be taken directly to a national repository. Timing for either of these options can be worked with the scheduling activity of the NSNFP.

4. GUIDANCE FOR PREPARATION OF REPOSITORY PACKAGE

4.1 Preparation of Data Package

This section provides the preparation guidance for the required data package components to assure compliance with the requirements/limits described in Tables 3.1 and 3.2. Areas where compliance processes are still being developed are noted with TBD (to be developed) or TBV (to be verified).

The format of this section follows the format of the OCRWM *Systems Requirements Document*, Rev 05B, August 1998. This provides the DOE SNF custodian with a sequential guidance path consistent with the CRD. The reader and user will note that the specific guidance associated with fuel and data preparation covered in earlier sections of this document are spread throughout the CRD requirements.

NOTE: ***Italicized section numbers, headings, and text in shaded, solid boundary box are from the RW CRD. Sections in shaded, dotted-line boundary box are from Disposability Interface Specification document (Rev. 01, July 1998, Draft B).***

4.1.1 Description

The following CRD requirements relate to description of the fuel and the procedures recommended for satisfying those requirements. Data relative to the Fuel Source, Operating History, Drawings, Dimensions Weights, and Physical Condition can be documented on the form in Appendix B.

3.6 INTERFACE REQUIREMENTS

3.6.1 External Interface Requirements

This section describes interface requirements between external organizations and the CRWMS.

3.6.1.1 Waste Acceptance and Transportation - Purchasers/Producers/Custodians Interface Requirements - *The interface requirements in this section are applicable to the interface between Waste Acceptance and Transportation and the Purchaser/Producer/Custodian.*

A. *Producer/Custodian and Waste Acceptance and Transportation shall ensure that waste forms and any canisters and CRWMS SSC designs are physically, chemically, dimensionally, functionally, and operationally compatible.*

Disposability Standard 2.1.1 - Compliance with Nuclear Waste Policy Act Definition of SNF

Disposability-Standard Description: The Nuclear Waste Policy Act (NWPA) describes the types of wastes that can be accepted by the MGR. Included in Section 1 (Definitions), Item 23, is the definition of SNF as fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. This disposability standard ensures that SNF entering the MGR meets the legally established NWPA definition of SNF.

Disposability Standard: SNF in disposable canisters delivered to the MGR under the classification as SNF shall meet the legal definition of SNF per NWPA 2(23). Fuel rods, assembly hardware, and nonfuel components are considered part of the SNF.

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 6.1 (Glossary), definition for "Spent nuclear fuel," p. 105.; **(2)** 10 CFR 961.11, Article I (Definitions), Item 18 (spent nuclear fuel); and **(3)** Nuclear Waste Policy Act [42 USC10101(23)], Section 1, Item 23.

Documentation to Certify Compliance: Canistered commercial fuel that meets the NWPA definition of SNF is compliant with this standard upon OCRWM approval of information provided in accordance with 10 CFR 961. Canistered nonfuel components withdrawn from the reactor after irradiation are similarly considered compliant. Canistered non-commercial SNF that clearly meets the NWPA definition of SNF shall be considered compliant with this standard upon delivery of the assembly data records package in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste" or "Memorandum of Agreement for Acceptance of Naval Spent Nuclear Fuel." Canistered non-commercial SNF for which there is some question about compatibility with the NWPA of SNF shall be considered compliant upon submission and acceptance by OCRWM of documentation prepared by the NRC or DOE General Counsel stating that the DOE SNF in question meets the legal definition in NWPA.

GUIDANCE: The completed DOE SNF Data Form in Appendix B will satisfy this requirement **<TBV>**. Custodian should use one of the characterization methods described in Section 3.2 for unavailable information or data on a particular fuel.

4.1.1.1 Source

GUIDANCE: Custodian should provide information on the fuel manufacturer, and fuel characteristics such as enrichment and fuel type.

4.1.1.2 Operating History

Disposability Standard 2.1.2 - Commercial SNF Cooling Time

Disposability-Standard Description: The Standard Contract (10 CFR 961.11, Appendix E, Section B.3) defines commercial SNF discharged from a reactor and subsequently cooled for less than five years to be "non-standard." This disposability standard controls MGR acceptance of this SNF to ensure that internal waste-package temperature and total thermal outputs from waste packages remain within acceptable limits.

Disposability Standard: All provisions for this disposability standard are covered by Disposability Standard 2.4.20 (Total Thermal Output for Disposable Canisters).

Basis for Standard: **(1)** 10 CFR 961.11, Article VI (Criteria for Disposal), Paragraph A (General Requirements), Item 2(b); and **(2)** 10 CFR 961.11, Appendix E, Paragraph B, Item 3 (Cooling).

Documentation to Certify Compliance: Documentation requirements are included in those covered in Disposability Standard 2.4.20.

GUIDANCE: Custodian should supply a) power history, b) use of the fuel, with power levels and dates, and c) where it has been stored over its life, so that a thermal, radiation, and isotopic evaluation can be made with a computer code like ORIGEN. If exact values are not known or obtainable, a range or limiting value should be provided.

4.1.1.3 Drawings

GUIDANCE: Drawings should provide the overall dimensions and configuration of the fuel in the physical package. Material location referred to in Section 4.1.1.5 should be indicated on the drawings.

4.1.1.4 Weights and Materials

Disposability Standard 2.1.4 - Canistering of Wastes Other than Intact Commercial SNF

Disposability-Standard Description: The types of wastes handled in the MGR surface facilities must be restricted to intact uncanistered BWR/PWR assemblies, nondisposable canisters containing either intact BWR/PWR assemblies or disposable canisters that require no special handling, and disposable canisters. This assures preclosure safety and maintains adequate surface-facility throughput rates. This disposability standard, subdivided into Standards 2.1.4.1 through 2.1.4.4, provides guidance on the acceptable forms for wastes other than intact SNF of commercial origin that can be delivered to the MGR. It specifically addresses degraded or damaged SNF (Standard 2.1.4.1), debris and corrosion products (Standard 2.1.4.2), nonfuel components (Standard 2.1.4.3), and DOE and naval SNF (Standard 2.1.4.4).

General Disposability Standard: Non-intact commercial SNF requiring any sort of special handling, and all DOE and naval SNF, shall be placed into disposable canisters (i.e., canisters that can be placed into a disposal container without emptying and repackaging canister contents) prior to shipment to the MGR. Commercial SNF single-element-sized canisters can have either screened ends to facilitate in-pool cooling, or be sealed (closed ends). Multi-element canisters and DOE SNF not of commercial origin shall be placed into sealed canisters. Both canister types must comply with all applicable Disposability Standards listed in Section 4.

GUIDANCE: Custodian should supply the weight and material content of all the fuel submitted for packaging or disposal. This information is required for packaging, handling, and calculations of thermal, radiation, and criticality parameters.

4.1.1.5 Physical Condition

Standard 2.1.4.1 - Canistering Degraded or Damaged SNF

Standard Description: This standard establishes the form in which degraded or damaged SNF can be accepted into the MGR.

Disposability Standard: Any SNF assembly that lacks the structural integrity to be lifted intact (e.g., handling features damaged) or has fuel cladding degradation or damage such that it requires any type of special handling (e.g., is classified as failed per 10 CFR 961.11, Appendix E (Section C.3) for any reason other than a pinhole leak too small to release solid radionuclides) shall be placed in a disposable canister before delivery to the MGR. Structural integrity is defined as **(1)** maintaining the capability to be lifted vertically like an intact commercial assembly (including compatible handling fixtures/features) and **(2)** maintaining cladding integrity while the assembly is handled remotely (as defined in Disposability Standard 2.2.22). SNF cladding integrity is considered damaged, and therefore subject to the assembly being canistered under this standard, if any of the following conditions are met.

- Visual evidence suggests that cladding corrosion or abrasion penetrates the entire thickness of the cladding to the degree that accelerated fuel degradation has occurred, and/or radionuclides (beyond gaseous fission products) are no longer confined.

- The assembly was stored in a facility or storage device that did not protect fuel-cladding integrity (e.g., SNF stored in conditions that violated temperature-pressure and/or other applicable provisions of 10 CFR Parts 50 or 72 or would have violated these provisions had the facility been so licensed).

- The assembly was transported in a cask that did not protect the fuel-cladding integrity (e.g., transported under conditions that violated temperature-pressure and/or other applicable provisions of 10 CFR Part 71).

- Knowledge or records of **(1)** the assembly or individual rods being designated as failed to the point that special handling is required; **(2)** assembly structural or cladding damage due to excessive force applied to the assembly (e.g., the assembly being dropped), such that the assembly requires special handling; **(3)** the assembly being exposed to materials not normally in contact with SNF but which can reasonably be expected to be corrosive to the cladding; or **(4)** the assembly being subjected to temperatures and pressures, or abrupt changes in temperature or pressure, such that cladding damage can be reasonably assumed to jeopardize the cladding integrity such that special handling is needed.

<u>Basis for Standard</u>: Same as the general Disposability Standard 2.1.4

<u>Documentation to Certify Compliance</u>: For commercial SNF, the SNF-classification documentation required by 10 CFR 961 is sufficient to demonstrate compliance with this Standard. DOE SNF shall be considered compliant with this standard upon OCRWM approval of the canistered-waste data records package submitted in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste."

<u>Standard 2.1.4.3 B Canistering Nonfuel Components</u>

<u>Standard Description</u>: The Standard Contract (10 CFR 961.11) defines nonfuel components as those that are an integral part of the fuel assembly, including 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 boiling water reactor channels that are an integral part of the fuel assembly. This standard defines the types of nonfuel components that shall be placed in disposable canisters prior to acceptance into the MGR if no longer physically inserted into the SNF assembly. It should be noted that the MGR prefers that these nonfuel components be delivered to the MGR integral to the assembly whenever possible.

<u>Disposability Standard</u>: Nonfuel components no longer physically inserted into an assembly shall be placed into a disposable canister prior to acceptance into the MGR. Nonfuel components physically inserted into the assembly can remain part of the assembly and be delivered to the MGR as either canistered or uncanistered intact SNF, assuming the component can reasonably be expected to remain inserted until after the assembly is placed into a disposal container.

<u>Basis for Standard</u>: Same as the general Disposability Standard 2.1.4

Documentation to Certify Compliance: The documentation for canistered waste required by 10 CFR 961 is sufficient to demonstrate compliance. DOE SNF shall be considered compliant with this standard upon OCRWM approval of the canistered-waste data records package submitted in accordance with the AMemorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste.≅

Disposability Standard 2.1.28 B Physical Condition of Disposable Canisters Containing SNF

Disposability-Standard Description: Disposable canisters and their contents shall be capable of being routinely transferred safely from their transportation cask into disposal containers at the MGR. These canisters must maintain their integrity and prevent loss of contents during transfer. The disposable canisters must be dimensionally compatible with the disposal container and the transportation cask. They must be free from significant bulges, holes, dents, swelling, out-of-roundness, bowing, and corrosion. This disposability standard specifies the physical condition and configuration for disposable canisters accepted at the MGR.

Disposability Standard: Provisions for this disposability standard are covered by other disposability standards as follows:

- Damage or deformation (bulges, swelling, out-of-roundness, bowing, or dents) shall not preclude the canister from meeting the dimensional envelope defined in Disposability Standard 2.2.20.

- Damage (dents/holes, deteriorated lifting features, or corrosion) shall not adversely affect the structural integrity of the canister to be lifted vertically and handled remotely (per Disposability Standard 2.2.22) without additional specialized tooling or canister-handling equipment.

∃ Damage (dents, holes, or corrosion) shall not compromise canister confinement capability (including preservation of the canister seal, per Disposability Standards 2.1.21 and 2.4.24).

Basis for Standard: **(1)** Repository Design (Surface) design-team recommended revision to the *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.2.7.A and B, p. 44; and **(2)** See additional sources in Standards 2.1.21, 2.2.20, 2.2.22, and 2.4.24.

Documentation to Certify Compliance: Documentation requirements are included in those described under Disposability Standards 2.1.21, 2.2.20, 2.2.22, and 2.4.24.

GUIDANCE: Custodian shall sufficiently describe the physical condition of the fuel for a packaging or repository receiver to evaluate the need for special handling and potential for radioactive release.

B. NO GUIDANCE REQUIRED

C. NO GUIDANCE REQUIRED

D. NO GUIDANCE REQUIRED

3.6.1.2 *Waste Acceptance and Transportation – Purchase Interface requirement*

A. NO GUIDANCE REQUIRED

3.6.1.3 RW. *Producers/Custodian Interface requirements.*

A. NO GUIDANCE REQUIRED

B. NO GUIDANCE REQUIREDXInstructions in CRD appear clear and sufficient

C. NO GUIDANCE REQUIREDXInstructions in CRD appear clear and sufficient

3.6.1.3.1. Preconditions*XThis section provides the preconditions that must be satisfied prior to acceptance of any HLW and/or DOE SNF into the CRWMS for disposal.*

A. NO GUIDANCE REQUIRED.

B. NO GUIDANCE REQUIRED.

C. Compliance with RW Requirement

GUIDANCE: This guidance document is the response to this requirement

D. Quality Assurance (QA) Requirements

1. The Producer/Custodian shall establish, maintain and execute a QA program satisfying each of the applicable criteria of the OCRWM QARD.

GUIDANCE: Section 5 of this document provides the directions on how to satisfy this requirement.

2. The Producer/Custodian shall prepare and maintain QA records documentation, etc.

GUIDANCE: Section 5 of this document provides the directions on how to satisfy this requirement.

3. Copies of completed DOE SNF & HLW packages etc.

GUIDANCE: The National Spent Nuclear Fuel Program has developed a fuel Data Sheet for collection and presentation of required SNF data. This data sheet is provided in Appendix B. Supporting documentation for the complete Repository Data Package is defined in Appendix B, along with the format and instruction for placement of that information on a CD-ROM. The CD-ROM will serve as the "carrier" of the Repository Data Package. An example of a completed CD-ROM is provided in a pocket in Appendix B.

3.6.1.3.2 Transfer of Responsibly and Custody

NO GUIDANCE REQUIRED

3.6.1.3.3 Notification of Improperly Described HLW and/or DOE SNF Waste Prior to Acceptance into the CRWMS

GUIDANCE: The DOE SNF custodian should verify with RW that proposed data package is complete and sufficient for title transfer at least <TBD> months prior to transfer of waste. The data form of Appendix B should be reviewed with the appropriate RW staff for completeness relative to the Waste Acceptance Criteria.

3.6.1.3.4 Resolution of Improperly Described HLW and/or DOE SNF After Acceptance into the CRWMS

NO GUIDANCE REQUIREDXInstructions in CRD appear clear and sufficient

4.1.2 Physical and Chemical Characteristics

3.6.1.3.5 Waste Acceptance Criteria (Regulatory)

3.6.1.3.5.A *All HLW and/or DOE SNF shall comply with the applicable provisions of the NWPA, appropriate EPA, DOT, and NRC regulations for transportation, storage (if approved)) and geologic disposal. The latter include but are not limited to 10CFR60, 10CFR71, 10CFR72, and 10CFR73.*

GUIDANCE: This document does not supply reference to or guidance on the compliance with requirements relating to transportation (10CFR71) or interim storage (10CFR72). The guidance supplied herein deals only with the requirements of geologic disposal and other agency requirements related directly to the activity.

3.6.1.3.5B. *General Criteria*

3.6.1.3.5.B.1. *The HLW and/or DOE SNF shall be in solid form and placed in sealed canisters. A limited amount of bare DOE SNF may be accepted by RW in accordance with the EM/RW MOA.*

Disposability Standard 2.1.3 – Provision that Canistered SNF Be a Solid

Disposability-Standard Description: Preclosure operational safety and postclosure repository performance require that SNF handled in the MGR be in a solid form. This disposability standard restricts MGR acceptance of disposable canisters containing SNF not in a solid form.

Disposability Standard: SNF accepted by the MGR shall be in a solid form (independent of size fraction) and, except for fission-product gases, shall be shown to remain as a solid over temperatures ranging from 25 ^{o}C to 400 ^{o}C and pressures of 1 to 5 atm.

Basis for Standard: **(1)** 10 CFR 60.135 (c)(1); and **(2)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.2.2, Item A(1).

Documentation to Certify Compliance: The canistered SNF shall be considered compliant with this standard upon waste owner submittal, and CRWMS approval, of documentation certifying that the canister inventory is a solid. For commercial SNF, the documentation required by 10 CFR 961 is sufficient. For other SNF, documentation shall include a description of the SNF sufficiently detailed to reasonably conclude that it is a solid, plus a description of waste preparation activities designed to minimize any radiogenic gases and/or liquids other than residual water in the SNF at the time of delivery to the CRWMS. Waste preparation procedures are to be selected by the waste owner, but must be acceptable under the terms of the repository operating license. Any non-trace radionuclide-bearing compounds present in the SNF that can reasonably be expected to transition to a liquid or gas at temperatures up to 400°C and/or pressures up to 5 atm also shall be identified in the documentation submitted.

GUIDANCE: The repository will not accept liquids or gases as a waste or waste form. This is not deemed a problem since no known DOE SNF is in a liquid or gas form.

Requirement

"Solidification. All such radioactive wastes shall be in solid form and placed in sealed canisters." 49 CFR 171.8 defines solid as follows: "Solid means a material which is not a gas or a liquid."

Discussion

Based on the above definition, all DOE SNF considered for repository emplacement is in a solid form. If is questionable as to whether the SNF is a solid or a liquid, ASTM D 4359-84 "Standard Test Method for Determining Whether a Material is a Liquid or Solid," 1984 edition, will be used. All DOE SNF is presently in solid form.

4.1.2.1 Particulate Material.

***3.6.1.3.5.b.2**. The HLW and/or DOE SNF shall be consolidated, if in particulate form, (for example, by incorporation into an encapsulating matrix) to limit the availability and generation of particulates.*

<u>Disposability Standard 2.1.23 - Particulates in Disposable Canisters Containing SNF</u>

<u>Disposability-Standard Description</u>: Quantities of reactive and non-reactive particulates must be limited in the MGR. Reactive particulates primarily result from the reaction between metallic fuel and water and provide the added complication that because they are pyrophoric and/or chemically reactive, they can both create a release and serve as the transport mechanism once the release occurs. Non-reactive particulates generally represent degradation products of SNF (metallic or non-metallic) and its associated hardware. Particulates provide a potential airborne pathway for contaminant release during repository operations and are subject to high radionuclide dissolution rates over time when exposed to water. This disposability standard establishes allowable ranges for particulates in canistered wastes.

<u>Disposability Standard 2.1.23.1 - Reactive Particulates in Canisters Containing SNF</u>

<u>Disposability-Standard Description</u>: This standard defines the acceptable quantities of reactive particulates in disposable canisters. This standard is closely linked to Disposability Standard 2.1.22.1 (Total Residual Water in Canistered Metallic-U Based SNF), Disposability Standard 2.1.24 (Total Pyrophoric Materials), and Disposability Standard 2.1.25 (Total Combustible, Explosive, or Chemically Reactive Waste Forms) because of the reaction between water and metallic uranium in the formation of pyrophoric uranium-hydride particulates.

<u>Disposability Standard</u>: Total existing and projected reactive particulates shall not total to more than 1.4 kg per canister (either an MCO or an equivalent adjusted total particulate mass per unit volume for other canisters)(TBV). Existing reactive particulates are those present at the time of canister loading/sealing. Projected reactive particulates are those generated via the reaction between residual water and metallic uranium after sealing and up to the time of delivery to the MGR. Particulate waste

forms with levels above this standard shall be consolidated by incorporation into an encapsulating matrix before acceptance into the MGR.

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.2.2(A) 2, p. 43; **(2)** 10 CFR 60.135 (c)(2); **(3)** *Issue 1 of the High Priority Performance Parameter (HPPP) Study - Surface Facility Preclosure DBE Analysis*, LV.SA.RPM.05/98-063, May 29, 1998, and **(4)** *Issue 3 of the High Priority Performance Parameter Study - Waste Package Gas Pressurization*, LV.WP.TAT.05/98-10, May 26, 1998.

Documentation to Certify Compliance: The DOE SNF shall be considered compliant with this standard upon OCRWM approval of the waste-form and canister-sealing portion of the canistered-waste data records package in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste." Waste-form records must include an estimate of the fuel damage ratio (volume percent of exposed fuel surface), the quantity of existing reactive particulates, and the calculated quantity of projected reactive particulates. The documentation shall also include an assessment of the uncertainty in the reported values and all assumptions used in the calculations.

Disposability Standard 2.1.23.2 - Non-Reactive Particulates in Canisters Containing SNF

Disposability-Standard Description: This standard defines the acceptable quantities of non- reactive particulates in disposable canisters.

Disposability Standard: Total existing and projected non-reactive respirable particulates shall not exceed 1.6 kg per PWR single-element-sized canister (or an equivalent adjusted total particulate mass per unit volume for other canisters)(TBV). Existing non-reactive particulates are those present at the time of canister loading/sealing. Projected non-reactive particulates are those generated via the reaction between residual water and any exposed fuel matrix after sealing and up to the time of delivery to the MGR. There is no prescribed method for measuring and/or calculating particulate levels, although whatever method is selected shall be preapproved by OCRWM. Particulate waste forms exceeding the standard can be brought into compliance via consolidation through encapsulation. [**NOTE**: The maximum acceptable quantities of particulates in this standard reflect studies that are currently limited to metallic uranium fuels. It is anticipated that a less restrictive limit will be applied to non-metallic-uranium once this SNF is investigated in greater detail.]

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.2.2(A) 2, p. 43; **(2)** 10 CFR 60.135 (c)(2); **(3)** *Issue 1 of the High Priority Performance Parameter (HPPP) Study - Surface Facility Preclosure DBE Analysis*, LV.SA.RPM.05/98-063, May 29, 1998, and **(4)** *Issue 3 of the High Priority Performance Parameter Study - Waste Package Gas Pressurization*, LV.WP.TAT.05/98-10, May 26, 1998.

Documentation to Certify Compliance: Documentation needed to demonstrate compliance includes the methodology used to measure and calculate particulate levels in the canister, where total particulate levels are below the standard, and records of particulate encapsulation if above the standard prior to treatment. For commercial SNF, the documentation for canistered waste required by 10 CFR 961 is sufficient to demonstrate compliance. DOE SNF and naval SNF shall be considered compliant with this standard upon OCRWM approval of the waste-form and canister-sealing portion of the canistered-waste data records package in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste" or "Memorandum of Agreement for Acceptance of Naval Spent Nuclear Fuel."

GUIDANCE: The fuels for which this requirement is applicable are identified in Table A-2 of Appendix A. A process has been defined to incorporate particulate material into an encapsulating matrix of sodium silicate. This process is described in Appendix D.1.

Status

The National Spent Nuclear Fuel Program is funding evaluations and experiments directed toward the resolution of problems associated with particulate fuel. A tentative procedure is included in this Appendix D.1.

Requirement

"Consolidation. Particulate waste forms shall be consolidated (for example, by incorporation into an encapsulating matrix) to limit the availability and generation of particulate."

Discussion

Particulate waste forms must be consolidated prior to acceptance into the repository. The question is: "What is meant by particulate?" The Waste Isolation Pilot Plant (WIPP) waste acceptance criteria (WAC) uses the following to determine "immobilization" requirements for waste destined for disposal at WIPP: "Waste materials shall be immobilized if > 1% by weight is particulate material < 10 microns in diameter, or if > 15% by weight is particulate material < 200 microns in diameter."

A similar approach will be used for DOE SNF destined for geologic disposal. The RW concern is from inhalation at the site boundary. There is a concern at preclosure concerning handling accidents at the surface facility. For postclosure, no model has been developed. A research program is underway to test and verify the consolidation of particulate SNF using sodium silicate as a binding agent using the process described in Appendix D.1.

4.1.2.2 Pyrophoric, Combustible, and Explosive Fuels

***3.6.1.3.5.D**. Confinement*

1. *The HLW and/or DOE SNF shall not contain or generate materials that are explosive, pyrophoric, or chemically reactive (in the repository environment) in a form or amount that could compromise the repository=s ability to perform its waste isolation function or satisfy its performance objectives.*

Disposability Standard 2.1.24 - Pyrophoric Materials in Disposable Canisters Containing SNF

Disposability-Standard Description: Per DOE-HDBK-1081-94 (DOE Handbook Primer on Spontaneous Heating and Pyrophoricity), a pyrophoric material is one capable of spontaneous combustion in air. Per 10 CFR 61.2, a pyrophoric solid is any solid material, other than one classified as an explosive, which under normal conditions is liable to cause fires through friction, retained heat from manufacturing or processing, or can be ignited readily, and when ignited, burns so vigorously and persistently as to create a serious transportation, handling, or disposal hazard. Preclosure safety concerns during SNF handling, emplacement in the repository, and retrieval (if necessary) require that limits be placed on disposable canisters with SNF that contains or can generate pyrophoric materials. Wastes expected to be pyrophoric under conditions ranging from 25 ^{o}C to 400 ^{o}C and 1 to 5 atm (surface to peak repository conditions and internal waste package environment) are excluded from the MGR. This disposability standard sets acceptable levels of pyrophoric materials in disposable canisters.

Disposability Standard: Canistered SNF accepted into the MGR shall not ignite spontaneously in air at or below temperatures of 400 ^{o}C, at pressures of 1-5 atm, and at or above a relative humidity of 5 percent (TBV). Trace quantities of pyrophoric material whose ignition can be shown to have no quantifiable effect on the pressure-temperature environment immediately adjacent to the assembly are exempt from this standard.

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.2.2(C), p. 43; **(2)** 10 CFR 60.135 (b)(1); **(3)** *Issue 1 of the High Priority Performance Parameter (HPPP) Study - Surface Facility Preclosure DBE Analysis*, LV.SA.RPM.05/98-063, May 29, 1998, and **(4)** *Issue 3 of the High Priority Performance Parameter Study - Waste Package Gas Pressurization*, LV.WP.TAT.05/98-10, May 26, 1998.

Documentation to Certify Compliance: The canistered SNF shall be considered compliant with this standard upon waste owner submittal, and CRWMS approval, of documentation certifying that the SNF includes no material that is pyrophoric in the abovementioned concentration and environment. For commercial SNF, the documentation required by 10 CFR 961 is sufficient unless the SNF has degraded such that degradation products known to be pyrophoric now exist in the SNF. For other SNF, documentation shall include a description of the fuel prior to any degradation; estimated quantities of potentially pyrophoric materials, included an assessment of the potentially pyrophoric compounds present; and computational and/or empirical data for the SNF demonstrating that this disposability standard can be met.

GUIDANCE: The fuels for which this requirement is applicable are identified in Appendix A, Table A-2. There are no known DOE fuels that are explosive or chemically reactive (other than by a benign oxidation process). A process for satisfying this requirement relative to potentially pyrophoric fuels is discussed below.

Status

Research is underway at Hanford to address the issue of pyrophoric fuels. The NSNFP is funding a portion of this research. Results of this work will be included in future versions of the Guidance Document.

Requirements

"(b) Specific criteria for HLW package designX(1) Explosive, pyrophoric, and chemically reactive materials. The waste package shall not contain explosive or pyrophoric materials or chemically reactive materials in an amount that could compromise the ability of the underground facility to contribute to waste isolation or the ability of the geologic repository to satisfy the performance objectives." 10 CFR 60.135.b.

Discussion

There is ample evidence that, under the right conditions, certain metallic and hydride fuels will self-ignite and undergo a rapid exothermic reaction. The question regarding the fuels destined for a national repository is, "Will the right conditions ever exist under which this pyrophoric and combusting situation can occur?"

Research is ongoing to test the ignition temperature of uranium metal fuels. The validity of these tests is in question because of the specimen size used in the test relative to the size and configuration of the elements. There are also questions on the oxygen availability in the repository and how this parameter is being considered in the tests.

Considerations

In order for the fuels in question to undergo a pyrophoric-initiated combustion process, there must be these initial and ongoing conditions:

- The fuel must be in a chemical and physical condition conducive to pyrophoric ignition.
- The fuel must be at a temperature which will initiate the pyrophoric behavior.
- The fuel must have a continuous supply of oxygen to support the combustion process.
- The oxygen supply must be at a rate high enough to support the combustion process at an undesirable (presently unknown) level.
-
- The combusting fuel must decompose in a manner that does not quench the combustion process or the oxygen supply to the combustion process.

Control Options

If any one of the necessary conditions above can be eliminated, or diminished below a certain level, the potentially negative effect on the repository will be eliminated. Some potential actions controlling the individual conditions are:

Condition 1: Fuel in conducive condition: If the fuel can be treated such that it is no longer pyrophoric or combustible at the maximum temperature expected, or possibly, in the repository, the problem is solved. Either complete oxidation of the fuel in a controlled manner, or oxidation to the point where the fuel will no longer be pyrophoric is a solution.

Condition 2: Fuel at sufficient temperature for ignition: If it can be shown through the performance analysis that the temperature can never get to the ignition temperature, the problem is solved. Maintaining good heat transfer to the boundaries of the repository may also be necessary.

Condition 3: Supply of oxygen to fuel: The fuel must have a supply of oxygen in order to get this process started. There is probably nothing that can be done that would stand the test of logic which guarantees that there would not be some oxygen, eventually, in the vicinity of the fuel. Since the long-term behavior of the containment assumes its eventual breaching, one has to assume that oxygen would then be available inside of an initially inerted containment. Stopping the process through this requirement can probably not be done. Condition 4, involving the rate at which oxygen can be supplied, is another matter with more opportunity for control.

Condition 4: Adequate flow rate of oxygen: For a damaging combustion process to occur, not only must oxygen be available but it must be available at a rate that can sustain a damaging combustion level. If one makes the assumption that the containment is eventually breached by the action of water rusting the outer containment, at some point in time a small hole will occur in the containment. Oxygen will enter the containment and, given that the fuel is susceptible to pyrophoric combustion, the combustion process will start. As soon as the combustion process starts, the combustion rate will be controlled by the rate the oxygen can enter the small hole, at the same time the combustion products are exiting the hole. One must also consider (or present logic that negates it) the fact that the causal factor in generating a holeXwater on the containmentXwill continue to the point that the canister is full of water. The containment full of water is not a condition under which pyrophoric combustion will occur. This condition would exist until a hole was rusted in the bottom, and the water drains out. It is at this time a canister with an oxygen environment and some rate of oxygen/combustion product transfer into and out of the canister must be considered. The effects of the water on the fuel from the time it initially perforates the canister until it drains from the canister must also be evaluated. This is precisely the condition in which the fuel at Hanford resided in basins for many years. While in the presence of water, this fuel was stable and underwent a slow oxidation into an even more stable sludge form.

If a disposal procedure can be defined which will eliminate, or at least minimize, the flow of oxygen to the containment (such as covering the fuel with clay), the rapid combustion of the fuel can be eliminated, thereby reducing the process to a slow oxidation/rusting process. Clay would not only reduce or eliminate the flow of oxygen to the fuel, but it also has enough plasticity that seismic activity would not reduce the blanketing action/capability. This functional control over an essential pyrophoric combustibility requirement would not negate any of the other assumptions of repository operation, such as eventual containment failure.

Condition 5: Fuel must not decompose and stop the process: If the fuel, in the process of pyrophoric combustion, either forms an oxygen protecting surface or deforms into a shape that prevents or slows the combustion, there is not a problem to be solved. The only way to address this situation, is to test the fuel in a geometry and environment typical of the repository. Testing of small specimens may not provide an accurate indication of the true behavior in the repository.

Summary

The resolution of the problem of pyrophoric materials in the repository reduces to three options:

1. Show that the material cannot exist in a pyrophoric condition, by demonstrating that:

    1.1 The particular material condition or geometry will not allow a pyrophoric condition to exist,

    1.2 A set of initiating conditions is not possible (i.e., temperature and oxygen availability)

2. Show that if a pyrophoric condition can be initiated, a damaging rate cannot be sustained due to:

    2.1 The inability to supply oxygen sufficient to maintain a damaging combustion rate.

        2.1.1 Surroundings will not allow oxygen to the combustion area or

2.1.2 Combustion process decreases oxygen availability

3. Show that a maximum feasible combustion rate will not harm or impair the function of the repository.

   3.1 Define what "harm or impair function" of the repository means (TBD)

   3.2 Define the maximum sustainable combustion rate

For packaging of known pyrophoric material, the following is recommended:

1. TBD

2. TBD

3. TBD

The above action should protect the stored pyrophoric material from ever having a source of oxygen at a rate sufficient to sustain any kind of damaging combustion process. The oxygen blocking effect of something like a clay cover should also greatly slow the oxidation process in the waste package. Both of which delay even a small amount of oxygen becoming available to initiate a pyrophoric combustion process.

3.6.1.3.5.B.3. *Combustible HLW and/or DOE SNF shall be reduced to a form such that they are noncombustible in the repository environment unless it can be demonstrated that a fire involving the waste package containing combustibles will not adversely affect other waste packages, any structure, system, or component important to safety, or the repository=s ability for waste isolation. (CRD 3.6.1.2.5.3)*

Disposability Standard 2.1.25 - Combustible, Explosive, or Chemically Reactive Waste Forms

Disposability-Standard Description: Preclosure safety concerns prohibit MGR acceptance of SNF containing compounds defined as explosive under 49 CFR 173.50, chemically reactive, or combustible under the temperature-pressure regime ranging from 25 ^oC to 400 ^oC and 1 to 5 atm (surface to peak repository conditions and internal waste package environment). This disposability standard restricts disposable canisters containing wastes that could be combustible, explosive, or chemically reactive over the temperature and pressure ranges in the repository or supporting surface facilities.

Disposability Standard: No canisters containing compounds in concentrations that could be considered to be combustible, explosive per 49 CFR 173.50, or chemically reactive under the temperature-pressure regime ranging from 25 ^oC to 400 ^oC and 1 to 5 atm shall be accepted into the MGR(TBV). At the time of delivery to the MGR, no canister shall contain more than 22 g of gaseous hydrogen (TBV). This amount of hydrogen shall be further reduced if potential for hydrogen deflagration (i.e., hydrogen concentration higher than 4 volume percent) inside a canister exists and results in pressures that exceed the canister pressure limit established in Disposability Standard 2.4.23.

Basis for Standard: **(1)** 10 CFR 60.135 (b)(1) and (c)(3); **(2)** *Mined Geologic Disposal System Advanced Conceptual Design Report* (CRWMS M&O 1996b) March 1996, Vol. 3, Section 6.2.1.3,

Table 6-1; **(3)** *Waste Acceptance Systems Requirements Document* (WASRD) DOE 1996b), Section 3.2.3.1.2.2(c), p. 43; and **(4)** *Issue 1 of the High Priority Performance Parameter (HPPP) Study – Surface Facility Preclosure DBE Analysis*, LV.SA.RPM.05/98-063, May 29, 1998, and **(5)** *Issue 3 of the High Priority Performance Parameter Study - Waste Package Gas Pressurization*, LV.WP.TAT.05/98-10, May 26, 1998.

Documentation to Certify Compliance: For commercial SNF, the documentation for canistered waste required by 10 CFR 961 is sufficient to demonstrate compliance unless there is evidence to suggest that restricted materials exist. DOE SNF and naval SNF shall be considered compliant with this standard upon OCRWM approval of the canistered-waste data records package submitted in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste" or "Memorandum of Agreement for Acceptance of Naval Spent Nuclear Fuel," unless there is evidence to suggest that restricted materials exist. If data for either commercial, DOE, or naval SNF suggest restricted materials may be present, similar additional documentation is required. This documentation includes descriptions of the types and concentrations of suspect materials present, and the technical argument for why these materials are not present in concentrations that might adversely impact MGR safety (with supporting physical analyses, if needed to make a technically convincing argument).

GUIDANCE: The fuels for which this requirement is applicable are identified in Table A-2 of Appendix A. A process for satisfying this requirement for these fuels is described below <TBD>.

4.1.2.3 Criticality.

3.6.1.3.5.C. *Criticality*

1. *All HLW and/or DOE SNF systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste shall be designed to ensure that together with the components of the CRWMS, a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety during processing, transporting, handling, storage, retrieval, emplacement, and isolation. All system components (e.g., DOE SNF and any canister) must be such that the system of which they are part will comply with this requirement.*

2. *All HLW and/or DOE SNF systems shall be designed for criticality safety assuming occurrence of design basis events..*

3. *The calculated effective multiplication factor (k_{eff}) must be sufficiently below unity to show at least a 5% margin, after allowance for bias in the method of calculation and the uncertainty in experiments used to validate the method of calculation. All system components (e.g., DOE SNF and any canister) must be such that the system of which they are part will comply with this requirement.*

GUIDANCE: Criticality is primarily an issue with the canister, as opposed to individual fuels within the canister. Discussion, status, and guidance regarding criticality is covered in Section 4.2.2.3 of Section 4.2 “Preparation of Physical Package.”

4.1.2.4 Free Liquids.

> ***3.6.1.3.5.D.2.*** *The HLW and/or DOE SNF shall not contain or generate free liquids in the waste package to an amount that could compromise the ability of the waste package to achieve the performance objectives related to containment of the waste form or result in spillage and spread of contamination in the event of waste package perforation during the period from placement in a waste package through permanent closure of the repository.*

<u>Disposability Standard 2.1.22 - Residual Water in Disposable Canisters Containing SNF</u>

<u>Disposability-Standard Description</u>: Quantities of residual water, defined herein as free water in the canister plus chemically bound water in canistered SNF, must be limited in the MGR. Residual water may provide a degradation mechanism for SNF (e.g., reacted with metallic uranium to create particulate pyrophoric materials), and may enhance gas-generation potential (e.g., radiolytic conversion of water to hydrogen and oxygen gas, or production of hydrogen via anoxic corrosion of steel) that increases combustibility and/or overpressurizes canisters. Residual water also accelerates internal corrosion of the canister and its contents, and makes any release from a preclosure accident more difficult to contain. This disposability standard restricts both chemically bound and free liquids in disposable canisters of SNF delivered to the MGR.

<u>Disposability Standard 2.1.22.1 - Residual Water in Canisters Containing Metallic-U SNF</u>

<u>Disposability-Standard Description</u>: This standard defines the acceptable quantities of residual water in sealed canisters containing metallic-uranium based SNF. This standard is closely linked to Disposability Standard 2.1.23.1 (Maximum Allowable Quantities of Reactive Particulates), Disposability Standard 2.1.24 (Total Pyrophoric Materials), and Disposability Standard 2.1.25 (Total Combustible, Explosive, or Chemically Reactive Waste Forms) because of the reaction between water and metallic uranium in the formation of pyrophoric uranium-hydride particulates plus H_2, and in the radiolysis of water to form H_2 and O_2.

<u>Disposability Standard</u>: Sealed disposable canisters of SNF shall contain as little residual (free and bound) water as possible, but shall not contain more than 0.2 kg to 1.3 kg (TBV) of total residual water per canister (either an MCO or an equivalent adjusted total water per unit volume for other canisters) at the time of canister sealing. The range represents a maximum number, above which non-compliance is probable; a minimum number, below which compliance is likely, and the range between the two, where compliance is uncertain until MGR designs and analyses are better refined. [**NOTE**: Preliminary analyses on gas generation due to radiolysis suggests that the 0.2 kg per canister "minimum" on the range of acceptability may need to be still lower. However, these analyses are based on assumptions that are very conservative, and additional evaluation is needed before their viability can be adequately assessed.]

<u>Basis for Standard</u>: **(1)** 10 CFR 60.135(b)(2); **(2)** *Issue 1 of the High Priority Performance Parameter (HPPP) Study - Surface Facility Preclosure DBE Analysis*, LV.SA.RPM.05/98-063, May 29, 1998, and **(3)** *Issue 3 of the High Priority Performance Parameter Study - Waste Package Gas Pressurization*, LV.WP.TAT.05/98-10, May 26, 1998.

<u>Documentation to Certify Compliance</u>: Metallic-uranium based SNF shall be considered compliant with this standard upon OCRWM approval of the waste-form and canister-sealing portion of the canistered-waste data records package in accordance with the "Memorandum of Agreement for Acceptance of

Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste." Waste-form records must include an estimate of the fuel damage ratio (volume percent of exposed fuel surface). Canister-sealing records shall include the method used to measure or calculate both free water and chemically bound water in the canister, and the results of these measurements/calculations. The documentation shall also include an assessment of the uncertainty in the reported values and all assumptions used in the calculations.

Disposability Standard 2.1.22.2 - Residual Water in Canisters Containing Non-Metallic-U SNF

Disposability-Standard Description: This standard defines the acceptable quantities of residual water in disposable canisters containing SNF with a matrix that is less likely to generate combustible gases or pyrophoric particulates when in contact with water than metallic-uranium fuels. This standard covers uranium oxide fuels, uranium-aluminum fuels, uranium-silicate fuels, uranium carbide fuels (including U/Th and U/Pu), mixed oxide (MOX) fuels, uranium-thorium oxide fuels, and U-ZR-Hx fuels.

Disposability Standard: There are no residual-water requirements for commercial SNF canisters with screened ends (the MGR will eliminate free water in these canisters prior to placing the canister in a disposal container, and preliminary analyses suggest chemically bound water is not problematic). Sealed disposable canisters shall contain as little residual water as possible but no more than 1.3 kg (TBV) of total residual water per canister (either an MCO or an equivalent adjusted total water per unit volume for other canisters) at the time of canister sealing. This shall be accomplished by dewatering and purging the canister to remove all but trace quantities of free water using either the method described in NUREG-1567, pp. 11-24, or any method that can be demonstrated to yield results comparable to, or better than, this method. [**NOTE**: The maximum acceptable quantities of residual water in this standard reflect studies that are currently limited to metallic uranium fuels. It is anticipated that a less restrictive limit will be applied to non-metallic-uranium once they are investigated in greater detail.]

Basis for Standard: **(1)** 10 CFR 60.135(b)(2); **(2)** *Issue 1 of the High Priority Performance Parameter (HPPP) Study - Surface Facility Preclosure DBE Analysis*, LV.SA.RPM.05/98-063, May 29, 1998, and **(3)** *Issue 3 of the High Priority Performance Parameter Study - Waste Package Gas Pressurization*, LV.WP.TAT.05/98-10, May 26, 1998.

Documentation to Certify Compliance: Documentation needed to demonstrate compliance includes the methodology used to dewater and purge the canister, the criterion for defining when the purging was complete, and operational records of the dewater/purging of the canister. For commercial SNF, the documentation for canistered waste required by 10 CFR 961 is sufficient to demonstrate compliance. DOE SNF and naval SNF shall be considered compliant with this standard upon OCRWM approval of the canister-sealing portion of the canistered-waste data records package in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste" or "Memorandum of Agreement for Acceptance of Naval Spent Nuclear Fuel."

GUIDANCE: No DOE SNF is known to have the ability to generate free liquids. A number of DOE fuels, however, have been stored in pools for years and contain free water, pore or capillary water, and water of hydration or some form of bound water. These fuels with potential free liquid problems are identified in Table A-2 of Appendix A. There are two primary reasons for removing the liquids from DOE SNF. The first is that free liquids have the potential to migrate to and enhance the corrosion of the waste package container. Second, if the liquids undergo **radiolysis,** excessive pressure could be generated in the waste package and the free oxygen and hydrogen can cause detrimental material effects. A process for removing the liquid from affected DOE SNF is described below.

Status

The NSNFP is sponsoring research on the subject of drying and will maintain updates to this guidance document based on the results of this research. The question of *how dry is dry* will be answered during FY 98 in a task called High Priority Performance Factors.

Requirements

10 CFR 60.135.b(2) "Free liquids." The waste package shall not contain free liquids in an amount that could compromise the ability of the waste packages to achieve the performance objectives relating to containment of HLW (because of chemical interactions or formation of pressurized vapor) or result in spillage and spread of contamination in the event of waste package perforation during the period through permanent closure.?

Discussion

Free liquids should be defined as those liquids which can be visibly detected (sloshing, pooling, volume measurement, dripping). Other forms of liquid may be trapped (nonvisible), interstitial, chemically bound (water of hydration), or exist as water vapor inside a package for the conditions (temperature, pressure) within the package.

The primary concern of free liquids is early and/or accelerated degradation of the internals of the waste package. Damage can occur either to the fuel assemblies, the internal support matrix, or the internal surface of the waste canister.

There are no real detrimental affects to the overall performance of the waste package until the waste package is breached. At that point in time, and depending on the initial amount of trapped water and how it reacted, the >burst release= of radionuclides, at the time of waste package breach, might be enhanced. Water trapped within the canister would be insufficient to cause a criticality if the support matrix allowed fuel reconfiguration. However, subsequent water entry and accumulation in the package might then cause an increase in the k_{eff}, although a criticality is not a foregone conclusion.

Of secondary concern would be the **radiolysis** products of the water and how they might affect the chemistries within the canister. Free radical formation, accelerated corrosion, possible hydride formation (for those fuels susceptible to hydride formation), and gas generation are all possible. Radiolysis is an equilibrium reaction that is self-reversing. Self-reversal is enhanced with ionic contaminants in the water. Some reactions are also limited by hydrogen gas (partial pressure) concentrations.

Assumptions: With few exceptions, virtually all DOE-owned SNF is stored underwater for cooling and radiation shielding. Varying storage conditions and time in storage have created various degrees of damage to some of the fuels, creating trapped water within the fuel element.

Undamaged fuels constitute a set of SNF suitable for underwater loading into a fuel canister and subsequent *in situ* drying. This drying step must address canister configuration (drain location, water pockets), drying duration and temperature, H_2O partial pressure measurement, and identified limit(s) for allowable quantity of water (>free= or otherwise).

Damaged fuels that either haveXor risk creatingXan immediate vulnerability may have been canned already (e.g., Tory IIA), or are designated to undergo individual fuel canning operations (N-Reactor). In the former case, canned or recanned fuels were reinserted into a wet-storage environment. Identification of subsequent water intrusion must be disproved in this case before these canned fuels can be considered acceptable (with respect to free liquid) in an SNF canister. In the latter case, ongoing packaging operations will provide some minimal treatment before dry canning and subsequent dry storage of the fuel. Data relative to the canning operation and subsequent dry storage facility records may suffice for showing compliance with the >no free liquids= requirements in 10CFR60.

Fort St. Vrain fuels in dry storage have documented reactor operating and storage facility records that could be used to qualify those fuels as free of liquids. Peachbottom fuels in “dry storage” wells may have been compromised due to known water intrusion, and will undoubtedly require some form of characterization and possible treatment.

Research Results from Drying Experiments

Several important observations have been noted during drying study work with the University of Idaho. These conclusions may be useful for technical and operational decisions regarding the transfer of wet fuel to dry storage.

- The existing Drying and Canning Station equipment can dewater the fuel canister containing complex fuel configurations packed with corrosion product and sediment. The current procedure of vacuuming until pressure trends indicate dewatering completion (insufficient liquid water to establish equilibrium water vapor pressure) and then heating for two hours (at a nominal vessel air temperature of 100°C) is adequate to remove free water inside the IFSF canister. No liquid water droplets remain on exposed fuel surfaces or on the fuel can. This is exactly what the system was designed to deliver. The station performs this function adequately based on experimental evidence with mock plate fuel, both with and without simulated corrosion product. (Experiments were not based on a fully loaded canister. These studies used a half-size mockup station with either one full-size mock ATR element or up to four one-foot-long sections of generic mock aluminum plate fuel elements.) Such experiments also indicate that procedural modifications such as heating prior to vacuuming and/or alternating between heat and vacuum for several cycles could significantly reduce the process time for dewatering and improve moisture removal from the fuel elements. The existing INEEL procedure relies entirely on the vacuum stage to dewater the fuel. The heat (or bake out) stage was originally intended as a limited passivation stage and a redundancy to ensure the entire canister was dewatered. While the heat stage is essential to successful passivation, it is not necessary for dewatering.

- If fuel is heavily loaded with corrosion product and sediment, physically occluded moisture (water absorbed, adsorbed or otherwise obstructed by the corrosion material from direct evacuation) may remain with that material after the prescribed vacuum and heat sequence. Thus, a distinct indication of the drying endpoint determination for removal of any occluded moisture is unavailable. Operating vessel pressure trends do not readily indicate the presence or absence of occluded moisture in corrosion product and sediment, and experimental work has shown that removal of this occluded moisture from such material by vacuum without heating takes as long as three days (i.e., if hydrated corrosion products are present in a fuel element it may take three days of vacuuming to achieve the state of “dryness” as outlined in operations current procedures). Prediction of endpoint is further complicated by scaling effects (canister loading, amount of corrosion, variations in fuel element configurations and constituents). In our experiments, successful removal of occluded water has been determined by 1) qualitative visual confirmation (presence or absence of visible damp spots in the corrosion material on the disassembled mock fuel plates after drying), 2) mass comparison to the initial constituents (gross weight change), 3) quantitative analysis of material microsamples with a thermo-gravimetic analyzer (TGA), and 4) temperature increase indicated by thermocouples located within the mock element after physically occluded water was removed. None of these techniques can readily be used with the actual fuel.

- Among the nonpyrophoric fuels, the aluminum plate fuels are expected to be the most difficult from which to remove water. Their complex physical geometries can trap wet sediment and extensively hydrated aluminum corrosion products on inaccessible inner plate surfaces. The other fuel types (including SS plate fuels, ceramic fuels, and zircaloy-clad) should be easier to dewater (and remove occluded water from) than the aluminum plate fuels. Thus, if the aluminum plate fuels can be dewatered successfully, dewatering of other fuel types should be readily achievable.

- There is no reason to attempt to dry the fuel, corrosion products, and sediment between the plates of nonpyrophoric fuels beyond the removal of occluded water if they are to be placed in vented storage. Studies using the drying and canning station mockup indicate that the dried simulated corrosion product material absorbs moisture from the surrounding air of the laboratory. Both TGA microsamples and the bulk material show weight increase following exposure to ambient air. Gross weight analysis indicates a 2.°5 weight percent increase after exposure to laboratory air. On average, a TGA sample gains about 1.0 weight percent during the first 10–102 minutes of the run while the temperature is still well below 100°C (the TGA is set to increase operating temperature 5°C per minute from 15°C up to 845°C). TGA results indicate that in the canning station mockup all of the water added to the simulated material at make up and as much as half of the waters of hydration from the constituent boehmite and clays are removed with the successful removal of physically occluded moisture. After drying, water vapor in ambient air is assumed to physically adsorb to the high surface area of the corrosion product material rather than rehydrating the oxides in the corrosion product with the formation of chemical bonds (waters of hydration). However, whatever the mechanism, if this material will pick up water from the surrounding air in vented storage there is no reason to attempt to dry the material more completely.

- Drying studies have not addressed problems specifically associated with the passivation of pyrophoric material. The focus has been on drying aluminum plate fuels that are not considered pyrophoric. However, with regard to fuel temperature, our experiments have consistently shown that individual fuel plate temperatures rise to a maximum of about 95°C until all of the occluded moisture has been removed from that particular plate and any adjacent corrosion product. In other words, an outer plate may exceed 100°C temperature levels if it is dry, but inner plates in the same element (if still wet) will stay at a much lower temperature until the remaining moisture is removed. This decouples fuel temperature from other measurable temperatures and impacts heat input needed to ensure complete temperature uniformity throughout a fuel element. Thus, if hydride passivation requires a particular fuel temperature to be attained and held, the fuel must be completely free of both occluded and free water. Removal of all occluded and free water will impose a long, difficult-to-verify process. This is a very difficult requirement to achieve for all fuel types when it appears that it is only necessary for pyrophoric fuels (very few compared to the rest of the INTEC inventory).

GuidanceXAnalysis and Evaluation Methodology

There are two basic approaches to assuring SNF is sent to the repository in "dry" packages. The typical method for commercial fuels will employ underwater loading of a cask, and a subsequent drying step of the packaged fuel. A second option for at least many of the DOE-owned fuels may involve drying individual elements prior to package loading. The expected tests and verification of "dryness" will certainly differ between the two methods of SNF loading.

For the underwater fuel loading scenario, the ability to verify the "dryness" of the fuel package will require testing and monitoring that is expected to differ from individual element drying and loading operations. Furthermore, fuels already in dry storage may require differing verification data than those fuels which may be dried individually prior to package loading.

Package "dryness" is relative and perhaps subjective to interpretation against the regulation, since free liquids that "could not compromise the ability of the waste packages to achieve the performance objectives" is left to interpretation. One or more scenarios may need to be created to justify some residual amount of liquid that can be accepted with any waste package. It will be important to differentiate between "free liquids" and interstitial or trapped water within the packaged SNF, since interstitial water will generally be unavailable for, and of insufficient quantity to promote early, internal package failure. Then, there must be a standardized basis for determining quantitatively the amount of water that actually might remain after drying based on time, temperature, pressure, and perhaps, ppm H_2O measurements. Furthermore, the scenarios for any anticipated corrosion should address the specific mechanism (i.e., localized or general), and the quantity of material affected. Even localized corrosion leading to development of a pin-hole leak will be self-limiting; internal pressures would be expected to pressurize pooled water out through the pin-hole. The corrosion mechanism promoting internal corrosion and the consequences of failure are likely different from externally promoted corrosion. Furthermore, the consequences of package failure from internally induced corrosion will be greater than that experienced from an externally induced corrosion failure.

Potential damage could be quantified from gram-moles of reactants considered available, the environmental conditions inside the package such as free radicals formed from radiolysis, and internal temperatures. Internal package temperatures somewhat in excess of 100EC and pressures at the limits specified for the individual packages are expected to promote general corrosion as opposed to localized corrosion. Some portion of the initial gram-moles water is expected to react with all metal surfaces to varying degree until such time in the future, the package internal temperatures allow localized pooling of water and potentially localized corrosion to proceed. Even at temperatures below 100°C, some portion of the liquid will exist in the vapor form within the sealed package.

For individually dried elements, it may be possible through a mockup test apparatus to establish time-temperature relationships specific to individual fuel types. This approach might obviate the need for excessive parameter monitoring for each individual fuel. If the fuel is dried prior to establishment of definitive packaging criteria, it should be expected that the individual fuel drying records will need to be more comprehensive than if they are being dried in a "standard" apparatus under specific conditions.

For just about any scenario "accepted" as the preferred method of estimating time and consequences of package failure, there will be many others rejected as less likely or improbable. In a three-layer package, (MPC/DPC and the two-layer overpack), there may be simultaneous, parallel paths to package failure as opposed to time dependent, sequential events leading to a package breach. In other words, while the overpack might be attacked externally from a drift drip on the top, the MPC/DPC would likely experience failure on the bottom. Interstitial space between the carbon steel/incaloy overpack and interstitial space between the DPC/incaloy interface afford a water pathway to facilitate corrosion both internal and external to the incaloy layer.

Drying operations for an SNF package loaded underwater are expected to copy the operations used by the commercial sites to load their fuels. Criteria for determining "dryness" based on time/temperature conditions might be modified to take into account the reduced mass and/or thermal output of the DOE fuels.

Drying individual fuels prior to "dry packaging" might result from a need to address a near-term vulnerability created by long-term underwater storage of a fuel. In such a situation, the mere fact of withdrawal of the fuel from water into a dry, shielded facility for either interim storage or dry SNF packaging provides some assurance of "no free liquids." If an individual element drying step is incorporated into the package loading operations, then data should be captured to reflect time, vacuum, and temperatures. Individually canned fuels that are then placed in interim dry storage may take credit for documented drying and storage conditions prior to canister packaging.

Drying individual canned fuels is a special case situation for certain fuels that have experienced breached cladding in the past, and element canning was a immediate corrective action to allow continued storage in a water environment. Subsequent failures of some of the initial cans resulted in additional over-canning. The fact these fuels have experienced past failures of the containment provided by fuel cladding and individual element cans suggests this is the largest potential source of "free liquid" addition to an SNF package. Some verification will be required that canned fuel does not contain free liquids. In an underwater environment, this method of verification and corrective actions suggest these individually canned fuels will all need to be removed from the storage basins for drying and repackaging. For multiple can layers, it will likely be necessary to remove the cans or provide multiple penetrations verified by radiography to have penetrated all layers up to the fuel element, and then subject this package to time and temperature in a vacuum prior to MPC/DPC package.

Fuels already in dry storage will be maintained in dry storage until the package loading. Credit should be available for the "no free liquids" certification based on documented storage conditions prior to SNF package loading. In the special case of Peachbottom fuels, the aluminum cans may either be removed or drilled to open for liquid drainage prior to dry packaging operations.

Options:

1. Loading individual canisters underwater and subsequently drying them.

   This approach would mirror procedures followed by the commercial industry when placing fuels in their dry storage canisters.

2. Loading individually-canned fuels underwater in a canister and subsequent drying operations of the canister.

   Individually canned fuels stored underwater were created (usually) when "leakage through a failed fuel cladding lead to fission product release into the basin water. Canning was generally conducted underwater, thereby "trapping" water inside the canister. Some canned fuels have had multiple overpack canisters installed.

   Loading these canned fuels underwater will require an intentional breach or removal of the canister lid to allow water removal in the subsequent evacuation of the loaded canister.

Greater reliance must be placed on physical measurements, (e.g., water partial pressures, pressure behavior upon isolation after package evacuation) when the fuels are packaged underwater. Drying individual fuels may have somewhat less rigorous standards where the individual handling of the fuels allows visual verification of lack of free water. The same cannot be said of fuels packaged and sealed underwater. Vacuum drying in either case will not totally address chemically bound (hydrates) or physically trapped water inside the fuel element or assemblies.

3. Drying fuels individually, then loading into a dry package.

   There will be a defined drying procedure specific to the fuel type and its storage condition. This procedure and equipment must provide time/temperature/pressure(vacuum) conditions necessary to assure water removal. Test procedures must identify the residence time, temperature measurements and vacuum conditions, and must meet QA records requirements (to be established).

   The CNF procedure isolates the SNF package after evacuation, and monitors for pressure buildup (indicative of water volatilization). If the vacuum remains below a prescribed limit within a given timeframe, the storage canister is considered free of liquids. NOTE: at this time, this drying procedure has not been "qualified" by the NRC as proof of absence of free liquids in any SNF package to be submitted for acceptance into the repository.

4. Drying fuels individually (perhaps to address an immediate vulnerability) for interim storage and (delayed) loading in an MPC/DPC.

   An immediate vulnerability associated with fuel storage may dictate removal from a water storage environment and interim storage in a dry environment. Prior to insertion in interim storage, the SNF should be dried to reduce the potential for water introduction into a storage rack (both from potential corrosion concerns and perhaps criticality control in the case of HEU fuels). Records of this drying operation should be retained as a quality document, that when coupled with interim storage facility records [air flows, operating conditions (temperatures, humidity)], will provide the necessary assurance of "dryness" when loaded into the MPC/DPC in a dry environment.

5. Loading fuels from existing dry storage.

   Currently, only graphite fuels [Fort St. Vrain and (perhaps) Peachbottom fuels] exist in dry storage. Documentation of storage conditions should be provided to show that there has been no water intrusion into the existing dry storage. Dry stored fuels which have been exposed to water shall be subject to the same standards applied to individually dried fuels.

4.1.2.5 Gas Generation

3.6.1.3.6 Waste Acceptance Criteria (Imposed for all Producer/Custodian waste forms by RW)
A. Confinement
1. Inert cover gas leak rate of the outermost closure shall be less than 1 x 10(-4) atm-cc/sec.

Disposability Standard 2.4.24 - Sealed Disposable Canister Leak Rate

Disposability-Standard Description: Sealed disposable canisters arriving at the MGR will be required to demonstrate that their containment envelope continues to retain its integrity. This disposability standard defines the disposable canister leak-rate limits and tolerances for acceptance at the MGR.

Disposability Standard: The sealed canister shall have no detectible leak rate in the outermost cover at the time of shipment to the MGR. At a minimum, the canister shall be shown via an OCRWM-approved method of fabrication controls and volumetric inspections to be properly sealed, or it shall be leak tested at the time of closure using an OCRWM-approved method. The canister shall be re-evaluated prior to shipment, as required, if suspected of leaking.

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Sections 3.2.3.1.1.3 (B)(7), p. 34 (also applied to disposable canisters containing SNF); and **(2)** *Standard Review Plan for Spent Fuel Dry Storage Facilities* (NUREG 1567).

Documentation to Certify Compliance: Documentation required to demonstrate compliance includes records of fabrication control and volumetric inspections, storage records indicating any evidence of leaking, records of any investigation of possible leaks, and operational records of any corrective action taken if the canister leaked. The canister shall be considered compliant with this standard upon OCRWM approval of the package containing this information.

GUIDANCE: Verification Procedure is <**TBD**>.

3.6.1.3.6.A.2. *After closure, the canistered waste form shall not contain or generate free gas other than air, residuals of air, inert cover, and radiogenic gases with an immediate internal gas pressure not to exceed 150 kPa (22 psia) at 25EC.*

Disposability Standard 2.4.23 - Sealed Disposable Canister Internal Pressure

Disposability-Standard Description: Sealed disposable canisters arriving at the MGR must not be over pressurized in order to be safely handled in the MGR Surface Facility. This disposability standard defines the range of acceptable internal pressures in sealed disposable canisters that can be accepted into the MGR.

Disposability Standard: Sealed SNF canisters (including sealed canisters inside sealed canisters) shall have an internal operating pressure that does not exceed 22 psig (150 kPa) unless the canister design is preapproved by OCRWM. After closure, the canister shall neither contain nor generate free gases other than air, inert cover gas, and radiogenic gases.

Basis for Standard: *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.1.11(A), p. 35 (also applied to disposable canisters containing SNF).

Documentation to Certify Compliance: Documentation required to demonstrate compliance includes manufacturer canister specifications, calculations of gas-generation potential of canister contents over the period between canister loading/sealing and delivery to the MGR, and the description of the calculational method, assumptions, and data used. The canister shall be considered compliant with this standard upon OCRWM approval of the package containing any combination of manufacturer records and operational, analytical, and calculation data that provides a technically defensible case for compliance.

GUIDANCE: The only gases expected to be generated by any DOE SNF are oxygen and hydrogen resulting from either radiolysis of water or as an oxidation or hydriding reaction involving water as the source (TBV). Pressure from pure water vapor is possible if the repository is operated at a temperature greater than that used in the drying process. A process for removing sufficient water, along with the use of getters (chemicals which preferentially and aggressively combine with certain gases), is described in Section 4.1.2.4.

4.1.2.6 RCRA Materials

3.6.1.3.6.B. *RCRA - The CRWMS shall only accept HLW and/or SNF that is not subject to regulation as hazardous waste under the RCRA Subtitle C for disposal in the first geologic repository licensed by NRC under the NWPA. Prior to acceptance for disposal, Producers/Custodians must determine and document that RCRA-regulated wastes are not present, and develop appropriate data to assure relevant state and/or EPA requirements are addressed.*

Disposability Standard 2.1.29 B RCRA and TSCA Regulated Substances in Disposable Canisters

Disposability-Standard Description: The MGR will not operate as a RCRA-regulated or a TSCA-regulated facility, meaning that none of the wastes managed at the facility can be RCRA regulated or TSCA regulated. The term "RCRA regulated≅ is defined for the purposes of this document as "exhibiting a characteristic of, or listed as, a hazardous waste per Nevada Administration Code (NAC) 444.≅ Specifically, Nevada regulation NAC 444.8565 defines a "hazardous waste≅ as:

1. Having the meaning ascribed to it in Nevada Revised Statute (NRS) 459.430

2. Including any (a) hazardous waste or constituent of hazardous waste which is subject to regulation under 40 CFR Part 261; (b) mixture of wastes from commercial chemical products identified in 40 CFR 261.33, which has been discarded or is intended to be discarded, if at least 10 percent of the mixture, by volume, is composed of one or more of its active ingredients; or (c) waste brought into Nevada that is designated as hazardous waste in the state of its origin.

3. Excluding waste containing polychlorinated biphenyls (PCBs), unless mixed with other wastes meeting the definition of "hazardous≅.

Treatment or delisting is required for wastes that meet the definition of "hazardous.≅

TSCA-regulated substances include asbestos and PCBs, which are subject to regulation under NAC 444 and/or 40 CFR 761. These regulations set acceptable levels of TSCA compounds, which cannot be exceeded in SNF delivered to the MGR.

This disposability standard sets limits on the levels of compounds regulated as hazardous or under TSCA to ensure that any regulated hazardous contaminants associated with the SNF are at concentrations below regulatory concern. Additional restrictions on organics are covered in Disposability Standard 2.3.23 (Total Organic Materials in Canistered SNF).

Disposability Standard: No disposable canister containing SNF shall be accepted into the MGR if any of its contents can be classified as a hazardous waste per NAC 444.8586. Under NAC 444.8565, a waste is "hazardous≅ if it **(1)** exhibits RCRA hazardous waste characteristics of ignitability, reactivity, corrosivity, or toxicity in accordance with 40 CFR 261, Subpart C; **(2)** is listed as "hazardous≅ per 40 CFR 261, Subpart D; **(3)** is part of a mixture of wastes from commercial chemical products defined in 40 CFR 261.33 and at least 10 percent of the mixture, by volume, is composed of one or more of the chemicals listed in 40 CFR 261.3; or **(4)** is considered hazardous waste in the state of generation. Also, no disposable canister containing TSCA-regulated substances, as listed in 40 CFR Parts 700-799 at levels such that the material must be reported to the U.S. Environmental Protection Agency and controlled under any provision in 40 CFR Parts 700-799 (or the Nevada Administrative Code 444.940-976), shall be accepted into the MGR. For any material previously regulated under TSCA, the waste owner shall demonstrate that the material is no longer regulated (because of treatment, exemption, etc.). For PCBs, no wastes shall be accepted into the MGR with PCB levels ≥ 50 ppm.

Basis for Standard: **(1)** State of Nevada regulation NAC 444 (including Section 444.9485 that requires that any facility used for the treatment, storage, or disposal of waste containing PCBs must obtain a permit from the state of Nevada); **(2)** MGR prohibition on RCRA waste, as documented in the June 22, 1995 memo from Daniel Dreyfus (DOE-RW) to the Secretary of Energy, Hazel O=Leary; and **(3)** *Mined Geologic Disposal System Advanced Conceptual Design Report* (CRWMS M&O 1996b) March 1996, Vol. 3, Section 6.2.1.3, Table 6-1.

Documentation to Certify Compliance: Canistered SNF shall be considered compliant with this standard upon waste owner submittal, and CRWMS approval, of documentation certifying that the waste has no contaminants that must be managed as hazardous waste or as a TSCA-regulated waste. For commercial SNF, the documentation required by 10 CFR 961 is sufficient, unless there has been an post-irradiation introduction of contaminants that require reclassifying the SNF as hazardous or TSCA-regulated. For other SNF, documentation shall include a description of the fuel relative to the existence of these contaminants at the time of reactor discharge, the SNF storage history, and discussion of any potential introduction, or possible mechanism for introduction, of contaminants that subject the SNF to regulation as a hazardous waste or TSCA-regulated waste.

GUIDANCE: This section provides a description of what constitutes a RCRA material and what can be done to materials so that they do not fall within the requirements for exclusion.

Status

The identification and conditions for acceptance of RCRA materials by a national repository are being evaluated by the NSNFP.

Requirement

The current RW policy on acceptance of RCRA wastes is as follows: (REFERENCE)

(1) Any spent nuclear fuel or high-level radioactive wastes that are regulated as RCRA Subtitle C hazardous wastes may not be disposed in the first repository licensed under the NWPA and
(2) prior to acceptance for disposal, waste generators/producers must determine and document that RCRA-regulated wastes are not present, and develop appropriate data to assure relevant state and/or EPA requirements are addressed.

Background

DOE and commercial spent nuclear fuel is generally a solid containing a mixture of fissionable material (uranium or plutonium), usually in a metallic oxide fuel compound. The fuel compound is then clad with metals such as zirconium, aluminum, or stainless steel to provide structural strength and further prevent release of fission products or corrosion of the fuel compound by preventing contact of the inner fuel with coolant. DOE and commercial nuclear fuels are considered "spent" when there is no longer enough fissionable material left to overcome the poisoning effect of fission products on the nuclear processes in the reactor. These fuels are then removed from the reactor and stored to allow them to thermally cool as the shorter-lived fission products decay. However, some DOE reactors were shutdown for programmatic reasons, and the fuel still has useable lifetime left in the core.

DOE high-level waste is derived from processing spent nuclear fuel. This processing usually is accomplished by dissolving the fuel in acid followed by organic extraction of the fissionable material or precipitation of the material by chemical reactions between the metals and a base. Reprocessing DOE fuels usually generated a waste considered to be hazardous because of its corrosive characteristic and leachable heavy metal content. Very few commercial fuels have been processed but West Valley, New York, is one example where this has been done.

Discussion

NSNFP initiatives regarding RCRA applicability to SNF have included establishing the DOE position that SNF is not waste during interim management pending ultimate disposition. This position is substantiated in DOE-SNF-REP-012 Rev. 0, *Regulatory Status of DOE-Owned Spent Nuclear Fuel*, December 1997. NSNFP initiates also included development of the best available process knowledge and characterization data on DOE SNF for a potential RCRA waste determination on the occasion that DOE SNF is eventually determined to be a waste. This process knowledge and data is detailed in DOE-SNF-REP-002 Rev. 4, *National Spent Fuel Program Report of RCRA Characteristics of DOE-Owned Spent Nuclear Fuel*, December 1997.

Process knowledge is acceptable as means of characterizing materials against the RCRA hazardous waste regulations [40 CFR §262.11 (C) "Standards Applicable to Generators of Hazardous Waste"]. Utilization of process knowledge is further encouraged by the recent "Joint NRC/EPA Guidance on Testing Requirements for Mixed Radioactive and Hazardous Waste," (62 Federal Register 62079, November 20, 1997). In the case that DOE SNF is determined to be solid waste, thereby regulated by RCRA, resolution to some potential RCRA concerns will likely require specific negotiation involving the site responsible for management of the specific fuel and the appropriate local regulatory agency.

Specific requirements for what documentation and data will serve in qualifying DOE SNF for disposition in a repository prohibiting RCRA hazardous waste are yet to be determined. Determination of specific characterization and documentation requirements will require eventual joint EM/RW interaction with the appropriate regulatory agencies having RCRA authority over the repository host state.

Recommendations

For Spent Nuclear Fuel:

In order to be subject to RCRA hazardous waste regulation, SNF must be a solid waste. The current DOE position is that SNF is material in inventory pending ultimate disposition. On the occasion that DOE SNF is determined to be waste, thereby subject to RCRA solid waste regulation, it must appear as a RCRA-listed hazardous waste under 40 CFR §261.31–33, or it must be determined to be a characteristic hazardous waste as detailed under 40 CFR §261.21–24 to be regulated as RCRA hazardous waste. These characteristics are reactivity, toxicity, ignitability, and corrosivity as defined in 40 CFR §261.21–24.

4.1.2.7 Material Compatibility

3.6.1.3.6.C. *Material Compatibility - The HLW and/or DOE SNF and canister materials shall preclude chemical, electrochemical, or other reactions (such as internal corrosion) of the canister or waste package such that there will be no adverse effect on normal handling, transportation, storage, emplacement, containment, or isolation, or on abnormal occurrences such as a canister drop accident and premature failure in the repository.*

Disposability Standard 2.1.20 - Disposable Canister Materials

Disposability-Standard Description: Compatibility is determined by the degree to which the canister compromises waste-package integrity or long-term repository performance. This disposability standard specifies the construction of the disposable canisters accepted at the MGR. This standard also defines the disposable canister shell, lids, and shield plug, and defines basket and neutron-absorber material for multi-element canisters.

Disposability Standard: In addition to being designed to meet the 10 CFR Part 71 requirements for transportation, the disposable canister and any associated internals (basket, neutron absorber material etc.) shall be constructed of the following materials:

- Canister Shell and Lids-Low carbon austenitic stainless steel (e.g ASTM A240), stabilized austenitic stainless steel, or other equally corrosion-resistant alloys such as Alloy 825 or other high-nickel alloys.

- Shield Plug-Depleted uranium, sheathed in a compatible material such as stainless steel or carbon steel; other high density materials except lead (e.g., low carbon austenitic stainless steel (e.g ASTM A240) or stabilized austenitic stainless steel) may be used without sheathing if compatible with the basket and shell materials.

- Basket and Other Internal Structures-Any metal or alloy except lead (or other RCRA-regulated material), provided the materials are chemically compatible with the canister shell, the SNF, and other canister internal components at any combination of temperatures up to 400^{o}C, pressures up to 5 atm, and humidities of 0-100 percent.

- Neutron-Absorber Material-Austenitic stainless steel with finely dispersed boron-containing phase (including Neutronit A 978), hafnium, or zirconium-hafnium alloys. Aluminum boron alloys or aluminum-B_4C composite materials cannot be used where long-term criticality control is an issue.

Other materials may be substituted for any of these components if pre-approved by OCRWM.

Basis for Standard: **(1)** *MPC Subsystem Design Procurement Specification* DBG000000-001717-6300-00001 REV 06 (CRWMS M&O 1996d), July 1996; **(2)** *Analysis of MPC Key Components Material Requirements*. (CRWMS M&O 1997a); and **(3)** 10 CFR 60.135(a)(1).

- Documentation to Certify Compliance: Documentation shall include manufacturer material specifications for the canister. For commercial SNF, the documentation for canistered waste required by 10 CFR 961 is sufficient to demonstrate compliance. DOE SNF and naval SNF shall be considered compliant with this standard upon OCRWM approval of the canister-material portion of the canistered-waste data records package submitted in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste" or "Memorandum of Agreement for Acceptance of Naval Spent Nuclear Fuel."

GUIDANCE: The fuel custodian should verify through data, testing, or peer review that dissimilar materials placed together in the DOE SNF canister will not attack the canister, thus potentially releasing its contents to the overall RW waste package. If requirement 3.6.1.3.5.D.2 (no free liquids) has been properly addressed, no corrosion exchanging liquids should be available to exacerbate material incompatibility.

4.1.2.8 Organic Material

3.6.1.3.6.A3. *After closure, the canistered water form shall not contain detectable amounts of organic materials.*

Disposability Standard 2.3.23 - Organic Materials in Disposable Canisters Containing SNF

Disposability-Standard Description: Organic materials may accelerate corrosion by providing nutrients for microbes, may form soluble species with radionuclides, may adversely affect hydrogen ion concentrations, or may assist in formation of radionuclide colloids. It is recognized that these organics may be a contaminate on some assembly surface, or may be introduced into the canister either during canister cleaning (e.g., degreasing) or by spilling/dripping of lubricants or fluids used in processing and handling equipment. Repository postclosure performance requires that strict limits be placed on organics in the wastes accepted by the MGR. This disposability standard establishes acceptable levels of total organic material in sealed disposable canisters entering the MGR if these organics or their degradation products accelerate radionuclide transport. It is subdivided into standards for single-element canisters (Standard 2.3.23.1), canisters with multi-element commercial assemblies (Standard 2.3.23.2), canisters of DOE SNF (Standard 2.3.23.3), and canistered naval SNF (Standard 2.3.23.4). Regulatory requirements governing organics are covered in Disposability Standard 2.1.29 (Restrictions on RCRA and TSCA Regulated Substances in Disposable Canisters).

Standard 2.3.23.3 - Organic Materials in Canisters Containing DOE SNF

Disposability-Standard Description: This standard covers acceptable organic limits in canisters containing DOE-SNF that will be co-disposed with vitrified HLW.

Disposability Standard: The co-disposed DOE-SNF canister accepted into the MGR shall have as little organics as possible. No component of the canister (e.g., shield plug) shall be made of organic materials. Total organics in the canister shall not exceed 17 µg to 900 g (100 µg to 5.4 kg for the waste package, equally distributed among the five HLW canisters and the one DOE-SNF canister) (TBV). The range reflects the number below which compliance with this standard is likely, and the number above which non-compliance with this standard is likely. The region between the two numbers represents organic-concentration levels where compliance with the Standard is uncertain until the performance assessment models are refined and the range converges to a single limit. [**NOTE**: Once Performance Assessment models are expanded to better address organics contaminant in SNF, it is envisioned that this Standard will be refined to address specific organics of concern, rather than the current total-organic limit.]

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b) Section 3.2.3.1.1.11(B), p. 35 (also applied to disposable canisters containing SNF); **(2)** *Mined Geologic Disposal System Advanced Conceptual Design Report* (CRWMS M&O 1996b) March 1996, Vol. 3, Section 6.2.1.3, Table 6-1; and **(3)** Performance Assessment expansion of the WASRD requirement, as documented in *Preliminary Performance Assessment Input to Waste Acceptance Criteria for Organic Material Limits within the Potential Emplacement Drifts*.

Documentation to Certify Compliance: Documentation required to demonstrate compliance includes an assessment of the levels of organics present in the loaded canister, the methodology used to complete the assessment, and assumptions and source data used in the assessment. For SNF where organics can reasonably be expected to exist in levels at or above this Disposability Standard limit, adequate assessment (even including physical measurement if not convincing otherwise) must be provided to make a technically defensible argument that the SNF complies with the standard.

GUIDANCE: Organics are restricted from the repository for reasons that (1) they may radiolyze and pressurize the waste containers as well as be a source of free hydrogen, or (2) they may break down and form complex compounds with the fuel or fuel components which migrate rapidly out of the repository. The only source of organics in DOE SNF are the metallurgical mounts (met mounts) made from fuels under postirradiation evaluation (PIE) and include everything from sections of single fuel pellets to the entire center bundle of the LOFT core. The epoxy compound used to make these mounts was most commonly **TBD**. A process for preparing these met mounts for including in canisters to be sent to the repository is described below. **(TBD)**

3.6.1.3.6.D. *Surface Contamination*

GUIDANCE: NO GUIDANCE REQUIRED: This requirement is relative to preparation and handling of the canister after the fuel has been placed inside and the canister has been sealed.

3.6.1.3.6.E. *Canister Label*

GUIDANCE: Same as 3.6.1.3.5.E (see section 4.2.1.4 Identification of Canister)

3.6.1.3.6.F. *Safeguards Verification*

1. DOE SNF and/or HLW Verification

GUIDANCE: NO GUIDANCE REQUIRED: Guidance in CRD appears clear and complete.

3.6.1.3.6.F.2. *Material Control and Accounting*

GUIDANCE: Completion of the fuel data form in Appendix B is sufficient to satisfy section (a) of this requirement. Additional material control and accounting requirements (b, c, d, and e) appear clear and complete.

3.6.1.3.6.F.3. *Observation by RW*

GUIDANCE: NO GUIDANCE REQUIRED.

4.2 Preparation of Physical Package

The physical portion of the repository package is the canister in which the SNF is contained for shipment to, handling, and disposal at a national repository. The following sections are concerned with obtaining, loading, sealing, and handling this canister as part of its preparation for transfer to a national repository.

3.6.1.3.7 Waste Acceptance Criteria (Imposed for specific HLW and/or DOE SNF by RW)
3.6.1.3.7.1 HLW - Not Applicable
3.6.1.3.7.2 Canistered DOE SNF

4.2.1 The Canister

A. Transportation and Storage Certification

GUIDANCE: This guidance document does not cover requirements specific to transportation or interim storage.

B. Disposal Criteria

GUIDANCE: No guidance required. DOE SNF shall support overall repository performance requirements by meeting all acceptance criteria for the specific fuel grouping as bounded in the Viability Assessment Design and as specified in the License Application. Failure to comply with these criteria may result in the need for the Custodian to modify or repackage the DOE SNF.

4.2.1.1 Canister Weights and Dimensions

C. Canister Specifications (e.g., dimensions, weight, etc.) (TBV)

Disposability Standard 2.2.20 - Dimensional Envelopes for Disposable Canisters Containing SNF

Wastes arriving at the MGR must be within prescribed size limits in order to be unloaded from casks, handled safely in the surface facilities, and loaded into disposal containers. The two principal reasons for specifying size limits and tolerances are interfaces with waste handling equipment (minimum and maximum reach, dimensions in staging racks, etc.) and compatibility with cavities in disposal containers. This disposability standard, subdivided into several standards, covers the dimensional envelope (including tolerance adjustments) for disposable SNF canisters that will be accepted into the MGR. It is subdivided into standards for single-element canisters (Standard 2.2.20.1), canisters with multiple assemblies (Standard 2.2.20.2), canisters with DOE SNF (Standard 2.2.20.3), and canistered naval SNF (Standard 2.2.20.4).

Standard 2.2.20.3 - Dimensional Envelope for Canisters Containing DOE SNF

Standard Description: Canisters of DOE SNF will not be opened prior to emplacement and must be of a size and shape to fit into the designated disposal-container cavity. These cavities may be in disposal containers designed either to co-dispose HLW and DOE SNF or are exclusively for DOE SNF. This standard defines the acceptable dimensions for disposable DOE SNF canisters to ensure compatibility with disposal-container cavities.

Disposability Standard: The loaded canisters of DOE SNF (excluding SNF of commercial origin) shall have the capability to stand upright without support on a flat horizontal surface, and shall comply with one of the following dimensional envelopes:

- Canisters to be placed in the center of a "co-disposal" waste package (termed "center location canisters" or "CLCs") shall have a diameter less than 18.0 inches (45.7 cm)(TBV) and overall lengths of less than 118.307 in (3.005 m) for "short" canisters and less than 180 in (4.57 m) for "long" canisters

- Canisters interchangeable with HLW canisters (termed "outside location canisters" or "OLCs") shall have

  - Diameter less than 24.63 inches (62.56 cm) and overall lengths less than 118.307 inches (3.005 m) for "short" canisters

  - Diameter less than 24.69 inches (62.71 cm) and overall lengths less than 180 inches (4.57 m) for "long" canisters

- Hanford MCO canisters shall have a diameter less than 25.310 inches (64.3 cm) and an overall length greater than 118 in (3.00 m) and less than 165.435 in (4.202 m).

The canisters shall have a maximum cylindricity such that they are capable of fitting without forcing (when lowered vertically) into a right-circular cylindrical cavity whose dimensions are:

- CLC: 18.**xx** inches (45.**xx** cm) by 119.69 inches (3.04 m) for the "short" canister (TBV) and 18.**xx** inches (45.**xx** cm) by 181 inches (4.60 m) for the "long" canister (TBV)

- OLC: 25.19 inches (63.98 cm) by 119.69 inches (3.04 m) for the "short" canister and 25.59 inches (65.00 cm) by 181 inches (4.60 m) for the "long" canister

- MCO: 26.102 inches (66.3 cm) by 166.232 inches (4.2223 m).

All dimensions include positive and negative tolerances.

Basis for Standard: **(1)** *Interface Control Document for the U. S. Department of Energy Spent Nuclear Fuel to the Mined Geologic Disposal System for Mechanical and Envelope Interfaces.* A00000000-01717-8100-00007, REV 00; and **(2)** *Evaluation of Co-disposal Viability for Aluminum-Clad DOE-Owned Spent Fuel; Phase I, Intact Co-disposal Canister* (CRWMS M&O 1997c), p. 42.

Documentation to Certify Compliance: Documentation required to demonstrate compliance with this standard includes the loaded canister length and diameter reported to an accuracy of +0.5 inch in length and +0.1 inch in diameter (TBV). DOE SNF shall be considered compliant with this standard upon OCRWM approval of the canistered-waste data records package submitted in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-

Level Radioactive Waste." Where canister design specifications were previously provided to OCRWM, it is acceptable to report only the canister design type and any loaded-canister dimensional deviation from the design specification.

Disposability Standard 2.2.21 B Weight of Loaded Disposable Canisters Containing SNF

Canistered SNF arriving at the MGR must meet prescribed weight limits in order to be handled safely in the surface facilities, and to ensure that waste packages do not exceed weight limits once the canistered SNF is loaded into them. This standard defines the maximum allowable weight (including tolerance adjustments) for canisters accepted into the MGR. It is subdivided into standards for single-element canisters (Standard 2.2.21.1), canisters with multiple assemblies (Standard 2.2.21.2), canisters with DOE SNF (Standard 2.2.21.3), and canistered naval SNF (Standard 2.2.21.4).

Standard 2.2.21.3 B Weight of Canisters Containing DOE SNF

Standard Description: Canisters of DOE SNF (excluding those of commercial origin) must be of a weight to ensure that waste packages loaded with these canisters do not exceed total weight limits. Candidate waste packages include those that co-dispose HLW and DOE SNF, and ones designed exclusively for DOE SNF. This standard defines the acceptable weight limits for DOE SNF canisters to ensure compatibility with loaded waste package weight limits.

Disposability Standard: Canisters containing DOE SNF shall have weights that do not exceed:

∃ Center Location Canister: 5000 pounds (2300 kg) for the loaded "short" canister (TBV) and 7500 pounds (3400 kg) for the loaded "long≅ canisters (TBV)

∃ Outside Location Canister: 9000 pounds (4100 kg) for the loaded "short≅ canister (TBV) and 14,000 pounds (6120 kg) for the "long≅ canister (TBV)

∃ Hanford MCO: 19,142 pounds (8700 kg) (TBV).

All weights include positive and negative tolerances.

Basis for Standard: **(1)** *Interface Control Document for the U. S. Department of Energy Spent Nuclear Fuel to the Mined Geologic Disposal System for Mechanical and Envelope Interfaces.* A00000000-01717-8100-00007, REV 00.

Documentation to Certify Compliance: Documentation required to demonstrate compliance with this standard includes the loaded canister weight reported to an accuracy of ±500 pounds (230 kg)(TBV). Where canister weights fall within 1000 pounds (460 kg) of the disposability-standard upper limit, weights shall be reported to the nearest 100 pounds (46 kg) and the measurement methodology shall be documented. DOE SNF shall be considered compliant with this standard upon OCRWM approval of the canistered-waste data records package submitted in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste.≅

GUIDANCE: The NSNFP is developing a standardized canister(s) which will satisfy the repository requirements. The fuel custodian should be in contact with the NSNFP and have the particular canister requirements of this fuel in the planning cycle. This planning cycle is part of the Master Logic Schedule and is maintained by the NSNFP.

4.2.1.2 Canister Handling

H. Canister Handling

Disposability Standard 2.2.22 - Capability to Lift Disposable SNF Canisters Vertically with Remote Handling Fixtures

Canistered SNF arriving at the MGR in transportation casks must be unloaded by raising the cask to a vertical position and removing the canisters. Once unloaded, disposable canisters are then loaded directly into disposal containers. These canisters must be capable of being moved vertically (lifted or lowered) fully loaded using remotely engaged hooks, grapples or other lifting fixtures at the various stages of unloading, moving, and storage. Canisters shall have lifting features that will be accessible and structurally sound to allow lifting vertically with canister-handling equipment. This standard defines these features. It is subdivided into standards for single-element canisters (Standard 2.2.22.1), canisters with multiple assemblies (Standard 2.2.22.2), and canistered naval SNF (Standard 2.2.22.3).

Standard 2.2.22.1 - Capability to Lift Single-Element Canisters

Standard Description: This standard covers the compatibility of disposable single-element canisters containing commercial SNF to properly interface with the MGR surface facility remote handling fixtures.

Disposability Standard: Disposable single-element canisters shall have the same interface with lifting fixtures and grapples as that for uncanistered assemblies. The canister shall have permanently attached lifting fixtures, and the combined canister and lifting fixture shall be compatible with canister diameter limits from Disposability Standard 2.2.20.1. The canister and lifting fixture shall be designs utilized at a facility licensed under 10 CFR Parts 50 or 72 and shall have the structural integrity to be lifted vertically.

Basis for Standard: **(1)** Repository Design (Surface) design-team recommended revision to the *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.2.7.A and B, p. 44; and **(2)** *MPC Subsystem Design Procurement Specification* DBG000000-001717-6300-00001 REV 06 (CRWMS M&O 1996d), Section 4.1.5.

Documentation to Certify Compliance: Documentation needed to demonstrate compliance includes a description of the canister lifting features/interfaces and a certification that these features/interfaces are in good physical condition on the canisters to be delivered. The documentation for canistered waste required by 10 CFR 961 is sufficient to demonstrate compliance with this Standard. For DOE SNF of commercial origin, the SNF shall be considered compliant with this standard upon OCRWM approval of the canister data records package supplied by DOE-EM in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste."

Standard 2.2.22.2 - Capability to Lift Multi-Element Canisters (excluding Naval SNF)

Standard Description: This standard covers the compatibility of disposable multi-element canisters containing SNF to properly interface with MGR surface-facility remote handling fixtures. Canisters containing naval SNF are covered in Standard 2.2.22.3.

Disposability Standard: The canister shall have either an intact permanently attached lifting fixtures or an undamaged interface (e.g., bolt holes) that allow easy attachment of the lifting fixture. The combined canister and lifting fixture shall be compatible with canister diameter limits in Disposability Standard 2.2.20, and the lifting fixture must be operable within this dimensional envelope. The canister and lifting fixture shall be designs utilized at a facility licensed under 10 CFR Parts 50 or 72 and shall have the structural integrity to be lifted vertically.

Basis for Standard: Repository Design (Surface) design-team recommended revision to the *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.2.7.A and B, p. 44.

Documentation to Certify Compliance: Documentation needed to demonstrate compliance includes a description of the canister lifting features/interfaces and a certification that these features/interfaces are in good physical condition on the canisters to be delivered. The documentation for canistered waste required by 10 CFR 961 is sufficient to demonstrate compliance with this Standard. For DOE SNF of commercial origin, the SNF shall be considered compliant with this standard upon OCRWM approval of the canistered-waste data records package submitted in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste."

GUIDANCE: The standard canister being designed by the NSNFP will include tooling and handling equipment required by both the DOE SNF custodian/packagers and RW operations at the repository. See Appendix C for details of the handling fixtures (TBD).

4.2.1.3 Sealing Process

Disposability Standard 2.1.21 B Disposable Canister Sealing

Disposability-Standard Description: Disposable canisters other than those with screened ends shall be sealed prior to delivery to the MGR in order to maintain material accounting, avoid any release of canister contents, and prevent introduction of water or contaminants. This disposability standard establishes general sealing specifications.

Disposability Standard: Disposable canisters, excluding those with screened ends, shall be vacuum dried (or using a method with equivalent results), backfilled with an inert gas (e.g., helium) and sealed. There is no prescribed method of sealing canisters, although the preference is seal-welded. Regardless of the sealing method used, the resulting canister shall prevent the loss or introduction of particulates, liquids, and oxygen or radioactive gases. The canister also shall prevent the introduction of oxygen in quantities that can accelerate degradation of the SNF or ignite any combustible materials within the canister (which are forbidden per Disposability Standard 2.1.25).

The canister, once sealed, shall meet the leak-rate defined in Disposability Standard 2.4.24 (Sealed Canister Leak Rates).

Basis for Standard: **(1)** *Controlled Design Assumptions Document* (CRWMS M&O 1997b), Key Assumption 005 (assumed to apply to canisters in the waste package as well as to the waste package itself); and **(2)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.1.2(A)1, p. 32 (assumed to also apply to disposable canisters containing SNF); **(3)** 10 CFR 74.55(a)(2); and **(4)** 10 CFR 60.135(a)(2).

Documentation to Certify Compliance: Documentation required to demonstrate compliance with this standard includes the method of drying, the criterion for defining when the drying was complete, the method for backfilling the container with an inert gas (e.g., helium), a description of the type of canister seal, the method used to seal the canister, certification that sealing procedures were properly followed, and the date the canister was sealed. For commercial SNF, the documentation for canistered waste required by 10 CFR 961 is sufficient to demonstrate compliance. DOE SNF and naval SNF shall be considered compliant with this standard upon OCRWM approval of the canister-sealing portions of the canistered-waste data records package submitted in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste≅ or "Memorandum of Agreement for Acceptance of Naval Spent Nuclear Fuel.≅

Disposability Standard 2.4.23 B Sealed Disposable Canister Internal Pressure

Disposability-Standard Description: Sealed disposable canisters arriving at the MGR must not be over pressurized in order to be safely handled in the MGR Surface Facility. This disposability standard defines the range of acceptable internal pressures in sealed disposable canisters that can be accepted into the MGR.

Disposability Standard: Sealed SNF canisters (including sealed canisters inside sealed canisters) shall have an internal operating pressure that does not exceed 22 psig (150 kPa) unless the canister design is preapproved by OCRWM. After closure, the canister shall neither contain nor generate free gases other than air, inert cover gas, and radiogenic gases.

Basis for Standard: *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.1.11(A), p. 35 (also applied to disposable canisters containing SNF).

Documentation to Certify Compliance: Documentation required to demonstrate compliance includes manufacturer canister specifications, calculations of gas-generation potential of canister contents over the period between canister loading/sealing and delivery to the MGR, and the description of the calculational method, assumptions, and data used. The canister shall be considered compliant with this standard upon OCRWM approval of the package containing any combination of manufacturer records and operational, analytical, and calculation data that provides a technically defensible case for compliance.

Disposability Standard 2.4.24 B Sealed Disposable Canister Leak Rate

Disposability-Standard Description: Sealed disposable canisters arriving at the MGR will be required to demonstrate that their containment envelope continues to retain its integrity. This disposability standard defines the disposable canister leak-rate limits and tolerances for acceptance at the MGR.

Disposability Standard: The sealed canister shall have no detectible leak rate in the outermost cover at the time of shipment to the MGR. At a minimum, the canister shall be shown via an OCRWM-approved method of fabrication controls and volumetric inspections to be properly sealed, or it shall be leak tested at the time of closure using an OCRWM-approved method. The canister shall be re-evaluated prior to shipment, as required, if suspected of leaking.

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Sections 3.2.3.1.1.3 (B)(7), p. 34 (also applied to disposable canisters containing SNF); and **(2)** *Standard Review Plan for Spent Fuel Dry Storage Facilities* (NUREG 1567).

Documentation to Certify Compliance: Documentation required to demonstrate compliance includes records of fabrication control and volumetric inspections, storage records indicating any evidence of leaking, records of any investigation of possible leaks, and operational records of any corrective action taken if the canister leaked. The canister shall be considered compliant with this standard upon OCRWM approval of the package containing this information.

The sealing process for the canister is **<TBD>**

4.2.1.4 Identification of Canister

I. Tamper-Safe and Inspection

Canistered DOE SNF (DPCs or MPCs) shall be designed to permit use of an NRC tamper-safe seal as provided in 10CFR70.51(e)(1)(i) for safeguards purposes. This seal may be achieved through the use of an NRC-approved tamper-indicating device. It must be designed such that the integrity of the weld or tamper-indicating devices may be inspected periodically.

3.6.1.3.6.E Canister Label

1. *The canister label shall be a material compatible with the canister material and the waste package material*
2. *The canister label shall be visible on the top and side of the canister.*
3. *The canister label shall not cause the dimensional limits to be exceeded.*

Disposability Standard 2.1.26 B Disposable-Canister Labeling

Disposability-Standard Description: Safe handling and proper material control and accounting of disposable canisters require that individual canisters handled by the various MGR systems be marked with a unique identifier that remains visible up to the end of the repository retrieval phase. These unique markings shall be large enough and located such that they are readily visible prior to and during canister handling. This disposability standard covers the size, location, and type of permanent markings for disposable canister.

Disposability Standard: The canister shall have a unique alphanumeric identifier that is located prominently on the canister, is visible (via remotely operated cameras) from the top of the canister, is integral to the canister, can be expected to remain legible through all handling activities (including retrieval up to 100 years after emplacement), does not impair canister integrity, is chemically compatible with the canister, and maintains the dimensional limits of the canister. Specifically, the identifier shall:

∃ Be located on the top external lid of the canister
∃ Still be visible with handling fixtures attached
∃ Consist of embossed or stamped numbers/letters at least 1-inch tall
∃ Follow a numbering convention consisting of a four-digit site/reactor identifier, then a dash, then a four-digit sequential number (OCRWM to provide site/reactor identifier codes).

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.1.17, p. 37; **(2)** *Spent Nuclear Fuel Verification Plan*, Revision 0 (DOE 1997), March 1997, Section 2.2, p. 4-6; and **(3)** *MPC Subsystem Design Procurement Specification* DBG000000-01717-6300-00001 REV 06 (CRWMS M&O 1996d), Section 4.9 (F) and (G).

Documentation to Certify Compliance: The canistered SNF shall be considered compliant with this standard upon waste owner submittal, and CRWMS approval, of documentation providing the canister identification number (ID), the locations of this number on the canister, the type of identifier (stamped or engraved, embossed, etc.), size of letters/numbers on the ID (letter height in inches, rounded to the nearest 0.25 inches), and physical condition of the label (like new, one or more characters partially illegible due to damage, completely illegible due to damage, one or more characters partially illegible due to corrosion or crud build-up, completely illegible due to corrosion or crud build-up) when viewed using remote or underwater video monitoring equipment.

Disposability Standard 2.1.27 B Tamper Indicating Devices on Canisters not Seal-Welded

Disposability-Standard Description: Safeguards and security requirements defined by the NRC rely in part on the use of tamper-indicating devices (TID) on transportation casks and canisters not weld-sealed to ensure that SNF has not been removed or disturbed. This disposability standard mandates the use of these devices on canisters that are not seal-welded and contain SNF regulated by the NRC as strategic special nuclear material.

Disposability Standard: There are no provisions for TIDs on canisters containing exempted special nuclear material, as defined in 10 CFR 73.26(g)(3), or on canisters that are weld-sealed. Other canisters containing strategic special nuclear material shall have an NRC-approved TID in accordance with NRC material control and accounting requirements in 10 CFR 74.55(a)(1) and (2).

Basis for Standard: **(1)** 10 CFR 73.26(g)(3); and **(2)** 10 CFR 74.55(a).

Documentation to Certify Compliance: For commercial SNF, the documentation for material control and accounting required by 10 CFR 961 is sufficient to demonstrate compliance. Applicable DOE SNF and naval SNF shall be considered compliant with this standard upon OCRWM approval of the canistered-waste data records package (specifically data on the presence, manufacturer, and installation date of the TID) submitted in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste.≅

GUIDANCE: A tamper-safe seal is not required for a canister that has been seal welded. The canister must be labeled, however, in accordance with the requirements E above. The alphanumeric identifier to be used is (TBD). The method and location of applying the identifier to the canister is (TBD).

4.2.2 Contents

There are certain acceptance requirements that relate to the complete fuel canister, as opposed to parameters of the individual fuels alone. These requirements are the canister radiation level, heat output of the canister, potential for a criticality in the canister, and isotopic inventory of the canister. Criticality considerations in the canister must include the canister by itself and as a component in a final waste package deposited in the repository.

4.2.2.1 Radiation Level

3.6.1.3.7.2.D. *Radiation Protection Criteria* - *The canistered DOE SNF shall not exceed a maximum gamma-ray dose rate of 10(5) rem per hour and a maximum neutron dose rate of 10 rem per hour at a distance of 1 meter from any accessible surface without intervening shielding at the time of acceptance.*

GUIDANCE: Calculations can be made to assure that when a particular SNF is placed in the standard canister defined in Appendix C, it will satisfy the above requirement, or a dummy canister section of the proper material and dimensions of the standard canister can be test loaded in a hot cell and measured for radiation level at 1 meter, or both of the above can be utilized. Measurements will be taken after the fuel is loaded in the actual canister destined for the repository and if the radiation limits are exceeded, the canister would have to be unloaded and reconfigured—not a desirable scenario.

3.6.1.3.7.2.E. *Physical Protection (10 CFR Part 73) Exemption for High External Radiation Dose Rate* - *The canister shall have a total external dose rate in excess of 100 rem per hour at a distance of 3 feet (~ 0.9 meter) from any accessible surface without intervening shielding at the time of acceptance.*

Disposability Standard 2.4.22 B Sealed Disposable Canister Surface Contamination

Disposability-Standard Description: The surface contamination on sealed disposable canisters received at the MGR should be minimized to permit operations that are consistent with ALARA principles. This is because they will be handled separately from uncanistered assemblies in areas that are designed to remain relatively free of contamination. Limits on canister surface contamination are adapted from the requirements of 49 CFR 173.443 that apply to casks. This disposability standard specifies the upper limit on allowable surface contamination on disposable canisters received at the MGR.

Disposability Standard: The level of non-fixed (removable) radioactive contamination on sealed-canister external surfaces at the time of canister loading into a transportation cask for delivery to the MGR shall not exceed 220 dpm/100 cm^2 for alpha emitting radionuclides and 2200 dpm/100 cm^2 for beta and gamma emitting radionuclides.

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.1.12(A), p. 35 (also applied to disposable canisters containing SNF); **(2)** 10 CFR

20.1101(b); **(3)** 10 CFR 71.87(I); and **(4)** 49 CFR 173.443.

Documentation to Certify Compliance: Documentation required to demonstrate compliance can include facility operational information that precludes surface contamination at levels above the Standard limit, or can report results of physical inspection of the canister surface. Operational information must present a technically defensible argument why the canister can reasonably be assumed to comply with the Standard. Physical inspection can include any OCRWM-approved procedure such as that defined in 49 CFR 173.443 (alpha and beta/gamma levels measured through radioassay on absorbent material that has been wiped, using moderate pressure, over a representative 300 cm^2 surface area of the canister). The canister shall be considered compliant with this standard upon OCRWM approval of the package containing any combination of operational, analytical, and calculation data.

GUIDANCE: There will be many cases where this self-protecting limit is not met by older, decayed out DOE SNF. These fuels should be identified as soon as possible by their specific custodians and an exclusion sought for their acceptance. The NSNFP will develop the process for satisfying the intent of this requirement. This requirement was originally made to deter theft of strategic nuclear material (SNM). NRC no longer considers this a necessary requirement and should accept the normal process of DOE preparation, transport control, and repository handling procedure as satisfying the intent of this requirement. NRC has not invoked this requirement for 6 years and doesn=t want to start now. Any material not meeting this criterion, however, should be identified and RW notified that it is below the self-protection limits.

Status:

The guidance in this section may undergo modifications as decisions are made relative to low radiation level SNF, especially in the contact handleable classification.

The NSNFP is addressing this issue and will update the guidance as necessary. No schedule has been set for modifications.

4.2.2.2 Heat Generation

3.6.1.3.7.2.F. *Thermal Considerations* **-** *After Packaging for disposal, the thermal output of the canistered DOE SNF shall be such that the total disposal package does not exceed a thermal output of 14.2 kilowatts (TBV) at the time of acceptance.*

Standard 2.4.20.3 B Thermal Output for Canisters Containing DOE SNF

Disposability-Standard Description: This standard lists the maximum acceptable thermal output of a DOE-SNF canister that will be co-disposed with vitrified HLW.

Disposability Standard: No DOE SNF canister shall have a thermal output in excess of **TBD** kW at the time of shipment to the MGR. [**NOTE**: There will be different standards for each of the various canisters]

Basis for Standard: **(1)** *Preliminary Design Basis for WP Thermal Analysis*

BBAA00000-01717-0200-00019 REV 00 (CRWMS M&O 1997d), Section 7.2.25.

Documentation to Certify Compliance: Documentation required to demonstrate compliance includes a measured thermal output or, if reactor operating histories are available, that data needed to calculate overall canister thermal output. This includes the quantities and types of SNF present in the canister, and the initial enrichment, burn-up, and date-of-last-criticality of each assembly or piece of fuel present. DOE SNF shall be considered compliant with this standard upon OCRWM approval of the canister thermal output measurements or inventory, initial enrichment, burn-up, and date-of-last-criticality information in the assembly data records package supplied by DOE-EM in accordance with the AMemorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste.≅

GUIDANCE: Each fuel should be evaluated for thermal output, or at least given an upper bound on its output. A prediction should be made on the thermal output of a standard canister with the material. If a sufficient need arises, the NSNFP will supply a calorimeter to test the thermal output of the fuel (TBD). Once the thermal output of the fuel is known, ranged, or bounded, possible packaging alternative can be defined.

The allowable output of a standard canister will depend on the output of the companion canisters in the total waste package. Determination of the allowable thermal output from particular canisters will require an ongoing interface and feedback link between the fuel custodian, the NSNFP, and RW.

Status

The final determination of allowable heat generation rate within a repository canister will depend on the design operating temperature of the repository. This design has not been completed to date but is the subject of evaluation as part of the Total System Performance Analysis (TSPA). The NSNFP is providing input to this evaluation and will include the results from these analyses in updates to this guidance document.

Thermal Loading of Repository Canisters

Requirements

After packaging for disposal, the thermal output of the canistered DOE SNF shall be such that the total disposal package does not exceed a thermal output of 14.2 kilowatts at the time of acceptance. [10CFR60.135(a)(2)]

Discussion

The regulation for thermal loading of individual waste packages results from a need to manage and control the ultimate temperature of the repository. The 14.2 kilowatt on a DOE SNF package is roughly equal to the expected thermal output of a waste package filled with commercial assemblies. As the requirement above states, a DOE SNF waste package submitted for acceptance to the repository must show, by test or with calculations, that the submitted package has a power generation rate of 14.2 kilowatts or less.

The maximum allowable thermal output of a DOE SNF canister depends on what is placed in the canister for the final disposal package. HLW canisters have from 40W output (Hanford) to 600W output

(SRS), or a total thermal output range for a four HLW canister waste package of 160W to 2,400W. For the disposal option of codisposing a DOE SNF canister with HLW canisters, the maximum thermal loading of a DOE SNF canister would be 11.8kW. Where multiple DOE SNF canisters are placed in one disposal package, the maximum thermal loading of a particular DOE SNF canister would be 11.8kw/n, where n is the number of DOE SNF canisters in one waste package.

Verification by calculation: Use of an ORIGEN (or equivalent code) run to calculate the thermal output of particular fuels, and then calculating the thermal load of the combination of all of the fuels in a single package, is an acceptable procedure for estimating the maximum thermal load of the package. The packaging organization should determine the margin of error on these calculations to guarantee that the total package thermal load will not exceed 14.2 kilowatts.

Verification by experiment: Performing a calorimeter test on each element or canister planned for inclusion in the waste package is an acceptable process for determining the thermal load of the waste package. An evaluation of the margin of error in this testing procedure should be made as insurance against exceeding the 14.2 kilowatt limit of the total package.

If required, an experimental procedure will be developed to determine the heat generation rate. The conditions dictating the need to develop an experimental procedure for heat generation rates are TBD.

4.2.2.3 Criticality

3.6.1.3.5.C. *Criticality*

1. *All HLW and/or DOE SNF systems shall be designed to ensure that together with the components of the CRWMS, a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety during processing, transporting, handling, storage, retrieval, emplacement, and isolation. All system components (e.g., DOE SNF and any canister) must be such that the system of which they are part will comply with this requirement.*

2. *All HLW and/or DOE SNF systems shall be designed for criticality safety under normal and accident conditions.*

3. *The calculated effective multiplication factor (k_{eff}) must be sufficiently below unity to show at least a 5% margin, after allowance for bias in the method of calculation and the uncertainty in experiments used to validate the method of calculation. All system components (e.g., DOE SNF and any canister) must be such that the system of which they are part will comply with this requirement.*

Disposability Standard 2.3.22 B Loaded Disposable-Canister Criticality Potential

Disposability-Standard Description: Multi-element canisters (single-element canisters are exempt from this standard) placed into disposal containers without being opened must provide sufficient criticality controls to ensure adequate repository preclosure safety and acceptable postclosure performance. The canister must provide these criticality controls both prior to loading into a waste package and over the design life of the waste package (hundreds to thousands of years). During this design life, there are substantial changes to the SNF, canister, waste package, and repository environment that must be assumed to occur that degrade canister criticality controls. This disposability standard reflects the current NRC position on repository postclosure criticality (10 CFR

60.131(h)), which requires establishing limits on criticality potential through the use of an effective neutron multiplication factor (k_{eff}). This disposability standard establishes limits on k_{eff} and defines the methodology and assumptions to be used in calculating this factor.

Disposability Standard: Multi-element canisters of SNF entering the MGR shall be shown to have a calculated k_{eff} of 0.95 (TBV) or less (under optimum water-moderated conditions) after allowance for bias in calculation methods and uncertainty in the empirical data used to validate the method of calculation (see Reference 2 below), assuming the following conditions:

∃ The most reactive configuration exists due to any combination of hardware and SNF degradation, ranging from everything intact to extensive hardware degradation (e.g., baskets have collapsed and degraded into component corrosion products such as iron oxides from carbon steel basket materials) such that all fuel assemblies are touching (for a corrosion-resistant zircaloy clad low-enriched U fuel), or assemblies are completely degraded (if a stainless steel or aluminum-clad fuel)

∃ SNF reactivity has increased to whatever peak level after reactor discharge may exist once the SNF is delivered to the MGR (if burn-up credit is used, or the SNF has a high Pu content).

∃ All soluble supplemental neutron absorber materials (e.g., boron from the metal borides of borated stainless steel), have degraded and are no longer part of the waste package. Neutron absorbers recognized to be insoluble (e.g., hafnium and gadolinium phosphate) can be assumed to remain, but the possibility of physical separation between the absorbers and the fissile material must be evaluated.

In lieu of this approach, the more comprehensive methodology of Item 2 in the ABasis for Standard≅ section may be followed.

Basis for Standard: **(1)** *Waste Acceptance System Requirements Document* (WASRD) (DOE 1996b), Section 3.2.3.1.1.6 (C), p. 34 (also applied to disposable canisters combining SNF); and **(2)** *Disposal Criticality Analysis Methodology Technical Report* B0000000-01717-5705-00020 REV 01 (CRWMS M&O 1996e).

Documentation to Certify Compliance: Documentation required to demonstrate compliance with this standard includes the calculated k_{eff}, the calculation used to determine this number, and an explanation of assumptions and data used in the calculation.

GUIDANCE: Individual components, containers, and the final canister configuration must be either analyzed for criticality safety according to the above requirements and 10CFR131(b)(7) or proven to be critically safe by an acceptable evaluation or logic process. This evaluation must assume a constant geometry during the various movement and handling loads to which the canister and its internal components will be subjected during transportation to and deposition into the repository.

Evaluation of criticality safety following closure of the repository is contingent on assumptions for degradation of the waste package. These assumptions are (TBD).

Status

Evaluation of criticality in repository canisters is the subject of an ongoing study. The NSNFP is an active participant in this study and will factor the results of the evaluations into updated versions of this guidance document as they are available.

Requirement

10CFR60.131(b)(7): Criticality control. All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste shall be designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Each system shall be designed for criticality safety under normal and accident conditions. The calculated effective multiplication factor (k_{eff}) must be sufficiently below unity to show at least a 5% margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation.

Discussion

The factors controlling potential criticalities in the repository are being debated by EM, RW, and the scientific community. The process by which fuel packages deteriorate, availability of water, and movement of materials are all factors in the potential criticality of SNF in a repository. Some of these items which will influence the final procedure for satisfying criticality requirements are listed below;

(A) Postclosure monitoring will not be required.

Basis: At this time, no explicit regulations with respect to postclosure monitoring and testing have been promulgated. Considerable difficulties can be anticipated in performing postclosure safety analyses for SNF disposal. Postclosure application of the double contingency principle in 10CFR60.131(b)(7) appears to be especially difficult. A closed repository likely precludes the ability to monitor for and correct deficiencies. Waste placement in a repository is intended to eliminate monitoring. Indeed, it can be claimed that postclosure monitoring is not compatible with the geologic repository concept. Thus, regulatory requirements (policy) to eliminate the need for postclosure monitoring should be established.

(B) Very low probability (**TBD**) of a repository criticality is acceptable.

Basis: Given enough time, groundwater corrosion or geological processes will breach the waste package and allow groundwater to enter. Water can leach fixed neutron poisons and uranium from the waste packages. Differential migration of HEU and neutron absorber through the repository can lead to either separation of neutron absorber from HEU remaining at the canister location or deposition and concentration of HEU elsewhere. Either circumstance creates the potential for a criticality within the repository (this statement is true even for the commercial SNF). Thus, the probability of a criticality in the repository must not be zero. Rather, the probability of a criticality should be very low. In the reactor world, an event or a process is considered negligible if the probability of such an event is less than **TBD** per year.

(C) Even if a criticality did happen, such an event will have no consequence to the repository performance or increase the risk to the public.

Basis: A preliminary performance assessment (Reference: SAND94-2563 vol 2 chapter 10 and vol 3 Appendix B) concluded that such an event will have no consequence to the repository performance or increase the risk to the public. For the Nuclear Regulatory Commission (NRC) to issue a repository license, further evaluations will likely be necessary to show that this preliminary conclusion is technically correct.

Present RW Approach: Based on two preliminary studies, RW presently believes that for typical commercial SNF (with less than 2% enrichment at end of life (EOL), the probability of a criticality is significantly low and thus such an event will be acceptable by the Nuclear Regulatory Commission (NRC). However, these design analysis have not been official reviewed nor accepted by the NRC at this time. The analyses are based on 21 commercial PWR SNF per each disposal package. Each disposal package contains nominally 9.74 MTHM (Reference TSPA-95 Page 3-15). The total fissile loading per each disposal package of low enriched fuel is about 200 kg U-235. Higher enriched fuels may be much more limited in the total amount of U-235 allowed per package.

GuidanceXAnalysis and Evaluation Methodology

For the DOE SNF, there are several approaches to assuring the disposal packages will not have any higher criticality probability than the commercial SNF. The simplest method is to dilute all highly enriched uranium (HEU) DOE SNF with depleted uranium down to the commercial SNF level. A second approach for the DOE HEU is to determine what the fissile limit could be based on an established acceptable criticality probability and method (based on definitive scenarios) to determine criticality potential. Other methods include a) the separation of the fissile material from the DOE SNF thus assuring a final waste form that could not lead to a criticality or b) limiting the amount of fissile materials in each final disposal canister.

All of these methods involve one of the following principles:

- limiting the mass of the fissile material in each disposal canister
- limiting the enrichment level close to the natural level by dilution
- removing the fissile materials from the SNF by processing.

Many of these methods require the SNF=s basic form be altered (such as dilution or processing). Limiting the fissile mass may be one option that could maximize the loading (thus minimize the number of canisters) without changing the basic form of the SNF. One of the possible solutions, as suggested by the OCRWM, is to dispose both the high-level waste (HLW) with the HEU SNF in the same disposal canister. By doing so, the potential increase in the number of canisters will not take up any more repository space. As part of an EM evaluation effort recently completed for the DOE uranium aluminum (U-Al) SNF, various planning values have been suggested for the various uranium enrichment. Another DOE EM evaluation team (INEEL SNF Evaluation Team) is presently evaluating the remaining DOE HEU SNF (Navy SNF is excluded) and will be suggesting a fissile loading limit for these fuels.

For DOE SNF with enrichment at the commercial SNF level (approximately 2 wt% enrichment), up to 200 kg U-235 could be loaded into final disposal canisters. For DOE SNF with enrichment above the commercial SNF level (greater than 2 wt% enrichment), they should be loaded into final disposal canisters in accordance with the recommendation as concluded by the INEEL SNF Evaluation Team. As part of this recommendation, other potential means to further reduce the likelihood of a repository criticality may also be implemented. As recommended by the Nuclear Waste Technical Review Board in their report to the U.S. Congress in 1995, these potential means include the placement of depleted uranium in the disposal packages and the repository drifts to minimize the potential for HEU reconcentration away from the disposal packages.

Another part of the criticality evaluation involves the dissolution of moderator-displacing filler materials or neutron absorbers. Presently, the commercial SNF disposal package basket will likely be constructed from borated stainless steel (SS). One of the challenges of the OCRWM waste package design group is to show that the chromium borides within the SS basket structure will not completely disappear over geologic time. The reason is that the longer (and most) the borides stay with the corrosion products or the SNF, the less likely a criticality would occur. As an example, the OCRWM design analysis estimated that if about 5 wt% of the borides were retained with the commercial SNF (retained with the corroded basket), the earliest possible criticality could occur in 1 million years. Thus, the retention of the neutron absorber materials with the SNF will play an important role to mitigate the potential of a criticality. Unless the dissolution information in a repository environment of a neutron absorber material is available, each site should consider using the borated SS as the neutron material in the packages. By using the same neutron absorber material as the commercial SNF, DOE SNF would benefit from all the solubility information used for the commercial SNF packages.

4.2.2.4 Isotope Inventory and Leachability Effects

Disposability Standard 2.3.20 B Radionuclide Inventories in Canistered SNF

Repository preclosure safety and acceptable long-term performance require that radionuclide levels in SNF entering the MGR be controlled. Establishing absolute radionuclide limits on individual canisters, based on assessments of long-term performance, is arbitrary because these assessments only consider the total repository inventory. This disposability standard establishes general limits on selected radionuclides, but provides a mechanism for accepting individual assemblies with higher levels of these radionuclides. It is subdivided into standards for commercial single-element canisters (Standard 2.3.20.1), canisters with multiple commercial assemblies (Standard 2.3.20.2), DOE-SNF canistered SNF (Standard 2.3.20.3), and canistered naval SNF (Standard 2.3.20.4).

Standard 2.3.20.3 B Radionuclide Inventories in Canisters Containing DOE SNF

Standard Description: This standard requires that information be provided on radionuclide inventories in DOE-SNF canisters delivered to the MGR.

Disposability Standard: Where reactor operating histories are available and NRC-approved neutronics codes are available for calculating radionuclide inventories, provide burn-up and cool-down times for SNF assemblies. Where such information is not available, provide radionuclide-inventory information for the following radioisotopes:

^{227}Ac, ^{241}Am, ^{242}Am, ^{243}Am, ^{14}C, ^{36}Cl, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{135}Cs, ^{129}I, ^{93}Nb
^{94}Nb, ^{59}Ni, ^{63}Ni, ^{237}Np, ^{231}Pa, ^{210}Pb, ^{107}Pd, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{226}Ra
^{228}Ra, ^{79}Se, ^{151}Sm, ^{126}Sn, ^{99}Tc, ^{229}Th, ^{230}Th, ^{232}Th, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U
^{93}Zr

There are currently no restrictions on the concentration of individual radionuclides in individual canisters of DOE SNF, although terms of the repository operating license and permits may place additional restrictions. [**NOTE**: This disposability standard does not include any controls to address preclosure safety issues, and is based on the assumption that localized (individual assembly) high radionuclide loadings are not problematic for postclosure performance (as long as the assembly does not significantly increase the total repository inventory for a given radionuclide). If further analysis, or a change in assumptions (e.g., how human intrusion scenarios are addressed), requires that an individual canister or waste package not contain high concentrations of a given radionuclide, a more stringent standard may be required.]

Source of Standard: Performance Assessment expansion of *Total System Performance Assessment - 1995*: *An Evaluation of the Potential Yucca Mountain Repository* (CRWMS M&O 1995b), as documented in *Limits on Radionuclide Concentrations in SNF and HLW from a Long Term Postclosure Total System Performance Assessment Perspective* (draft memo).

Documentation to Certify Compliance: DOE SNF shall be considered compliant with this standard upon OCRWM approval of the burn-up and date-of-last-criticality information (if available) in the assembly data records package, and calculated or measured radionuclide levels for other SNF, in accordance with the "Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste.≅ If such data are not available, alternatives methods for calculating radionuclide concentration or for statistically representative sampling/measurements may be used if pre-approved by OCRWM.

Disposability Standard 2.3.21 B Total Fissile Material in a Disposable Canisters

[Placeholder for any additional limits on total fissile material beyond that covered in Disposability Standard 2.3.22.]

Status

The number of isotopes, and the accuracy by which the quantities are determined, are presently under evaluation. The NSNFP is supplying input to this research and will include the results from these evaluations in updates to this guidance document.

Requirements

The waste acceptance criteria regarding the amounts and leachability rates of isotopes acceptable in the repository is <TBD>.

Discussion

Accurate knowledge of fission and activation products is needed for calculating shielding requirements, release/dose calculations, and assuring SNF self-protection. Accurate knowledge of actinides in general is needed for release/dose calculations, and specifically for fissile material content used with criticality safety evaluations and IAEA accountability. The number of isotopes required for calculation of these various parameters, and the accuracy with which the isotopic concentration must be known, is presently under evaluation as part of the performance assessment of the repository. This information will be available <TBD>.

GuidanceXAnalysis and Evaluation Methodology

Determination of radionuclide inventories must necessarily have two of the following three parameters:

- Beginning-of-life (BOL) fissile material inventory

- End-of-life (EOL) fissile material inventory

- Burnup.

Burnup determinations necessarily require use of ORIGEN code calculations, given initial fuel composition and operating characteristics of the specific reactor. Lacking such detailed information for many of the older DOE SNF types, some conservative estimates will be required.

Leach/Solubility Testing

10CFR60.112 The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated processes and events.

10CFR60.135 (a) High-level-waste package design in general. (1) Packages for HLW shall be designed so that the in situ chemical, physical, and nuclear properties of the waste package and its interactions with the emplacement environment do not compromise the function of the waste packages or the performance of the underground facility or the geologic setting.

40CFR191.13 (a) Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based upon performance assessments, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall: (1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A); and (2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).

YMP/94-05 (LAAO) Chapter 5 Section 5.2.1.12.1 Solubility: Analysis of potential for dissolution of all waste and WP materials and impurities expected to be on or in them. For SNF, determine inventories of C-14, Cs-135, and I-129 in gap and grain boundaries and on cladding surface. Analyze any other radioactive species whose dissolution might pose a problem for containment/release, or demonstrate that there are no others. Support for conclusion that SNF dissolution at clad surface is congruent. Analysis of dissolution rates in all waste and WP materials of concern. Discuss effect of varying water temperature, pH, carbonate concentrations, surface area, amount and type of surface oxidation, etc. Conclusions as to effect of above calculated dissolution rates on ability of WP to contain radionuclides over required containment period and over 10,000 year period.

Discussion

(1) Leach/solubility information will be required to show the engineered barrier system (including the waste package design) in general does not compromise the functional performance of the underground facility or the geologic setting.

Basis: To show that the engineered barrier system (including the waste package design), in general, does not compromise the functional performance of the underground facility or the geologic setting, a performance assessment will be conducted to show that the repository and the engineered barrier system meet the performance requirements. To conduct the performance assessment, the leach/solubility information for the DOE SNF form will have to be available as input data.

Present RW Approach: RW is presently conducting various tests to gather the leach and solubility information for the commercial SNF. These tests are being performed at various locations such as the Pacific Northwest National Laboratory (PNNL), Argonne National Laboratory-East (ANL-E), and Lawrence Livermore National Laboratory (LLNL). However, the OCRWM will be utilizing other concepts such as bounding, grouping, and similarity to qualify all other nonstandard commercial SNF. This nonstandard SNF includes fuel that is breached, water logged, higher burnup, higher fissile loading (at end of life), possible older commercial SNF that do not have all the information required by 10CFR961 standard contract, and other variations from the standard commercial fuels.

GuidanceXAnalysis and Evaluation Methodology

For the DOE SNF destined for the repository, the fuel with the similar properties (such as fuel meat, burnup value, condition, etc.) as the commercial, the leach and solubility data of the commercial SNF should be used in the performance assessment evaluation. Thus, very little or no testing of these fuels should be required. If the DOE SNF has similar properties but has a higher burnup value or larger surface area per volume as compared to the commercial SNF, the leach and solubility data will be adjusted to reflect the differences.

For the DOE fuels that are different from the commercial SNF, existing leach and solubility data will be utilized whenever possible. If this information is not available, other means of gathering them will be considered first. The methods include bounding by another fuel type, or similarity, sensitivity analysis showing that no impact to performance due to small quantity even if leach and solubility are infinite, or any other method acceptable by the OCRWM waste acceptance system.

As the last resort, based on sensitivity analysis showing that accurate leach and solubility information for an SNF type are required, testing and characterization of the DOE SNF will be considered. Before such a test will be funded, the entire DOE SNF inventory requiring such test will be consolidated and evaluated to optimize such testing efforts through bounding, grouping, similarity etc. These efforts have been initiated at the INEEL SNF Program to minimize the testing efforts and the technique could be utilized throughout the DOE complexes.

If the fuel is well characterized with respect to (1) initial material content and (2) operating history, the fuel can be packaged and sealed prior to calculating the end of life (EOL) conditions and isotopic inventory. The assumption is that sufficient information is known at the time of sealing for an ORIGEN (or equivalent) analysis to be made at a later date.

5. QUALITY ASSURANCE

The Nuclear Regulatory Commission has established in 10CFR60, Subpart G, the quality assurance requirements for licensing a national repository. RW has implemented the requirements of Subpart G in the OCRWM Quality Assurance Requirements and Description (QARD) DOE/RW-0333P Document. The SNF physical package and SNF data package must meet requirements of the QARD for the fuel to be accepted for disposal by RW.

5.1 Site QA Programs

The following activities regarding DOE-owned SNF are subject to the QARD:

- Characterization of SNF for data collection to be used as input of SNF to an NRC-licensed repository or storage facility.

- Acceptable conditioning of SNF for interim storage or into final form for disposal in an NRC-licensed storage facility or repository;

- Handling and packaging of SNF for interim storage or into final form for disposal in an NRC-licensed storage facility or repository.

EM sites responsible for characterization, conditioning, or packaging DOE SNF for disposal in a national repository will develop and implement QA programs that apply the QARD to SNF activities. Those QA programs shall include site-specific procedures by which SNF activities are controlled.

The NSNFP QA Program Manager has the responsibility for review, acceptance, and oversight of QA programs for SNF activities at EM sites. The site operating organizations will submit SNF QA program and procedures for acceptance through a formal process established by the NSNFP QA Program Manager. Following acceptance of the QA programs the SNF QA Program Manager and QA staff will perform oversight activities to provide confidence that DOE SNF will meet disposal acceptance requirements.

5.2 Qualification of Data

Data used to support OCRWM acceptance of DOE-owned SNF are subject to requirements in the QARD. Data must either be collected under a QA program which is in conformance with the QARD, or be qualified for use by other methods described in the QARD.

Information about DOE SNF consists of data generated by contemporary activities and data previously generated during manufacture, irradiation, and storage of fuel. Data generated by contemporary activities including SNF characterization will be collected under QA programs that have been accepted under the QARD. Previously collected data that are used in support of disposition of SNF in a national repository must be qualified by methods described in the QARD.

Appendix E of this document contains guidance for application of QARD requirements for qualifying data for DOE SNF.

6. REFERENCES

1. **Civilian Radioactive Waste Management System Requirements Document (CRD)**, Revision 5B, DOE QAP-6.2, Review, DI:A00000000-00811-1708-00003 REV 05B, August 1998.

2. NUREGS - 1297, 1298

3. **DOE/RW/0333P Quality Assurance Requirements and Description** Revision 7, U. S. Department of Energy Office of Civilian Radioactive Waste Management, Washington, D. C., April 4, 1997.

4. DOE Orders - see Reference (1), pg C-4.

5. **DOE/EIS-02030F Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement**, U. S. Department of Energy Office of Environmental Management Idaho Operations Office, April 1995. Modified Record of Decision for the Programmatic SNF Management and INEL Environmental Restoration and Waste Management Program issued March 1996. Court Order (Settlement Agreement, Civil No. 91-0054-S-EJL, October 17, 1995 between the State of Idaho, the Department of Energy and the Department of the Navy.)

6. Code of Federal Regulations - see Reference (1), pg C-1.

7. **Idaho Nuclear Technology Engineering Center Fuel Receipt Criteria Questionnaire**, FORM INTEC-6468X(10-95) REV. 2, Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, October, 1995.

8. Fuel Acceptance Criteria for Savannah River Site

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