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**PRELIMINARY WASTE ACCEPTANCE CRITERIA FOR THE
ICPP SPENT FUEL AND WASTE MANAGEMENT
TECHNOLOGY DEVELOPMENT PROGRAM**

**L. L. Taylor
R. Shikashio**

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**Westinghouse Idaho
Nuclear Company, Inc.**

PREPARED FOR THE
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FOREWORD

The Department of Energy has operated nuclear facilities at the Idaho National Engineering Laboratory (INEL) to support national interests for several decades. Since 1953, it has supported the development of technologies for the storage and reprocessing of spent nuclear fuels (SNF) and the resultant wastes. However, the decision to discontinue reprocessing of SNF has left nearly 768 MT of SNF in storage at the INEL with unspecified plans for future dispositioning. Past reprocessing of these fuels for uranium and other resource recovery has resulted in the production of 3800 m³ calcine and a total inventory of 7600 m³ of radioactive liquids (1900 m³ destined for immediate calcination and the remaining sodium-bearing waste requiring further treatment before calcination). These issues, along with increased environmental compliance within DOE and its contractors, mandate operation of current and future facilities in an environmentally responsible manner. This will require satisfactory resolution of spent fuel and waste disposal issues resulting from the past activities.

A national policy which identifies requirements for the disposal of SNF and high level wastes (HLW) has been established by the Nuclear Waste Policy Act (NWPA)[1982]. The materials have to be conditioned or treated, then packaged for disposal while meeting U.S. Environmental Protection Agency (EPA) and Nuclear Regulatory Commission (NRC) regulations. The spent fuel and HLW located at the INEL will have to be in a form and package that meets these regulatory criteria.

The emphasis of Idaho Chemical Processing Plant (ICPP) future operations has shifted toward investigating, testing, and selecting technologies to prepare current and future spent fuels and waste as appropriate for final disposal. This preparation for disposal may include mechanical, physical and/or chemical processes, and may differ for each of the various fuels and wastes.

There are three distinct categories of materials stored at ICPP requiring varying degrees of funding and development support. Treating the liquid wastes stored in the stainless steel tanks located above the Snake River aquifer is the first priority. Such actions are needed to support compliance with the Resource Conservation Recovery Act (RCRA) requirements for secondary containment of hazardous wastes. A Notice of Noncompliance (NON) was issued on January 29, 1990, by the EPA because the concrete vaults providing secondary containment are subject to attack by the acidic solutions stored in the tanks were a leak to develop. A consent order to resolve this NON has been negotiated between DOE and the State of Idaho. The parties agreed to milestones for removal of all liquid waste stored in existing tanks. Final consent order signatures were obtained on April 3, 1992.

Next in priority is the treatment and packaging of the dry, granular calcine generated from years of prior operations at ICPP. While continued operation of the New Waste Calciner Facility (NWCF) and calcine production is in violation of LDR since May 8, 1992, the State of Idaho has signed a letter of consent to continue calciner operation as best demonstrated available technology (BDAT) for solidification of current (non-sodium) liquid wastes in storage. Ultimately, there will be a need to provide facilities to vitrify and store the calcine prior to shipment to a repository.

Finally, the various spent nuclear fuels will require some treatment/packaging prior to disposal. Present efforts are directed toward transferring some of the fuels from older storage basins to a newer facility. A dry fuel storage facility is also being evaluated for interim fuel storage prior to geological disposal.

1
2 Determining a proper direction for the development program and a basis for future waste form
3 evaluation suggested the need for Preliminary Waste Acceptance Criteria (PWAC). A WAC
4 normally would be the responsibility of the repository operator; however, since a repository for all
5 of the INEL wastes has not been identified, the SF&WMTDP developed a PWAC to guide
6 technology development. The PWAC defines the waste form characteristics and criteria necessary
7 to assure compliance with federal regulations. To confirm that the established criteria are sound
8 and have a high probability of meeting federal regulations, performance assessment (PA) studies
9 will be conducted by constructing computer models of waste form placement in hypothetical
10 repositories.
11

12 *Note: A performance assessment is an internationally accepted method required by the Code of*
13 *Federal Regulations (CFR) to analyze engineered disposal systems for proper isolation of*
14 *radioactive waste. PA's quantify aspects of waste disposal decisions by identifying and examining*
15 *the effects of various processes and events on the performance of the disposal system and*
16 *estimating the cumulative releases of radionuclides and hazardous materials as agreed with*
17 *appropriate regulatory agencies. For further details concerning the PA for INEL materials, please*
18 *refer to the Initial Performance Assessment of the Disposal of Spent Nuclear Fuel and High-Level*
19 *Waste Stored at Idaho National Engineering Laboratory - Vol 1 & 2 (to be published 12-93*
20 *[SAND93-2330]).*

21
22 Throughout the SF&WMTDP, various program documentation (i.e., planning, technical development, and
23 implementation documents) will be developed and distributed to identify and present program criteria,
24 plans, reports, etc. The Preliminary WAC is one of several technical development documents required to
25 support the INEL SF&WMTDP Program. The preparation of the PWAC fulfills an agreement between
26 DOE and the State of Idaho that identifies waste form(s) and options that would be followed by DOE in
27 preparing the materials for final disposal.
28

29 A more complete discussion of the issues covering regulatory compliance and legislated requirements
30 placed on nuclear materials with respect to disposal is included as an attachment to the PWAC transmittal
31 document.
32
33
34

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1.0 Introduction

The purpose of this document is to identify requirements to be met by the Producer/Shipper of SNF/HLW in order for DOE to be able to accept the packaged materials. This includes defining both standard and nonstandard waste forms (see glossary for definitions).

2.0 Repository Characteristics

Several geological sites with differing characteristics have been proposed in recent years. The 'generic' repositories listed herein pertain to a characteristic type of media (salt or granite) rather than to a specific location. The performance assessment conducted to support selection of a future repository measures how that medium performs in conjunction with one or more engineered barrier systems.

For any waste disposal to be permitted in a geological repository, four basic criteria must be satisfied¹, in addition to the compliance issues, with respect to regulatory guidelines.

- Geological Criteria: The geology (topography, lithology, thickness, and structure) shall provide suitable assurance that the repository shall not be breached by natural phenomena as long as the waste is considered hazardous to humans.
- Hydrologic Criteria: The hydrology of the site shall not allow a possible breach of the repository by dissolution of the geological medium, thereby releasing the waste.
- Tectonic Criteria: The repository site shall be suitably stable, and no geological activity shall occur to breach the repository as long as the stored waste is hazardous to humans.
- Physico-Chemical Criteria: The geological medium must not accelerate reactions with the waste material, and must not pose a threat to humans.

¹ Reference: Chapter 4. "Hypothetical Disposal Systems in Geological Media", Proposed Description of the Geological Barrier Surrounding the Hypothetical Salt and Igneous Rock Repositories (draft), Sandia National Laboratories, December 1992.

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Salt Repository

Typically, the use of the word 'salt' in describing a repository refers to common salt, or sodium chloride (NaCl). Geological salt formations occur from the evaporation of many materials, to include: halite (NaCl), sylvite (KCl), gypsum ($\text{CaSO}_4 \cdot x\text{H}_2\text{O}$), anhydrite (CaSO_4), limestone (CaCO_3), and dolomite ($\text{Ca} \cdot \text{MgCO}_3$). The shape of a salt formation is often described as either 'bedded' or 'domed'.

One significant advantage of common salt formations with respect to highly enriched uranium (HEU) disposal is the quantitative exclusion of water (<3%), which allows for a higher HEU loading per canister with minimal risk of criticality. A disadvantage is the increased corrosion rates of typical canister materials in a salt environment.

Granite Repository

Igneous rock formations such as basalt, granite, or tuff offer characteristics of permeability, porosity, heat conductivity, and density thought necessary for a repository host rock.

The saturated, fractured granite proposed herein offers the advantage of a batholith structure that is generally stable toward seismic events, and the general lack of a ground water source within the matrix.

A drawback in saturated, fractured rock media with respect to the disposal of waste material is the likelihood of water collection in fractured areas due to percolation and/or movement of water through the medium. The potential for water accumulation is a significant concern due to moderation when dealing with HEU materials.

3.0 Responsibilities/Organization

The responsibilities, relating to the PWAC, of the organizations implementing the criteria contained herein are defined in the following sections.

3.1 DOE

3.1.1 DOE Headquarters

The DOE Headquarters Office of Environmental Restoration and Waste Management (DOE/EM), along with the DOE/ Repository Project Office (RPO) will be responsible for the final approval of the WAC [Note: this PWAC is for a hypothetical repository], and the Quality Assurance Program Plan (QAPP) for the [TBD] Waste Characterization Program, along with any subsequent revision to these documents.

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3.1.2 DOE Operations Office

The DOE Operations Office is responsible for administering a program to demonstrate the safe placement and disposal of radioactive wastes resulting from defense activities and programs of the United States, which are at this time exempted from regulation by NRC. [NOTE: while NRC rules and regulations do not specifically apply to defense wastes, the combination of defense wastes with commercially generated nuclear wastes may invoke application of NRC rules to future storage when combined in a common repository].

3.1.3 DOE Repository Project Office

The DOE/RPO serves as the principal repository representative to any regulatory and oversight organizations. This office also is responsible for administering the various aspects of interfaces, documentation, reviews, surveillance, and repository activities in general.

3.2 NRC

[TBD]

3.3 Repository Offices

3.3.1 Interim Storage Facility

Interim storage needs at the repository site will be identified based on anticipated schedules for receipt of waste packages. In any case, the interim storage capacity will not exceed [TBD] months worth of shipments at the typical, projected rate of shipment to the repository.

3.3.2 Transportation

Transportation of the radioactive waste shipments will be coordinated by the Repository Project Office in compliance with applicable DOE, DOT and NRC regulations. The Producer shall make the arrangement for individual shipments.

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3.3.3 Geological Disposal Site

Salt Repository

The generic salt repository for this PA was modeled on the site characterization of the Waste Isolation Pilot Plant near Carlsbad, New Mexico. A detailed description of the assumptions for this repository can be found in the "Initial Performance Assessment of the Disposal of Spent Nuclear Fuel and High-Level Waste Stored at Idaho National Engineering Laboratory Volume 2: Appendix B".

Granite Repository

The generic granite repository for this PA was modeled on the site characterization of the Lac Du Bonnet site in Canada. A detailed description of the assumptions for this repository can be found in the "Initial Performance Assessment of the Disposal of Spent Nuclear Fuel and High-Level Waste Stored at Idaho National Engineering Laboratory Volume 2: Appendix B".

3.4 Waste Generation Site(s)

Waste generator and/or storage sites are responsible for preparing plans, including QA plans, that document the methods used by the site(s) to comply with each of the requirements/criteria identified in this document. These plans must include all activities pertaining to waste certification, preparation for transportation of waste packages, compliance with RCRA, and fulfillment of PA requirements as appropriate. Methods of compliance with each criterion/requirement shall be documented or specifically referenced. The waste generator and/or storage sites are responsible for the preparation of accurate data packages and assuring that the data packages match the payload shipped.

The DOE/RPSO assures regulatory compliance of the waste and provides formal waste acceptance notification. All incoming wastes will undergo acceptance testing and in the event a waste package does not meet stated requirements, the Repository and the Shipper shall have procedures and agreements in place for return of the waste to the Producer.

It is the responsibility of each waste generator and/or storage site to ensure that any activities that are subcontracted meet the applicable requirements specified herein. Subcontracted activities will be subject to audits by the Producer and/or DOE as appropriate.

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3.5 Waste Acceptance (WA) Overview

The Nuclear Waste Policy Act (NWPAA) assigned DOE the responsibility for management and disposal of SNF and HLW wastes of domestic origin.

3.5.1 WA Background

The process and the schedule for management and disposal of SNF and HLW wastes were specified initially in the NWPAA (1982). Additionally, a Presidential Memorandum dated April 30, 1985, stated that there was no compelling reason to build a separate repository for defense HLW; therefore, the waste will be placed in a civilian geologic repository. In the Nuclear Waste Policy Amendments Act (NWPAA)[1987], Yucca Mountain, Nevada was designated for characterization as the candidate site for a geologic HLW/SNF repository. However, legislated limits for Yucca Mountain and projections of future commercial SNF, along with timing on the treatment of defense wastes, suggest a second repository will be needed at some time in the future.

The NWPAA defines SNF as the fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. As used in this document, SNF is defined to include the nonfuel components and hardware as identified in 10 CFR 961. HLW is defined as the highly radioactive material resulting from the reprocessing of SNF. This includes liquid waste produced directly in reprocessing, any solid material derived from such liquid waste that contains fission products in sufficient concentrations, and other highly radioactive material that has been determined by the Nuclear Regulatory Commission, consistent with the law, as requiring permanent isolation. As used in this document, HLW is defined to include commercial and defense HLW. The Civilian Radioactive Waste Management System (CRWMS) will accept both SNF and solidified HLW. [Note that the 10 CFR 60 definition of HLW includes SNF.]

In the NWPAA, Congress identified that long-term storage of SNF in Monitored Retrievable Storage (MRS) facilities is a safe and reliable option for management of SNF. In the NWPAA, Congress authorized the Secretary of Energy to site, construct, and operate one MRS facility, and as stated in 10 CFR 72, the MRS facility will have an initial 40-year license term with the option for renewal by the NRC. The MRS is to provide temporary storage of SNF until the SNF is shipped to the geologic repository for disposal. HLW will be shipped from the Producer sites directly to the geologic repository.

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1
2 A graphical representation of the SNF/HLW flow of materials is
3 shown in Figure 3.5-1.
4

3.5.2 System Definition

5
6
7 Sections 302(a)(1) and 302(a)(5) of the NWPA authorize the Secretary
8 to enter into contracts with Producers and take title to their SNF and
9 HLW as expeditiously as practicable upon request, in return for
10 payment of fees.

11
12 The functions, function flow diagrams, N-Square diagrams, system
13 description, cross-reference of the allocation of functions to segments,
14 and assumptions to accomplish this task are contained in the following
15 sections.

3.5.2.1 Waste Acceptance System Functions - Accept Waste

16
17
18
19
20 With the mission of Waste Acceptance (WA) identified as
21 managing the acceptance of SNF and HLW into a
22 repository from the Producers of such waste and to account
23 for the inventory of the waste in the CRWMS, a functional
24 analysis identified the essential functions that the system
25 must perform. Physical System Requirements Accept Waste
26 documented the first iteration of that functional analysis
27 and was used as the primary reference source of the
28 functions for WA identified in this document.

29
30 The WA function includes the activities necessary to meet
31 the requirements for establishing the criteria for waste
32 acceptance and all the preparation (including contractual)
33 and operation activities to take title, and maintain control
34 and accountability of the waste in a manner that protects
35 the health and safety of the public and maintains the
36 quality of the environment.
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Figure 3.5-1
ICPP Spent Fuel and Waste Management
Technical Development Program Interface Diagram

1
2
3 **3.5.2.2 Waste Acceptance Functional Relationship**
4

5 Functional identification is accomplished in this document
6 by the use of function flow diagrams to depict functional
7 relationships, and by the use of N-Square diagrams to
8 identify inputs and outputs of a function. Throughout the
9 iterative system engineering process, each design phase
10 involves a more progressively detailed functional analysis.
11 The functions identified in this document are the system-
12 level functions that are required to meet the mission.
13

14 Figure 3.5-2 shows the function flow diagram for the
15 primary functions of the repository system.
16

17 The function flow diagrams identify the primary
18 interactions between the functions in accepting SNF and
19 HLW. Additional function interactions are identified on
20 the N-Square diagrams (see Figure 3.5-3). On the N-
21 Square diagrams, the Waste Acceptance functions appear
22 in the bold outlined boxes on the diagonal. The double-
23 lined boxes on the diagonal identify an interface with a
24 function external to WA. Inputs to a function appear in
25 the column above and below the function. Outputs from a
26 function appear in the row to the left and right of a
27 function.
28

29 **3.5.2.3 System Description**
30

31 Waste Acceptance is an integral part of the total repository
32 system in which all elements, segments, subsystems, and
33 facilities are optimized as parts of a single system. WA
34 will interface the repository with the Producers by
35 observing preparatory operations during the waste
36 acceptance process, and perform other functions if
37 determined necessary or desirable by future federal
38 mandates, studies, analyses, operational requirements,
39 etc. Figure 3.5-4 shows the relationship of WA to the
40 repository. The top-level architecture is in the WA system
41 Architecture.
42

Legend	
Dotted Box	Function Outside CRWMS
Solid Box	Functions Within CRWMS

Figure 3.5-2 Manage Waste Disposal Function Flow Diagram

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Provide Private Industrial Support			Unloaded Transportation Casks on Transporters Prime Movers	Utilities Equipment, Parts, and Supplies Vehicles Emergency Response	Utilities Equipment, Parts, and Supplies Vehicles Emergency Response	
	Provide Waste (Purchase and Producers)	Contracts/Agreements SNF/HLW Fees Documentation Loaded Transportation Casks on Transporters Reports				
	Unloaded Transportation Casks on Transporters Reports Contract/Agreements Regulations	Accept Waste 1.1	Loaded Transportation Casks on Transporters Documentation Reports SNF/HLW	Reports SNF Documentation	Reports SNF/HLW Documentation	Reports
Procurement Contracts		Unloaded Transportation Casks on Transportation Reports	Transport Waste 1.2	Loaded or Unloaded Transportation Casks on Transporters Documentation Reports HLW/SNF	Loaded or Unloaded Transportation Casks on Transporters Documentation Reports SNF/HLW	Radiation Radionuclides Emissions (Heat, Liquid Effluent) Reports
Solid Waste Salvage Parts and Equipment Packaged Low Level Radwaste		Reports	Loaded or Unloaded Transportation Casks on Transporters Documentation Reports SNF	Store Waste 1.3	Reports SNF Documentation	Radiation Radionuclides Emissions (Heat, Liquid Effluent) Reports
Solid Waste Salvage Parts and Equipment Packaged Low Level Radwaste		Reports	Unloaded Transportation Casks on Transportation Reports	Reports	Dispose of Waste 1.4	Radiation Radionuclides Emissions (Heat, Liquid Effluent) Reports
		Laws Rules Orders Policies	Laws Rules Orders Policies Licences	Laws Rules Orders Policies Licences	Laws Rules Orders Policies Licences	Affect Environment (Physical, Legal, etc)

Legend: Dotted Line Outside CRWMS Boundary
Solid Line Within CRWMS Boundary

Double Box Functions Outside CRWMS
Thick Box Functions Within CRWMS

Figure 3.5-3 N-Square Chart for 1. Manage Waste Disposal

Figure 3.5-4 CRWMS Architecture

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3.5.2.4 Major Considerations and Assumptions

Generally, the following assumptions are intended to provide guidance to proceed with waste acceptance activities, and are based on informed technical opinion, preliminary study results, and accumulated institutional experience.

- A. The standard HLW form accepted into the repository will be : (1) vitrified borosilicate glass or glass-ceramic and (2) packaged SNF from Savannah River, Hanford, INEL, West Valley, and other DOE facilities.
- B. WA will accept fissile material (typically in an SNF form) for storage at a designated MRS facility, and SNF and HLW for disposal at the Mined Geologic Disposal Site (MGDS).
- C. Receipt of SNF packages at the MRS facility will commence in the year [TBD]. Acceptance of waste package intended for the MGDS will commence in the year [TBD].
- D. Receipt of SNF at the MRS facility will commence in the year [TBD].
- E. Ownership of SNF stored at the Purchaser sites remains with the Purchaser.
- F. DOE (OCRWM) accepts title for SNF at the time of physical possession.
- G. Transfer operations at the Purchaser facility are governed by each Purchaser's operating license. (Utility licenses are governed by 10 CFR 50, which is not applicable to the CRWMS.) Some activities related to a cask and Multi-Purpose Canister (MPC) that take place in the 10 CFR 50 licensed fuel building are required by 10 CFR 71 (for transportation casks) and 10 CFR 72 (for storage casks) Certificates of Compliance or license. These activities include the closing and sealing of the cask or MPC. Nothing in this requirements document should be construed to countermand any provision of a Purchaser license.

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NOTE:

A multi-purpose canister (MPC) option is being considered for the Yucca Mtn. repository, and cannot be ruled out as an option for a second repository. The MPC concept allows for larger package emplacement in a repository drift as opposed to borehole placement of smaller, individual canisters. This PWAC is not intended to address MPC's specifically other than to indicate the fact they are not excluded from future consideration; it is just that they are not included in the evaluation of engineered barriers considered in this document or its supporting PA.

- H. The designation and certification of the On-site Storage and Transfer System (OSTS) is the responsibility of DOE (OCRWM). The procurement and operation will be the responsibility of the Purchaser. The requirements related to the OSTS should be considered [TBR] because their applicability to the CRWMS has not been officially established. Final determination of licensing, procurement, and operational responsibilities will be addressed in agreements with the Purchasers that are yet to be established.
- I. MPCs will remain sealed through the expected life cycle, and will not be routinely opened at the MGDS. Filler material may be added to the MPC by the Producer as part of the preparation for disposal.
- J. The primary and normal means of shipping SNF will be in MPC transportation cask systems. In the event some Purchasers do not use MPCs, the CRWMS will maintain the capability to transport bare SNF to the MRS facility and the MGDS in (non-MPC) transportation cask systems.

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3.6 Schedules

3.6.1 Repository Services

Repository services in terms of time to receipt of the package shipment will be **TBD**.

3.6.2 SNF Receipts

Until the packaged SNF materials are accepted by the repository, the Producer/Shipper shall provide for and pay for the costs of interim storage.

3.6.3 HLW Receipts

The repository will begin accepting HLW packages for disposal beginning in **TBD**.

3.6.4 Receipt Rate

The repository will begin accepting waste packages in the time frame and at the rates shown in Table 3.6-1.

Table 3.6-1

Year	MRS		MGDS				
	SNF Rec'd	Total SNF	SNF from MRS	Total SNF	HLW Rec'd	Total HLW	Total SNF & HLW
1st	tbd	tbd	tbd	tbd	tbd	tbd	tbd
2nd	.	.	.	.	.	.	.
3rd	.	.	.	.	.	.	.
4th	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
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3.7 Interface Requirements

This section addresses interface requirements between the various organizations and other elements such as transportation and interim storage (if applicable), and the geological disposal site.

3.7.1 Repository Offices - Interim Storage Facility

An MRS facility (if applicable) will be qualified to receive, handle, and store waste packages in a safe and secure manner prior to acceptance at the geological disposal site.

3.7.2 Repository Offices - Transportation

The types of interfaces between the repository and transportation elements reflect the safe movement of both loaded and unloaded cask systems (which includes MPCs) along with the documentation, reports, security, and communications regarding the cask systems.

3.7.3 Repository Offices - Geological Disposal Site

This interface reflects the internal transfer and caretaker responsibility of SNF/HLW documentation, reports, and communications.

3.8 Methods and Controls

Measures shall be established to ensure that purchased material, equipment and services conform to established procurement guidelines.

3.8.1 Material Management

3.8.1.1 Inventory Control

Government materials acquisition, use, and surplusage will follow standard government regulations in effect at the time of repository construction and operation.

3.8.1.2 Radioactive Material Inventory

The Repository Office shall establish, maintain, and follow written material control and accounting procedures that enable the CRWMS to account for Producer generated material in transit, storage, and disposal.

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The Repository Office shall retain copies of current inventory records and current material control on an accessible computer database until repository closure. At that time, the database information shall be used to prepare (1) a final hard copy of the information (microfiche), and (2) a permanent electronic media copy.

Inventory accounting and control systems for acceptance of SNF and HLW shall comply with the requirements of 10CFR75, in compliance with US/IAEA agreement. SNF may be in individual canisters or loaded into MPCs.

3.8.2 Government Furnished Property

Repository Design Requirements shall identify, as appropriate, any property to be furnished by the U.S. Government.

Requirements pertaining to the receipt, maintenance, operation and disposal of Government furnished property shall be specified in the repository Design Requirements documents, as appropriate.

3.8.3 Computer Resources

Computer resources are to be addressed in the repository Design Requirements documents, as appropriate.

The design of the repository computer systems shall provide for compatibility of CRWMS computer resources, including hardware and software. The design intent shall be to allow for a common 'platform' for databases and other information by all the CRWMS elements.

The computer system will provide 'Internet' capability to promote and facilitate electronic data interchange between the repository and the various Producer/Shipper sites.

3.8.4 Documentation

3.8.4.1 Test Plans and Procedures

Through testing and evaluation, conformance of the system's elemental requirements shall be demonstrated as detailed in the verification matrix in [TBD].

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3.8.4.2 Producer Records

The Producer shall maintain records consistent with the requirements identified in this criteria. Both hard copy and electronic media shall be available. Prior to any shipment, the Producer shall have transmitted the electronic file information to the repository and shall have received approval for the shipment. After the shipment has arrived at the repository, then the hard copy documentation may be transmitted to the repository offices. Typical records to be prepared and maintained by the Producer are identified in Section 6.1 of this document.

3.8.4.3 Quality Assurance Program Description

Quality Assurance documentation shall be prepared, maintained, and stored in accordance with the requirements specified in DOE/RW-0333P.

3.8.4.4 Records Management

The repository and Producers/Shippers shall maintain sufficient records to furnish evidence of activities affecting quality. [DOE/RW-0333P][DOE/RW-194P Sections 6.1 and 6.4b]

Records shall be identifiable, traceable to associated items and activities, and retrievable. [DOE/RW-0333P]

3.8.4.5 Computer Documentation

Quality affecting analytical and computational models, and software user documentation developed for the repository, shall be prepared in accordance with the QARD. [DOE/RW-0333P]

3.9 Personnel and Training

Training may be accomplished through a combination of formal structured programs and on-the-job training, addressing both operational and administrative aspects of repository operations. Training requirements include both the training of personnel initially assigned to the repository and the training of replacement personnel throughout the system life cycle as required.

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3.9.1 General Requirements

A training requirements document for the repository shall be provided to identify the requirements of operator and maintenance training for facilities, hardware, and software procured or constructed for the repository. The document shall address the following subjects:

- (A) The contractor and government agency responsibility for training shall be defined. This will include the concept of how training will be accomplished, e.g. in-house, formal school, contractor.
- (B) Equipment required for training purposes shall be identified.
- (C) Training devices to be developed, characteristics of training devices, and training and skills to be developed through the use of training devices shall be identified.
- (D) Training time and locations shall be identified as the training modules become available.
- (E) Source material and training aids to support the specified training shall be identified.
- (F) Documentation of training records for all personnel associated with the repository shall be retained in file for the duration of their employment with repository operations.

3.9.2 Special Requirements

Training relative to handling radioactive waste packages shall include actual trial tests with dummy loads. Additionally, repository operations personnel shall witness the initial loading of any waste package/canister combination at each Producer/shipper location.

3.10 Human Factors Engineering

[TBD]

4.0 Product Criteria

4.1 Summary of Waste Acceptance Criteria and Requirements

The DOE Order 5820.2A (process of being written under 5820.2B),

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1 "Radioactive Waste Management" requires that the waste generator and/or storage
2 sites must comply with consolidated criteria and requirements for waste to be
3 transported and placed within [TBD].
4

4.1.1 Repository Operations and Safety Criteria

5
6 The compliance criteria are structured to ensure safe handling of
7 wastes at the repository and to assist those responsible for the
8 certification of the waste packages in preparing site-specific
9 certification plans and detailed procedures to meet the repository
10 WAC. Site certification plans and procedures incorporate process and
11 administrative controls, and may include tests on individual waste
12 packages to accomplish certification. Mandatory approvals on
13 certification and QA plans are required. Request for exceptions or
14 changes to the criteria, once approved, will require approval by the
15 same review organizations involved in the initial approval(s).
16
17

4.1.2 Transportation: Waste Package Requirements

4.1.2.1 Ground Transport

18
19
20 Both Producer(s) and the repository site are expected to be
21 equipped with railhead capabilities. Any highway
22 transport will be limited to special tractor/trailer
23 transporters for local transport only to the nearest available
24 railhead.
25
26

4.1.2.2 Canister/Cask System

27
28 The transport cask will be designed specifically for an
29 over-length canister (see Section 4.2.1) of the standard
30 diameter. Non-standard canister shipment will require
31 Producer supplied inserts to assure necessary restraint of
32 the canisters inside the cask during transport.
33
34

35
36 Cask design will require certification by Department of
37 Transportation (DOT) personnel in addition to any other
38 certification established by DOE. Cask design and testing
39 shall consider containment under the maximum credible
40 events for the design accident scenario. Surface exposure
41 rates for loaded casks shall not exceed 200 mR/hr on any
42 package surface, from any source. [10 CFR 71]
43

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4.1.3 RCRA Requirements

Radioactive waste that contains hazardous constituents is designated mixed waste and is subject to dual regulation under the Atomic Energy Act (AEA) and RCRA. Where defense wastes may contain hazardous materials, they will be regulated under RCRA.

Future regulatory requirements, as applicable to this PWAC, will be incorporated into this and all other affected documents associated with the repository. For ease of reference at various waste management facilities, citations of federal as well as state regulations are included.

Producers must prepare a specific hazardous waste manifest in accordance with the EPA requirements of 40 CFR § 262.20 through 262.23 if hazardous waste is present. Generators must also sign the certification on the manifest that indicates that a program is in place to reduce both the volume and the toxicity of the waste generated. Identification numbers that link each RCRA-regulated waste container and its waste data package must also accompany the manifest, and identification numbers must be attached to the waste profile documentation. The Land Disposal Restriction (LDR) Certification required by 40 CFR 268 must also accompany the manifest and data package.

The RCRA regulations, as they may apply to the repository, include Standards for the Owners/Operators of Treatment, Storage, or Disposal (TSD) facilities that are codified in 40 CFR Parts 264 and 265. These regulations require the owner/operator to obtain a chemical and physical characterization of the waste, and ensure that the waste shipped to the facility is the waste specified on the shipping manifest. These RCRA requirements for the repository will be satisfied at the Producer site(s) before shipment of waste to the repository.

4.1.4 Performance Assessment Criteria

Performance Assessment Criteria are for the characterization of waste forms to be sent to the repository. The relationship between the test requirements, the quality assurance matrix (Ref. RW-0333P), and the Producer and/or storage site(s) is identified herein.

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For waste generated and/or shipped from storage, one or more of the following criteria must be satisfied for the waste packages:

- radiography or equivalent examination
- radionuclide assay report at time of production
- visual examination of the waste package
- waste package contact dose rate at time of shipment

4.2 Package Waste Criteria

4.2.1 Dimensions

The recommended size of a standard canister size is 61 cm (+1.5 cm, -1.0 cm) O.D. and 300 cm (+5.0 cm, - 20 cm) in length. See Figure 4.2-1.

Overall size of a canister shall not exceed an outer diameter of 61 cm with allowance for dimensional variations for standard pipe sizes. Canister diameters to a minimum of 16.0 cm may be allowed under special circumstances, and under no circumstances may a canister exceed 458 cm in overall length.

All deviations from the standard canister size must be approved by the repository prior to filling by the shipper. Furthermore, the shipper shall notify the repository, one year prior to shipment, of the quantity and schedule for shipment of any non-standard canister sizes. This requirement is in addition to the Delivery Commitment Schedule (DCS) identified in Section 6.9.

The physical shape of the container shall be cylindrical in nature. End closures shall consist of 1 each: reversed dished head which will allow the canister to stand on end unsupported, and a head with a grapple feature (lifting flange) that will allow vertical lifting or horizontal pulling. (Ref. Section 1.2.7 for specific details).

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Figure 4.2-1
Standard HLW Canister

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1
2 In all cases where solid materials will be loaded into a 'standard'
3 canister, it is expected that the weld closure of the canister will be at
4 the canister/reducer interface rather than a plug closure in the lifting
5 flange. The empty canister must be able to accommodate loading the
6 solid forms.

7 8 4.2.2 Canister Weight

9
10 An individual waste canister w/o overpack or super-canister
11 construction shall not exceed a weight of 6 metric tons.

12
13 A loaded shipping cask/waste canister combination shall not exceed
14 [TBD] metric tons.

15 16 4.2.3 Canister Material

17
18 The canister material shall consist of 304L stainless steel. Material
19 thickness will be such that canister integrity is guaranteed to meet the
20 50-year retrievability requirement once the package is placed in the
21 Mined Geologic Disposal System (MGDS).

22 23 4.2.4 Heat Generation

24
25 There are two thermal limits for decay heat within the repository: 1)
26 the total heat from the radioactive decay of the radioisotopes within an
27 individual canister and 2) the total decay heat from all canisters within
28 the repository itself.

29
30 The thermal power generated by the waste materials in any single
31 canister shall be calculated based on the known contents and shall not
32 exceed 1500 watts without approval from the repository operators;
33 that information is to be included in the data package. In determining
34 whether or not a waste package or group of waste packages meets the
35 established limits, any error or measurement uncertainty must be
36 added to the calculated value.

37
38 The design basis for the repository for total heat load is based on
39 [TBD] kW per hectare. Using the [TBD] kW per hectare limit,
40 this allows for an average heat generation of [TBD] watts per
41 canister package.

42
43 The calculated maximum allowable heat generation rate of less than
44 1500 watts per typical canister will allow for a small number of
45 canisters generating the maximum watts per canister without
46 exceeding the design heat load of the repository. The Producer must

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check with the repository to determine the allowable percentage of canisters with maximum heat output that can be accommodated.

4.2.4.1 Graphite

The Producer of the packaged graphite fuels must certify that multiple elements in a single canister (if allowable by criticality calculations for the repository) will not be affected by a heat buildup within the canister.

4.2.4.2 SNF

The Producer of the packaged SNF must certify that multiple elements in a single canister (if allowable by criticality calculations for the repository) will not be affected by a heat buildup within the canister.

4.2.4.3 HLW

The Producer of oxide waste forms must verify with the repository the specific parameters controlling heat conduction away from the canister once placed in the ground. Canister temperatures relative to phase transition temperatures will be a function of the repository media characteristics, e.g. thermal conductivity, heat capacity, canister spacing.

4.2.5 Allowable Void Space

4.2.5.1 Graphite

Salt Repository

Granite Repository

Inert material such as silica sand or molten metal may be added to fill interstitial spaces in the fuel canister to increase the mechanical rigidity of the package in a salt repository.

NA

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4.2.5.2 SNF

Salt Repository

Granite Repository

Inert material such as silica sand or molten metal may be added to fill interstitial spaces in the fuel canister to increase the mechanical rigidity of the package in a salt repository.

NA

4.2.5.3 HLW

The Producer shall fill the canister to a height of 80% (by volume) of the empty canister and the Producer shall report this percentage in the production records.

4.2.6 Package Labeling

4.2.6.1 Canister Labeling

The shipper shall be responsible for installing a metal etched bar code and visible, alphanumeric identifier on each canister. This bar code shall be the key reference that links all documentation associated with a given canister to all the records generated during its production, transportation, and storage.

4.2.6.2 Label Information

Each canister package waste form label shall meet the following criteria:

- a) The number must have a unique alphanumeric identifier; this identifier must appear on all documentation pertinent to that particular package.

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b) The package identification marking shall be in medium to low density Code 39 barcode symbology per MIL-STD-1189B in characters at least 2 inches high.

c) The label must not impair or degrade the integrity of the canister.

d) The label must be a material that is compatible with the canister material.

e) The label must be visible from the top and side of the canister.

f) The label must not cause the exterior dimensional limits to be exceeded.

g) The label must be an integral part of the canister, remaining legible for a period of 50 years under the anticipated conditions for interim storage.

4.2.7 Canister Handling Features

Design features of any waste form canister are intended to provide a simple, standardized method for movement of the canister during shipping and storage/repository operations.

a) Each canister shall be configured with an axial lifting pintle of a design approved by the repository.

b) No lifting fixtures shall be attached to the canister other than the pintle. The canisters must be cylindrical, smooth-sided, and have no protrusions that would hinder the insertion into other canisters or removal from shipping casks.

b) The Producer shall supply the repository with a working duplicate of the pintle grapppling device used by the shipper to facilitate movement of the canister within the shipper's facility.

c) The Producer shall provide a complete set of drawings, and operating instructions/procedures for the complete system used to move canisters within the shipper's facility.

d) The grapple, when attached to the hoist and engaged with the flange, shall be capable of lifting the canistered waste form in the vertical direction.

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e) Handling equipment drawings and procedures for canister movement within the repository will be available at the repository offices.

4.3 Form Criteria

4.3.1 Solids

All radioactive waste shall be in a solid form.

4.3.1.1 Graphite

a) standard form

Graphite whole block disposal, or encapsulated components from mechanical or chemical treatment provide adequate containment of radionuclides to meet release limits set in 40 CFR 191.

The anoxic environment of a typical geological repository will retard any oxidation of the bulk carbon surrounding the radionuclides, thereby further delaying any transport within the repository.

b) nonstandard form

None anticipated.

4.3.1.2 SNF

a) standard form

Spent nuclear fuels, when contained within a standard canister, will meet the release constraints for an MGDS per 40 CFR 191, whether as individual elements or in combination with other HLW forms.

b) nonstandard form

Fuel elements which have undergone destructive testing that breached the integrity of the cladding, or fuel elements which have demonstrated leakage due to failed cladding must be repackaged in a 304L SS sealed canister with a [TBD] mm minimum wall thickness.

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4.3.1.3 HLW

a) standard form

Material treatment/processing will convert all HLW materials into monolithic forms within a canister. The waste form selected for inclusion in a canister must qualify as BDAT or demonstrate equivalency to other qualified forms.

b) nonstandard form

Granular or powdered material is generally prohibited from inclusion in canisters unless specific exemption is sought from the repository prior to shipment. Justification must be provided, and compliance with transportation issues must be assured.

4.3.2 Liquids

Free liquids are prohibited, either internal or external to the canister, for any package(s) shipped to the repository.

Where material(s) may be added to the canister at the Producer site as a liquid, such as in the production of borosilicate glass, test and sample results must be able to demonstrate or otherwise provide assurance that a residual liquid content of less than 1 volume % exists within the canister at time of closure.

The prohibition against the presence of liquids is based on limiting the release of contaminated liquids if a container fails during handling or emplacement operations. This restriction also guards against any adverse affects these liquids might have on the structural integrity due to internal corrosion of the canister.

4.3.3 [RESERVED]

4.3.4 Explosiveness, Pyrophoricity, Combustibility

Pyrophoric materials, other than radionuclides, shall be rendered safe by mixing them with chemically stable materials, or shall be processed to mitigate their hazardous properties, e.g. conversion to an oxide form. Not more than 1% by weight of the waste in each canister may be pyrophoric forms of radionuclides, and these shall generally be dispersed in the waste package. Wastes containing any metallic radionuclides are to be treated with a validated process that either renders the material less leachable or

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1 or disperses and binds it within an inert matrix.

4.3.5 Chemically Reactive Species

2
3
4
5 Waste form shall not contain explosive, pyrophoric, chemically reactive
6 materials, or phase volume changes in an amount that could compromise the
7 repository's ability to satisfy the performance objectives.

4.3.5.1 General - All Waste Forms

a) Chemical Composition

8
9
10
11
12
13 The Producer shall provide records indicating the chemical
14 composition and crystalline phase projections for the waste
15 form.

b) Chemical Compatibility

16
17
18
19 Chemical additives used during the preparation or processing of
20 the canistered waste shall not, as demonstrated through qualified
21 process data, increase the chemical reactivity of any species
22 present in the waste.

c) Waste Form - Container Compatibility

23
24
25
26 The contents of the canistered waste form shall not lead to or
27 promote internal corrosion of the canister such that there will be
28 an adverse affect on normal handling, during interim storage,
29 nor for the abnormal occurrence such as a canister drop accident
30 after glass formation or temperature elevation exceeding the
31 lowest phase transition temperature.

4.3.5.2 Graphite

32
33
34
35 The quantity of metal carbides (UC_2 , ThC_2), along with the
36 reaction rates of the metal carbides with water at temperatures
37 ranging from 30°C to 90 °C should be reported as part of the data
38 associated with the fuels.
39

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4.3.5.3 SNF

Specific materials integral to the fuel elements or assemblies/subassemblies such as cladding (Zircaloy, aluminum, stainless steel), fuel metal matrix (oxide, hydride, metal), or others (sodium, cadmium, asbestos) shall be identified and reported for each fuel type.

4.3.5.4 HLW

The Producer shall report the composition of the waste form for oxides of elements present in concentrations greater than 0.5% by weight, and estimate the error bounds of the composition.

4.3.6 Criticality Safety

In general, fissile material loadings in individual canisters will be dictated by the geological medium surrounding the canister at the time of placement in the repository.

The canister content shall remain subcritical under all credible conditions likely to be encountered at the Producer's site, including any interim storage array. The calculated effective neutron multiplication factor, k_{eff} , must be shown to be less than 0.95 after allowing for bias in the method of calculation and uncertainty in the experiments used to validate the method of calculation. The Producer shall describe the method of compliance in the Waste Form Compliance Plan (WCP) and provide supporting documentation in the Waste Form Qualification Report (WQR). The WQR shall also include sufficient information on nuclear characteristics [such as fissile material density, and enrichment], of the canistered waste form to enable subcriticality to be confirmed under the repository storage and disposal conditions stipulated herein.

Where mixed fissile species are present, fissile gram equivalents (FGE) will be used to determine allowable fissile loadings in the canisters.

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4.3.6.1 Graphite

Packaged graphite fuels shall account for all fissile species where they constitute >1% by weight of the total fissile species present in the spent fuel.

Salt Repository

Canister packages may contain up to 10.0 kg FGE U-235.

Granite Repository

Canister packages may contain no greater than 0.700 kgs FGE U-235.

In all cases where solid materials will be loaded into a 'standard' canister, the weld closure of the canister shall be at the canister/reducer interface rather than a plug closure in the lifting flange. The empty canister must be able to accommodate loading the solid forms.

4.3.6.2 SNF

Spent fuels with HEU characteristics may neglect the fissile contribution made by Pu-239. Spent LEU fuel configurations must account for Pu-239 concentrations if they constitute greater than 1% of the fissile species in the element.

Salt Repository

Canister packages may contain up to 10.0 kg FGE U-235.

Granite Repository

Canister packages may contain no greater than 700 grams FGE U-235.

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4.3.6.3 HLW

Fissile material content of any HLW waste package may be neglected if the Producer can demonstrate the fissile material content of any individual canistered waste form falls below 400 grams.

All limits will be related to a fissile gram equivalent (FGE) for U-235. It will therefore be necessary to convert U-233 and Pu-239 species (as a minimum) in the spent fuels, to an equivalent mass of U-235 for purposes of criticality calculations.

4.3.7 Solubilities

4.3.7.1 Graphite

Fuels need not typically be packaged or repackaged before insertion into the canister unless it is a designed portion of the canister into which the fuels will be placed.

4.3.7.2 SNF

Fuels need not typically be packaged or repackaged before insertion into the canister unless it is a designed portion of the canister into which the fuels will be placed.

4.3.7.3 HLW

Selection and qualification of chemical species found within the HLW matrix is intended to minimize solubilities. Except in cases where a product form would be chemically more reactive, soluble, or corrosive, oxide forms of the radionuclides are the preferred species.

4.3.8 Leach Rates

4.3.8.1 Graphite

Allowable specific leach rates for radionuclides from graphite fuels are predicated on the combined barriers provided by the fuel element matrix itself and the canister(s) containing the material.

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4.3.8.2 SNF

Allowable specific leach rates for radionuclides from SNF are based on the combined barriers provided by the fuel element matrix itself, cladding, and any canister(s) containing the material.

4.3.8.3 HLW

Leach rate for the HLW product form shall be based on comparing the total normalized release rates of matrix elements from production samples to the total normalized release of matrix elements from the benchmark glass established in the Environmental Assessment for the vitrified high-level waste forms.

The measured or calculated mean results for cationic constituents of the formulations which describe the phase(s) containing the radionuclides requiring isolation shall be included in the Production Records. The Production Records shall contain results derived from actual sample analyses, as well as process control information used for verification. When using process control information to project leach rates, the Producer shall demonstrate in the WQR that the method used will provide information equivalent to the testing of samples of actual production glass.

4.3.9 Corrosion

Corrosion models indicate that a 304L stainless steel canister will resist damage within a typical repository environment to assure the 50 year retrievability limit.

Additionally, the waste form itself will be qualified under BDAT guidelines to guard against transport of radionuclides in the geological media after the canister is breached.

4.3.10 Gas Generation

Materials within the waste form itself that promote gas generation in the repository are prohibited if they release any gas form in quantities greater than [TBD]. Gas generation due to general corrosion of the canister and/or its overpack canister, or due to the radiolysis of water,

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are acceptable where it can be demonstrated that neither explosive conditions nor accelerated transport of materials are promoted within the repository.

4.3.11 Mechanical Properties

Salt Repository

Lithostatic pressures within the salt repository are expected to be as high as 20 MPa. To prevent canister rupture, the combined strength of all layers/barriers should be designed as a solid body to withstand the peak pressures that will develop due to salt creep around the canister after repository closure.

Granite Repository

The water pressure for the repository modeled by the Sandia PA report was found to range from 3.21 to 3.25 MPa. The gas pressures were found to range from 3.26 to about 3.32 MPa. [Sand93-2330, Pg 16-27]

4.3.12 Radiolysis

Any shielding material necessary to prevent significant radiolysis and ground water chemistry changes that might result from such radiolysis will be dictated by the repository at the time of waste package emplacement based on the nature of the waste form.

4.3.13 Surface Dose Limits

The canistered waste form shall not exceed a maximum surface (on contact) gamma dose rate of 10^5 R/hr nor a maximum neutron dose rate of 10^3 R/hr.

The Producer shall report in the WQR the expected values and ranges of variation for both gamma and neutron dose rates projected in the year 2030. The Producer shall describe the method for demonstrating compliance in the WCP.

The Producer shall provide in the storage and shipping records the estimated values for both gamma and neutron dose rates at the year of shipment for each canistered waste form, and shall describe the method of compliance in the WCP.

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4.3.14 Radionuclide Inventory

Waste form reporting shall identify the inventory of radionuclides (in Curies) that have half-lives longer than 20 years and that are present in concentrations greater than 0.05 % of the total radioactive inventory for each waste type, indexed to the year 2030.

The Producer shall provide in the WQR estimates of the total quantities of individual radionuclides to be shipped to the repository for each waste type. Estimates shall include not only an average inventory per canister, but also an upper limit for each distinctive waste type generated by the Producer.

The production records shall provide estimates of inventories for individually reportable radionuclides for each canister and each type of waste. The error associated with these individual estimates will be reported in the WQR.

4.3.15 Organics

The Producer shall certify that the canistered waste form does not contain a significant amount (> 1.0% by weight) of free organic material. The Producer shall describe the method for complying with this requirement in the WCP, and document the basis for compliance in the WQR.

4.3.16 Inert Gases

Inert gases such as argon may be used during canister closure where required during the welding processes. At no time should the internal pressure of the gas inside the canister at closure exceed 150 kPa @ 25°C.

4.4 Waste Cask/Transportation

[NOTE: Development of details relative to cask configuration and transportation requirements will have to occur at a later date, depending on the final waste form selection/qualification and regulatory constraints on transportation in effect at the time of waste shipment.]

4.4.1 DOT Standards

[TBD]

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4.4.2 Cask configuration

4.4.2.1 Weight

[TBD]

4.4.2.2 Dimensions

[TBD]

4.4.2.3 Allowable Dose Rates

[TBD]

4.4.3 Accident Criteria

[TBD]

4.4.4 Handling Criteria

[TBD]

4.4.5 Materials of Construction

[TBD]

4.4.6 Identification

[TBD]

4.4.7 Security

[TBD]

4.5 Repository Criteria

[NOTE: much of the information to be included in Section 4.5 will be based on the results of the calculations associated with the performance assessment now underway.]

4.5.1 Total MTIHM

The total MTIHM capacity of the repository is [TBD].

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[NOTE: the capacity of the repository will be determined at some point in the future based on more current estimates of the volume of materials which must be accommodated in a repository.]

4.5.2 Natural Barrier

A natural barrier will retard migration or transport of hazardous materials beyond a defined boundary. With the presence of radionuclides, a time frame is also stipulated.

4.5.3 Engineered Barrier Design

The engineered barriers within the repository are intended to provide multilevel protection against radionuclide transport. A combination of waste form, canister type (e.g. material, thickness, overpack), and canister emplacement design will assure the waste packages meet regulatory requirements.

4.5.3.1 Backfill Material

Salt Repository

Individual boreholes in the repository drifts will be backfilled with crushed salt (from the drift excavation) or a bentonite clay buffer [Sand93-2330, pg 16-78] after waste package emplacement. The backfill will naturally undergo plastic flow around the canister under the lithostatic pressures within the repository.

Individual drifts within the repository, as they are filled with the individual waste packages, will be backfilled with the host material from the excavation of other drifts.

Granite Repository

Placement of waste packages in the granite media will use a bentonite clay buffer [Sand93-2330, pg 16-78] material placed around the canister in the borehole in the drift.

Detritus from tunneling operations will be used to backfill the tunnel and associated drifts.

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4.5.4 Ground Water Releases

Salt Repository

The selected site will have no continuous, measurable water flow, either as a permanent stream on the surface or through an identified aquifer meeting potable water standards, within the designated boundaries of the repository.

Granite Repository

The selected site will have no continuous, measurable water flow, either as a permanent stream on the surface or through an identified aquifer meeting potable water standards, within the designated boundaries of the repository. Any measurable ground water flows shall not be capable of reaching the repository boundary within 10,000 years as measured from the geographical center of the repository.

4.5.5 50 Year Retrieval

Salt Repository

While canister integrity will be assured through the first 50 years, retrievability from a salt media would be complicated by the plastic flow of the salt over time. Canister placement markers will be utilized to identify specific canister locations at closure of the repository.

Granite Repository

na

4.5.6 300-1000 Year Canister Integrity

Salt Repository

[NOTE: Accelerated corrosion rates in a salt repository will breach 304L stainless steel within

Granite Repository

[NOTE: Even though 304L stainless steel will maintain its integrity for greater than 1000

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a 1000 year time frame.

However, radionuclide transport behavior in a characteristic salt repository obviates the need for a more robust canister design.]

years, calculated corrosion rates indicate a high alloy Inconel 625 or equivalent will be required to satisfy containment requirements to meet repository release limits under 40 CFR 191.]

4.5.7 10,000 Year Releases (40 CFR 191)

Salt Repository

Performance assessment indicates radionuclide transport will fall below current regulatory limits for the hypothetical salt repository.

Granite Repository

[NOTE: radionuclide transport in this type repository is very dependent on assumptions made with respect to fracture characteristics and water movement within the repository. Detailed characterization of any actual site will be required.]

4.6 Other Criteria

4.6.1 Canister Fabrication Reporting

[TBD]

4.6.2 Canister After Closure

After closure, the canister package shall not contain:

a) Free gas other than air, cover, or radiogenic gases with an internal pressure not to exceed 150 kPa (22 psia) at 25°C. Cover gas shall be argon.

b) Known amounts of organic material of > 1.0% by weight.

4.6.3 Canister at Delivery

At time of delivery, the canister shall stand upright without support on a flat horizontal surface and properly fit into a right-circular,

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cylindrical cavity ($64 \pm 0.5 + 1.0$ cm and 310 ± 3.0 cm in length).

4.6.4 Surface Contamination on Canister

The levels of removable (smearable) radioactive contamination of all external surfaces of each canistered waste package shall not exceed 220 dpm/100 cm² for alpha radiation and 2200 dpm/100 cm² for beta and gamma radiation.

The Producer shall inspect each canistered package and remove visible debris from the exterior surface of the canister prior to shipment.

4.6.5 Consistency Test

4.6.5.1 Graphite

For partial elements, each segment shall be tied back to the original data sheet, i.e. two fractions of two different elements shall have the necessary documentation to show the original parent element.

For acceptance, the individual fuel element data sheets shall document the reactor source, overall dimensions, weight, estimated burnup, and measured radiation fields 1.0 ft from the exposed fuel element.

4.6.5.2 SNF

The Producer shall demonstrate control of waste canister loading through detailed documentation of individual fuel element placement.

For acceptance, the individual fuel element data sheets shall document the reactor source, overall dimensions, weight, estimated burnup, and measured radiation fields 1.0 ft from the exposed fuel element.

4.6.5.3 HLW

The Producer shall demonstrate control of the waste form production by comparing (either directly or indirectly) batch production samples to the Environmental Assessment (EA) benchmark glass using the Product Consistency Test (PCT) or equivalent, accepted method of testing.

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For acceptance, the concentrations of matrix elements in the leachate, after normalization for the concentrations in the glass, shall be less than those same elements of the benchmark glass.

4.6.6 Hazardous Waste Determination

The Producer shall determine, quantify, and report to DOE/OCRWM the presence of any hazardous waste listed in 40 CFR 261.31 through 40 CFR 261.33, in any feed stream leading to waste production that ends in ultimate disposal or storage.

If no "listed hazardous wastes" are present in the waste or in any feed stream, the Producer shall perform initial tests of the feed stream using "Toxicity Characteristic Leaching Procedure" (TCLP) described in 55 Federal Register 26986, 6/29/90. Additional periodic tests may be warranted for any known change in feed stream composition. Other RCRA characteristic test(s) described in 40 CFR 261.20 through 261.24 as appropriate, may require samples from production runs or prototypical specimens. Modifications must be approved prior to DOE/OCRWM approval and the method to be used must be described in the WCP, with results documented in the WQR.

Based on the criteria listed above, the Producer shall certify in the WQR whether or not the waste is hazardous.

For hazardous wastes, the Producer shall prepare "Hazardous Waste Manifest" logs as required by 40 CFR 262. These logs must be included in the Production Records and must accompany waste during shipment.

4.6.7 Canister Impact Characteristics

The canister package shall be capable of withstanding a drop of 7 meters onto a flat, unyielding surface without breaching or dispersing radionuclides. The test results shall include information on the measured canister leak rates and canister deformation after the drop test.

5.0 Repository Closure

[TBD] [NOTE: this section will be developed based on the type and location of the repository once identified.]

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6.0 Supporting Documentation

6.1 Records

6.1.1 Waste Form Compliance Plan (WCP)

The WCP shall describe the Producer's plan for demonstrating compliance with each requirement in the Waste Acceptance Quality - System Requirements Document (WAQ-SRD), including tests, analyses, and process controls to be performed by the Producer. The WCP will also identify records to be provided as evidence of compliance.

6.1.2 Waste Form Qualification Report (WQR)

The WQR shall compile all the results from waste form testing and analysis to demonstrate the Producer's ability to comply with the WA-SRD.

6.1.3 Production Records

The production records shall describe the conditions associated with the individual canistered waste forms. This will include items such as: inspection records, material certifications, process records (e.g. temperature, pressure, batching information for additives), and in cases where SNF's are involved, accountability of fissile material either through burnup calculation of a known amount or neutron interrogation.

6.1.4 Storage and Shipping Record

The storage and shipping records shall describe the physical attributes of each waste canister and identify any unexpected events, e.g. thermal transients or drops, which may have occurred during movement or storage.

6.1.5 Waste Package Annual Report

The Producer shall provide annual reports of waste package generation and projections of future waste package generation.

6.1.6 Product Specification

[NOTE: examples of a typical product specification are provided in the attachments accompanying this document.]

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6.2 Certification & Waste Form Approval

It shall be the responsibility of the Producer to qualify the waste form generated in the licensed facility operated by the Producer. Guidelines may vary with time, but an example of an existing guideline is Environmental Assessment of Waste Form [DOE/EA-0179].

6.3 Waste Volume Minimization

Waste volume minimization will be governed by one or more applicable documents. The following listed documents make reference to waste minimization, and it will be up to the Producer to develop a waste volume minimization plan in concert with the regulating agency that identifies the applicable regulation(s) and how each applies to the waste form produced.

DOE 5400.3	40 CFR 264.75(i)
DOE 5280.2A I.3.b(7)(a)	40 CFR 264.73(b)(9)
40 CFR 262.41(u)(6)(b)(7)	40 CFR 265.75(h)
40 CFR 262 Appendix	40 CFR 265.75(i)
40 CFR 264.75(h)	

6.4 QA Plan

The Producer shall establish, maintain, and execute a quality assurance program satisfying each of the applicable criteria of the DOE OCRWM *Quality Assurance Requirements and Description* (QARD), and any specific provisions which are applicable to WA activities. [DOE/RW-0333P]

The Producer quality assurance program shall cover the activities from the time of waste form production through waste acceptance. [DOE/RW-0333P]

The Producer shall prepare and maintain documentation sufficient to demonstrate canistered waste form compliance with the WCP and WQR as lifetime QA records. Copies of these records must be made available to the Federal Repository Operator at the time the repository is ready to begin accepting canistered waste forms from the Producer. Other documentation generated during preparation and implementation of the WCP and WQR must be collected and maintained as nonpermanent records. [DOE/RW-0333P]

The Producer shall handle notification and disposition of other-than-standard SNF and canisters of HLW in accordance with section 4.3.1. [10 CFR 961.11 Article VI.A.2(b)][DOE/RW-0333P]

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DOE HLW producers will have a QA program meeting the requirements of the OCRWM QARD as applied through the appropriate EM project offices.

6.5 NEPA Documentation/Permits

[TBD]

6.6 State Documentation/Permits

[TBD]

6.7 NRC Documentation/Permits

[TBD]

6.8 Annual Capacity Report

DOE shall issue an annual capacity report for planning purposes for SNF as specified in 10 CFR 961.11 Article IV.B.5. [10 CFR 961.11 Article IV.B.5]

6.9 Delivery Commitment Schedules

Beginning January 1, [TBD], the Producers shall submit to DOE the delivery commitment schedules (DCS) for all SNF the Producers intend to deliver to DOE beginning 63 months thereafter. The DCS should be in the format set forth in Appendix C of 10 CFR 961 as provided in the Office of Management and Budget (OMB) approved form number 1901-0260. [10 CFR 961.11 Article V.B.1]

DOE shall approve or disapprove of the Producer's DCS within 3 months after receipt, and must notify the Producer in writing of the reasons for disapproval. DOE must request the Producer to submit a revised DCS within 30 days after receipt of DOE's disapproval. [10 CFR 961.11 Article V.B.1]

DOE shall approve or disapprove the Producer's revised DCS within 60 days after receipt. In the event of disapproval, DOE must advise the Producer in writing of the reasons and proposed schedules, and if the reasons and proposed schedules are not acceptable to the Producer, the parties must promptly try to negotiate mutually acceptable schedule(s). [10 CFR 961.11 Article V.B.2]

The Producer shall have the right to adjust the quantities of SNF and/or HLW plus or minus 20%, and the delivery schedule up to 2 months, until the submission of the final delivery schedule. [10 CFR 961.11 Article V.B.2]

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1 If the Producer fails to provide the annual forecast discussed in section 6.1.5,
2 DOE may, at its sole discretion, require a rescheduling of any DCS then in
3 effect [10 CFR 961.11 Article IV.A.1(c)]
4

6.10 Exchange Requests

5
6
7 Not less than 6 months prior to the delivery date specified in the Producer's
8 approved DCS, the Producer shall be allowed to submit to DOE an exchange
9 request. [10 CFR 961.11 Article V.E]
10

11 DOE shall approve or disapprove the proposed exchange request within 30 days
12 after receipt. In the event of disapproval, DOE must advise the Producer in
13 writing of the reasons. [10 CFR 961.11 Article V.E]
14

6.11 Request for Nonstandard or Nonconforming Waste Delivery

15
16
17 The Producer shall obtain delivery and procedure confirmation from DOE prior
18 to delivery of other-than-standard waste (failed SNF and nonstandard
19 SNF/HLW). DOE shall advise the Producer within 60 days after receipt of a
20 confirmation request as to the technical feasibility of accepting the other-than-
21 standard waste on the currently agreed to schedule, and any schedule
22 adjustment for such services. [10 CFR 961.11 Article VI.A.2(b)]
23

24 The Producer shall submit an action plan for correction or disposition of
25 nonconforming waste; this verification and documentation for approval shall be
26 completed in the identified time frame. The action plan must adequately identify
27 and describe the nonconformance and any action to change or correct the
28 existing nonconformance. The action plan must be signed by authorized
29 personnel/organization. [DOE/RW-0333P, p. 15-1 (Section 15.0 - 15.2)]
30

6.12 Final Delivery Schedules

31
32
33 The Producer shall submit to DOE, not less than 12 months prior to delivery,
34 final delivery schedule(s) (FDS) as specified in 10 CFR 961.11 Appendix D.
35 [10 CFR 961.11 Article V.C]
36

37 DOE shall approve or disapprove an FDS within 45 days after receipt. In the
38 event of disapproval, DOE must advise the Producer in writing of the reasons,
39 and request a revised schedule. The Producer shall submit the revised schedule
40 within 30 days after receipt of DOE's notice of disapproval. [10 CFR 961.11
41 Article V.C]
42

43 DOE shall approve or disapprove the revised FDS submitted by the Producer
44 within 60 days after receipt. If DOE disapproves the revised schedule, the
45 reasons for disapproval must be provided in writing [along with DOE's
46 proposed schedule] to the Producer. If these are not acceptable to the

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1 Producer, the parties must promptly seek to negotiate mutually acceptable
2 schedules. [10 CFR 961.11 Article V.C]

6.13 Final Description of Waste Packages

5
6 A data package with certification attesting to the waste package contents and
7 how they meet the requirements of these criteria shall be submitted to the
8 repository manager in advance of the shipment. This data package/certification
9 shall be based on a QA program subject to audit and verification, and shall
10 provide information on the specific items listed as follows:

- 11 • Package identification number
 - 12 • Package assembly identification number (if applicable)
 - 13 • Date of waste package certification
 - 14 • WAC exception number (if applicable)
 - 15 • Waste generation site
 - 16 • Date of package closure
 - 17 • Maximum surface dose rate in R/hr and specific neutron
18 dose rate if greater than 0.20 R/hr at the surface of the
19 shipping cask
 - 20 • Weight of package (in kgs)
 - 21 • Container's materials of construction
 - 22 • Physical description of waste form (content code)
 - 23 • Assay or calculated information, including fission products
24 and alpha emitters (in Ci's), and fissile gram equivalent (in
25 gms)
 - 26 • Radioactive mixed waste (identify and quantify listed
27 wastes and those that exhibit the characteristics of a
28 hazardous waste)
 - 29 • Measured or calculated thermal power (if over 1.0
30 watts/m³)
 - 31 • Shipment number
- 32
33
34
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45

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- Date of canister closure
- Date of shipment
- Vehicle/transport cask identification
- Name of certifying official who approved the waste canister

The format of this information is not dictated by this document; however, all listed parameters must be included in any site documentation. This documentation may be computer generated based on the Producer's waste data base.

7.0 Waste Acceptance Management and Support

7.1 Waste Acceptance Management Segment

Waste acceptance management encompasses issues such as: contract agreements, oversight and coordination functions, fee assessments, support to Producers.

7.1.1 Waste Acceptance Management Segment Description

This segment provides the procedures and personnel required to accept custody of wastes in accordance with established contracts/agreements. It includes inspecting the waste at the Producer site while it is being prepared and loaded into the transportation cask, ensuring the proper type of transportation cask system is delivered to the MGDS, and accepting the waste into the CRWMS with all required documentation.

7.1.2 Waste Acceptance Management Segment Functions

This segment shall be capable of performing the assigned functions. These functions are:

Accept Waste

Accept Waste Custody

Observe Waste Preparations

-Observe Preliminary

Waste Preparations

-Verify Waste Description

-Notify Producer of Improperly Described Waste

Accept Title/Documentation

Resolve Improperly Described Waste

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7.1.3 Waste Acceptance Management Segment Interfaces

The lower level Design Requirements documents identify, describe, and specify requirements for interfaces between segments.

7.1.4 Waste Acceptance Management Segment Requirements

Management segment requirements identify the detailed information necessary to effect a transfer of the waste form from the Producer to the repository.

7.1.4.1 Shipping Records

The Producer shall provide written documentation and certification:

- A. Of cask conditions and contents prior to transfer to the receiving party in accordance with 10 CFR 961.1, Article VI.B.2
- B. That the transportation cask system has been packaged to meet DOE, DOT, and NRC requirements, and to transfer care, custody, and control of the shipment. [10 CFR 71.5a] [10 CFR 961.11, APPENDIX E.B.6(c)] [49 CFR 172.204(a)]
- C. Of the name of each radionuclide that is listed in 49 CFR 173.435, in order of decreasing radiotoxicity, whose activity comprises 1% or greater of the total activity at the time of shipment.
- D. That the standard HLW form did not exceed the lowest phase transition temperature after manufacture.
- E. Of the hazardous waste classification for land disposal. [40 CFR 262]

7.1.4.2 Fee Receipt Determination

None of the HLW, SNF or Graphite materials generated or owned by any Department of the United States shall be disposed of in a CRWMS facility unless appropriate fees

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have been deposited in the Nuclear Waste Fund equivalent to the fees that would have been paid if the waste were generated by civilian nuclear power reactors. [NWPA Section 302(b)(4); 52 CFR 31507]

7.1.4.3 Routine Determinations

Prior to each shipment of licensed material, the Producer shall ensure that the transportation cask, with its contents, satisfies the applicable requirements of 10 CFR 71.87.

7.1.4.4 Title Transfer

- A. Delivery and acceptance in writing by DOE/OCRWM of any SNF and/or HLW at a DOE facility shall constitute a transfer of title to DOE/OCRWM of the SNF and/or HLW.
- B. DOE/OCRWM shall accept SNF and/or HLW packages at a designated loading facility within or adjacent to the Producer's HLW facility.
- C. Title to all waste packages shall transfer to DOE at the Producer's site. DOE shall be solely responsible for control of all the material upon transfer of title. DOE has the right to dispose of, as it sees fit, any SNF and/or HLW to which it has taken title. Producers shall have no claim against DOE or the Government for such SNF or HLW, nor shall the Government be obligated to compensate the Producer for such material.

7.1.4.5 Observations by DOE

- A. DOE/OCRWM may designate a representative(s) to observe preparatory activities conducted at the Producer's site, and the Producer shall allow such designated representative(s) access to the site. [10 CFR 961.11 Article IV.A.2(a)]
- B. DOE/OCRWM shall verify the description of the SNF and/or HLW during transportation cask loading and prior to acceptance in accordance with 10 CFR 961.11 Appendices E and F. [10 CFR 961.11 Article IV.B.2]

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7.1.4.6 Notification of Improperly Described Waste Prior to Acceptance into CRWMS

If SNF and/or HLW is determined by WA to be improperly described prior to acceptance by DOE/OCRWM at the Producer's site, WA shall promptly notify the Producer in writing. DOE/OCRWM reserves the right to refuse to accept improperly described waste. The Producer may not transfer title of improperly described SNF and/or HLW unless DOE/OCRWM agrees to accept title under other arrangements agreed to in writing by all parties. [Producer: 10 CFR 961.11 Article VI.B.3(a)] [Producer: DOE/RW-0333P]

7.2 Support Segment

Support segments detail the material and personnel issues along with the coordination efforts between the repository operations and the Producer/Shipper.

7.2.1 Support Segment Description

This segment identifies the facilities, equipment, and personnel required to support the Waste Acceptance Segment (WAS) planning and operation. It includes administrative and support facilities (a complex for all the administrative and personnel services necessary for operation of WA; it may be co-located with another CRWMS facility), support equipment, ADP support, and records/data management.

7.2.2 Support Segment Functions

This segment shall be capable of performing the functions assigned to it in Table [TBD]. These functions are:

Accept Waste

Define Waste Acceptance Criteria

Establish Contracts/Agreements

Plan for Waste Acceptance

Allocate Waste System Capacity

Collect Waste Data

Rank/Order Waste

Allocate Annual Capacity to Producers

Identify Waste Location/Characteristics

Evaluate DCS

Evaluate Exchange Requests

Evaluate Request for Nonstandard Waste

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1 Delivery
2 Evaluate FDS
3 Define Site Interface Capabilities
4 Accept Waste Custody
5 Observe Waste Preparations
6 Observe Preliminary Waste Preparations
7 Verify Waste Description
8 Notify Producer of Improperly Described
9 Waste
10 Accept Title/Documentation
11 Resolve Improperly Described Waste
12 Provide Fee Collection
13

7.2.3 Support Segment Interfaces

14
15
16 The lower level Design Requirements documents identify, describe,
17 and specify requirements for interfaces between segments.
18

7.2.4 Support Segment Requirements

19
20
21 This segment describes the facilities, equipment, and personnel
22 required to support WA planning and operation. It includes
23 administrative and support facilities (a complex for all of the
24 administrative and personnel services for operation of WA; they may
25 be co-located with another CRWMS facility), support equipment,
26 ADP support, and records/data management.
27

7.2.4.1 Resolution of Improperly Described Waste After Acceptance into CRWMS.

28
29
30
31 If, subsequent to its acceptance, WA find waste packages
32 improperly described or documented, WA shall promptly
33 notify the Producer in writing of such a finding. In this
34 event, the Producer must provide WA with a proper
35 description within 30 days. In the event that the Producer
36 fails to provide the proper description, CRWMS may hold
37 in abeyance any and all further scheduled deliveries.
38

7.2.4.2 Annual Report to Producer

39
40
41 CRWMS shall annually provide to the Producer pertinent
42 information on the waste disposal program including
43 information on cost projections, project plans, and
44 progress reports. This information shall be available to the
45 Producer upon request.
46

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7.2.4.3 Waste Process Records

WA shall provide storage area(s) to keep records showing the receipt and inventory (including location) of all waste packages in the CRWMS. The records must include, as a minimum, the name of the shipper of the material for each shipment, the estimated quantity of radioactive material per item, item identification, and storage location.

7.2.4.4 Duplicate Records Storage

WA shall provide storage facilities to keep duplicate records of the waste packages. The duplicate set of records must be kept at a separate location sufficiently removed from the original records such that a single event would not destroy both sets of records.

7.2.4.5 Records Disposition

WA shall disposition records in accordance with DOE Order 1324.2 [DOE Order 3790.1A (5)(b)(2)(g)(3)]

8.0 Qualification/Quality Assurance

8.1 Quality Assurance Activities

Quality assurance is an integral part of certification program activities and shall be implemented by all users of this WAC. This section defines planned and systematic QA activities which provide confidence that each Producer site's Waste Certification Program will perform satisfactorily. Each waste generator and/or storage site shall be responsible for developing and documenting a QA plan(s) that will provide the specifics of implementing the guidelines provided in this document. Each waste Producer shall assure that their QA Program (QAP) will result in only fully certified waste packages being shipped to the repository.

8.2 Operations and Safety Criteria QA Requirements

Programs developed and properly implemented using RW-0333P will meet all operational and safety QA requirements.

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8.3 Transportation Packaging QA Requirements

The QA requirements for transportation packaging efforts will be addressed in the QA section of the Safety Analysis Report for Packaging (SARP's). The site-specific QA Plan for transportation packaging activities must meet the requirements of 10 CFR 71 Subpart H, 49 CFR Part 173, DOE/(repository specific)[TBD], and the specific transportation packaging certificate of compliance.

8.4 Waste Characterization Quality Assurance Requirements

The QA requirements for the waste characterization efforts at the generator and potential storage sites are contained in the QARD. The individual sites are responsible for identifying QA and quality control activities in the site-specific Quality Assurance Project Plan (QAPjP) if RCRA determination dictates EPA licensing of the facility.

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GLOSSARY of TERMS

Accessible environment is defined as "... (1) the atmosphere; (2) land surfaces; (3) surface waters; (4) oceans; and (5) all of the lithosphere that is beyond the controlled area". [Ref. 40 CFR 191, Section 2.2.3, § 191.12]

Barrier means any material or structure that prevents or substantially delays movement of water or radionuclides toward the accessible environment. For example, a barrier may be a geologic structure, a canister, a waste form with physical and chemical characteristics that significantly decrease the mobility of radionuclides, or a material placed over and around waste, provided that the material or structure substantially delays movement of water or radionuclides. [§ 40 CFR 191.12.]

Borosilicate glass typically contains 20 to 40 wt% waste oxides, 40 to 65 wt % silica, 5 to 10 wt% boron oxide, and 10 to 20 wt % alkali oxides, plus other oxide constituents.

Calcine is a dry, granular powder formed during the fluidized-bed solidification of 1st cycle raffinate wastes at the Idaho Chemical Processing Plant (ICPP).

Calcination is one process used to convert HLW liquid wastes into solid, granular oxide particles consisting of fission products, trace actinides, hazardous materials, and other non-radioactive materials.

Canister is a structure surrounding the waste form that facilitates handling, storage, transportation, and/or disposal. A standard metal receptacle with the following purpose: (1) for solidified HLW, its purpose is a pour mold or container for smaller components, and (2) for spent fuels, it may provide structural support and containment for loose rods and solid non-fuel components (irradiated materials with activation products).

Canistered waste form is the final waste form in a sealed canister.

Cask is the container for shipping or storing spent nuclear fuel and/or canistered high-level waste which meets all the regulatory requirements.

Civilian Radioactive Waste Management System (CRWMS) is the composite of the sites, and all facilities, systems, equipment, materials, information, activities, and the personnel required to perform those activities necessary to manage spent nuclear fuel and high-level radioactive waste disposal.

Combustible material is any material that can be ignited readily, and when ignited will burn rapidly.

Consolidation is the packaging of spent fuel elements, either in a disassembled form for space saving or to facilitate mixing the parts with HLW forms.

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1
2 **Controlled area**, as defined in Subpart B of 40 CFR 191 is the "(1) location, to be identified by
3 passive institutional controls, that encompasses no more than 100 square kilometers and extends
4 horizontally no more than five kilometers in any direction from the outer boundary of the original
5 location of the radioactive wastes in a disposal system; and (2) the subsurface underlying such a
6 surface location". [§191.12]

7
8 **Criticality** describes the condition where the number of neutrons propagated within the mass of
9 fissile material at least equals the number of neutrons escaping from the system plus those required
10 to sustain neutron production.

11
12 **Critical mass** is the quantity of fissile material (stated in grams or kilograms) necessary to
13 generate a self-sustaining neutron production.

14
15 **Defense High-Level Radioactive Waste (DHLW)** is the high-level radioactive waste, as
16 defined by NWPA Sec. 2(12), resulting from reprocessing spent nuclear fuel in a defense facility.

17
18 **Department of Energy (DOE)** is the department of the U.S. Government which is responsible
19 for the management and disposition of the defense high level wastes.

20
21 **Disposal system** means any combination of engineered and natural barriers that isolate spent
22 nuclear fuel or radioactive waste after disposal. [§ 40 CFR 191.12]

23
24 **Drift** is a secondary mine passageway between two main shafts or tunnels.

25
26 **DU** is depleted uranium left over from the production of U-235; typically the U-235 content
27 ranges from 0.3 to 0.4 wt% U-235 as opposed to ~0.7 wt% in natural uranium.

28
29 **Engineered barrier** consists of backfill material and plugs in the boreholes, the canister, and
30 waste form itself.

31
32 **Engineered barrier system** means the waste packages and the underground facility. [§ 10
33 CFR 60.2]

34
35 **Explosive material** is a substance, that in its normal state, is characterized by chemical
36 properties that remain unchanged with time, but may undergo rapid chemical change without an
37 outside source of oxygen, whereupon it releases substantial energy and hot gases. [§ 49 CFR Part
38 173, Subpart C, Classes A and B]

39
40 **Free gas** is any cover or radiogenic gas trapped inside the canister that could contribute to its
41 pressurization. This includes gases mechanically trapped in the waste form and those generated by
42 chemical reaction and radiolytic decomposition.

43
44 **Fissile materials** can sustain a nuclear chain reaction given adequate mass or concentration.

45
46 **Fissile gram equivalent** is the number of grams of fissile material of a given fissile species that

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1 it takes, on an equivalent basis comparison to U-235, to form a critical mass.

2
3 **General environment** is defined as the "total terrestrial, atmospheric, and aquatic environments
4 outside sites within which any activity, operation, or process associated with the management and
5 storage . . . radioactive waste is conducted". [Ref. 40 CFR 191,§ 191.02]
6

7 **Glass-ceramic** material formed with a combination of calcine and flux material in the Hot
8 Isostatic Press (HIP) process.
9

10 **Glass transition temperature** is the temperature at which the slope of the thermal expansion
11 vs. temperature curve of the glass shows a sharp increase. Below this temperature, the viscous
12 flow or molecular rearrangement in glass is negligible.
13

14 **Grapple** is a device designed to mate with the lifting flange or pintle, used to suspend the
15 canistered waste form from an overhead crane for lifting and transporting.
16

17 **Heavy Metal** means all uranium, plutonium, or thorium placed into a nuclear reactor. [§ 40 CFR
18 191.12]
19

20 **High-level Radioactive Waste (HLW)** means (1) the highly radioactive material resulting
21 from the reprocessing of spent nuclear fuel, including liquid waste produced directly in fuel
22 reprocessing, and any solid material derived from such liquid waste that contains fission products
23 in sufficient concentrations; and (2) other highly radioactive material that the NRC, consistent with
24 existing law, determines by rule requires permanent isolation. [NWSA Section 2(12)][10 CFR
25 72.3] [10 CFR 960.2] [10 CFR 961.11]
26

27 **Hot Isostatic Press (HIP)** is a device used to apply heat and isostatic pressure in the process
28 that converts calcine into monolithic structure consisting of crystalline and amorphous phase.
29

30 k_{eff} equals (rate of neutron production)/(rate of neutron absorption + neutron leakage). As the
31 k_{eff} approaches a value of unity, criticality may be achieved for a finite system; values less than
32 one indicate a system that will be subcritical.
33

34 **Metric tons initial heavy metal (MTIHM)** denotes the mass of the initial heavy metal
35 materials originally present in the fuel element, or an equivalent number based on calculations of
36 the fission product concentrations in the waste. MTU, MTHM, and MTIHM are often used
37 interchangeably. [Ref.40 CFR 191]
38

39 **Monitored Retrievable Storage (MRS)** facility would accept spent fuels and/or HLW on
40 either an interim or permanent basis, depending on the final outcome of the decision relative to
41 siting and opening any repository.
42

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1
2 **Multiple Element Sealed Canister** is an engineered structure containing multiple fuel
3 elements and is comprised of guide sleeves, spacer discs, and top and bottom shield plugs
4 (optional) formed into a corrosion resistant stainless steel canister.
5

6 **Natural barriers** are the subsurface geological and hydrologic systems with the controlled area
7 that inhibit the release and migration of hazardous materials.
8

9 **Nonconforming Waste Form** is an individual canister/package that has been produced,
10 handled, or stored such that its compliance with the WA-SRD requirements on the waste forms
11 cannot be demonstrated.
12

13 **Nonstandard Waste Form** is a nonconforming waste form, but its nonconforming condition
14 has been reviewed and deemed acceptable into the CRWMS. Nonstandard, canistered materials
15 may also be in a condition which require special handling.
16

17 **Performance Assessment (PA)** means an analysis that: 1) Identifies the processes and events
18 that might affect the disposal system; 2) examines the effects of these processes and events on the
19 performance of the disposal system; and 3) estimates the cumulative releases of radionuclides,
20 considering the associated uncertainties, caused by all significant processes and events. These
21 estimates shall be incorporated into an overall probability distribution of cumulative release to the
22 extent practicable [40 CFR 191.12].
23

24 **Producer** is any generator of high-level radioactive waste resulting from atomic energy defense
25 activities or any producer of vitrified commercial HLW.
26

27 **Production records** document or otherwise provide the details associated with each canistered
28 waste form, e.g. radioactive inventory, fissile material loading, external contamination levels,
29 surface dose rates, recorded QA information.
30

31 **Purchaser** is any entity, other than a Federal agency, who is licensed by the Nuclear Regulatory
32 Commission to utilize a production facility under the authority of section 103 or 104 of the Atomic
33 Energy Act (42USC2133,2134), or who has title to SNF or HLW and who has executed a contract
34 or other contractual agreement with DOE. Purchaser's SNF includes Government-owned SNF
35 from commercial industry and civilian development programs.
36

37 **Pyrophoric materials** are those which can ignite spontaneously in air below 54.4°C: any solid
38 material, other than one classed as an explosive, which under normal conditions might cause fires
39 through friction or retained heat from manufacturing or processing, or which can be ignited and
40 burn so vigorously and persistently as to create serious transportation, handling, or disposal
41 hazards. Included are spontaneously combustible and water-reactive materials such as those
42 specified in 49 CFR 173, Subpart E.
43

44 **Radiogenic gas** is produced through radioactive transformation. The transmutation of an
45 element into a gaseous species by change in atomic nucleus through processes such as fission,
46 fusion, neutron capture, or radioactive decay.

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Spent Nuclear Fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, where the constituent elements have not been separated by reprocessing. [NWPA Section 2(23)] [10 CFR 961.11]. {Specifically in this document, SNF includes (1) intact non-defective fuel assemblies; (2) failed fuel assemblies in canisters; (3) intact fuel assemblies in canisters; (4) consolidated fuel rods in canisters; (5) nonfuel components inserted in PWR fuel assemblies, including but not limited to, control rod assemblies, burnable poison assemblies, thimble plug assemblies, neutron source assemblies, instrumentation assemblies; (6) fuel channels attached to BWR fuel assemblies, and (7) nonfuel components and structural parts of assemblies resulting from consolidation in canisters.

Standard Waste Form is a waste form that meets the physical characteristics specified in the WAC as standard. Other standard HLW forms will be defined in subsequent revisions of this WAC.

Storage and shipping records document the physical attributes of each canistered waste form which may be stored at the producer's site for later shipment to a repository. These records also identify any routine or unexpected events for which data is recorded during the storage of the canisters prior to shipment.

Systems Analysis is the process of analyzing the components, attributes, and relationships in a system when they interact in some manner.

System Engineering Process is an interactive process encompassing changes at any point in the process. Possible impacts of change to the system and their net effects should be analyzed during the conduct of the project. These impacts should be examined for validity, consistency, desirability, and attainability with respect to current technology, physical resources, human performance capabilities, life-cycle costs, and other constraints. The output of this analysis should either verify the existing requirements or lead to the development of new requirements that are more appropriate for the mission.

Time-temperature-transformation diagrams identify the duration of exposure at any temperature that causes significant changes in either the phase structure, the phase compositions, or the PCT response of the borosilicate glass waste type.

Underground facility means the underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals. [Ref. 10 CFR 60.2]

Undisturbed performance means the predicted behavior of a disposal system, including consideration of the uncertainties in predicted behavior, if the disposal system is not disrupted by human intrusion or the occurrence of unlikely natural events. [Ref. 40 CFR 191.12]

Waste Acceptance is the system element or organization that manages the Accept Waste function which includes acceptance of SNF and HLW into the CRWMS from the Purchaser/Producer of such waste.

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1 **Waste form** means the materials comprising the radioactive components of waste and any
2 encapsulating or stabilizing matrix. [Ref. 40 CFR 191.12]

3
4 **Waste Form Compliance Plan (WCP)** is a document prepared by a waste producer
5 describing planned analyses, tests, and engineering development work to be undertaken and
6 information to be included in individual waste form production records to demonstrate compliance
7 of a proposed waste form within the waste acceptance specifications.

8
9 **Waste Form Qualification Report (WQR)** is documentation prepared by a waste producer
10 which describes results of analyses, tests, and engineering development work actually performed
11 to demonstrate waste form compliance with waste acceptance specifications.

12
13 **Waste Package** is the waste form itself (canistered SNF or HLW) and any containers shielding,
14 packaging and other absorbent materials immediately surrounding an individual waste container.
15 [Ref. 10 CFR 60.2]

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ACRONYMS AND ABBREVIATIONS

1		
2		
3		
4	ADP	Automatic data processing
5		
6	AEA	Atomic Energy Act
7		
8	ANSI	American National Standards Institute
9		
10	ASCII	American Standard Code for Information Interchange
11		
12	ASME	American Society of Mechanical Engineers
13		
14	BDAT	Best Demonstrated Available Technology
15		
16	BWR	Boiling Water Reactor
17		
18	CCDF	complementary cumulative distribution functions
19		
20	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
21		
22	CFR	Code of Federal Regulations
23		
24	CRWMP	Civilian Radioactive Waste Management Program
25		
26	CRWMS	Civilian Radioactive Waste Management System
27		
28	DCS	Delivery Commitment Schedule
29		
30	DOE	Department of Energy
31		
32	DOT	Department of Transportation
33		
34	DP	Office of Defense Programs (DOE)
35		
36	DWPF	Defense Waste Production Facility (Savannah River)
37		
38	EA	Environmental Assessment
39		
40	EM	Office of Environmental Restoration and Waste Management (DOE)
41		
42	EPA	Environmental Protection Agency
43		
44	FDS	Final Delivery Schedule
45		
46	FGE	fissile gram equivalent

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1		
2	HANF	Hanford Site
3		
4	HEU	highly enriched uranium (>20% U-235)
5		
6	HIP	Hot Isostatic Press
7		
8	HTGR	High Temperature Gas Reactor
9		
10	HLW	High Level Waste
11		
12	IAEA	International Atomic Energy Agency
13		
14	ICPP	Idaho Chemical Processing Plant
15		
16	INEL	Idaho National Engineering Laboratory
17		
18	LDR	land disposal restriction
19		
20	LEU	low-enriched uranium (<20% U-235)
21		
22	MGDS	Mined Geologic Disposal System
23		
24	MPC	Multi-Purpose Canister
25		
26	MRS	Monitored Retrievable Storage
27		
28	NRC	Nuclear Regulatory Commission
29		
30	NWCF	New Waste Calcining Facility
31		
32	NWPA	Nuclear Waste Policy Act of 1982
33		
34	NWPAA	Nuclear Waste Policy Amendments Act of 1987
35		
36	OCRWM	Office of Civilian Radioactive Waste Management (DOE)
37		
38	OMB	Office of Management & Budget
39		
40	OSTS	On-site Storage and Transfer System
41		
42	PA	Performance Assessment
43		
44	PCT	Product Consistency Test
45		
46	PR	Production Records

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1		
2	PWAC	Preliminary Waste Acceptance Criteria
3		
4	PWR	Pressurized Water Reactor
5		
6	QA	Quality Assurance
7		
8	QAPP	Quality Assurance Program Plan
9		
10	QAPjP	Quality Assurance Project Plan
11		
12	QARD	Quality Assurance Requirements Document
13		
14	RCRA	Resource Conservation and Recovery Act
15		
16	RPO	Repository Project Office
17		
18	RW	Office of Civilian Radioactive Waste Management (DOE)
19		
20	SARP	safety analysis report for packaging
21		
22	SF&WMTDP	Spent Fuel and Waste Management Technology Development Program
23		
24	SNF	spent nuclear fuels
25		
26	SRS	Savannah River Site
27		
28	SDWA	Safe Drinking Water Act
29		
30	TBD	to be determined
31		
32	TBP	to be published
33		
34	TBR	to be resolved
35		
36	WAC	Waste Acceptance Criteria
37		
38	WCP	Waste Form Compliance Plan
39		
40	WIPP	Waste Isolation Pilot Plant
41		
42	WQR	Waste Form Qualification Report
43		
44	WVDP	West Valley Demonstration Project
45		
46	YMP	Yucca Mountain Project

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REFERENCES

American Society of Mechanical Engineers (ASME), "Quality Assurance Programs Requirements for Nuclear Facilities," ASME/ NQA-1, 1989 or current revision.

Nuclear Regulatory Commission, "Packaging and Transport of Radioactive Material," NRC Reg 10 CFR 171 or current revision.

U.S. Congress, Atomic Energy Act of 1954, Public Law 703, as amended.

U.S. Department of Defense, "Standard Department of Defense Bar Code Symbolology," MIL-STD-1189B, August 10, 1989.

U.S. Department of Energy, "General Design Criteria," DOE Order 6430.1A or current revision.

U.S. Department of Energy, "Hazardous and Radioactive Mixed Waste Program," DOE Order 5400.3, February 22, 1989 or current revision.

U.S. Department of Energy, "Hazardous Material Packaging for Transport," DOE Order 1540.2, or current revision.

U.S. Department of Energy, "Material Transportation and Traffic Management," DOE Order 1540.1, or current revision.

U.S. Department of Energy, "Radioactive Waste Management," DOE Order 5820.2A, September 26, 1988 or current revision.

U.S. Department of Energy, "Record Disposition," DOE Order 1324.2A or current revision.

U.S. Department of Transportation, "Shipper - General Requirements for Shipments and Packages (Subpart I)," DOT Reg 49 CFR 173 or current revision.

U.S. Environmental Protection Agency, "Interim Guidelines and Specifications for Preparing Quality Assurance Program Plans," QAMS-005/89, December 29, 1980 or current revision. Available from the Office of Monitoring systems and Quality Assurance, U.S. Environmental Protection Agency, Washington D.C., 20460.

U.S. Government Printing Office, "Energy, Title 10, Code of Federal Regulations, Part 71, Packaging and Transportation of Radioactive Material," January 1991.

U.S. Government Printing Office, "Protection of Environment, Title 40, Code of Federal Regulations, Parts 261, 262, 264, 265, and 268," July 1990.

U.S. Government Printing Office, "Transportation, Title 49, Code of Federal Regulations, Part 172, 173, 178, and 179," January 1990.

TABLE A-1

Table A-1

Cross Reference Requirements by Supporting Documents

PWAC Criteria			Waste Acceptance Preliminary Specifications		
Waste Package					
Canister Dimensions	4.2.1	WA-SRD 3.7.1.2.1.1.2.1 EM-WAPS 3.11.2 & 2.4 DOE/RW-0184	2.4	2.4	2.4
Container Weight	4.2.2	WA-SRD 3.7.1.2.1.1.2.1 EM-WAPS 3.11.2 DOE/RW-0184	3.11	3.11	3.11
Canister Material	4.2.3	10 CFR 60.135(a)(1) EM-WAPS 2.1 WASRD 3.7.1.2.1.2.7	2.1	2.1	1.7, 2.1
Canister Handling Features	4.2.7	WA-SRD 3.7.1.2.1.2.16 EM-WAPS 3.13 10CFR60.135(B)(3) 10CFR71.45 49CFR173.411(a-d)	3.13	3.13	3.13
Heat Generation	4.2.4	WA-SRD 3.7.1.2.1.2 EM-WAPS 3.8 49CFR173.442(a) 49CFR173.416(d&f)	3.7	3.7	3.7
Allowable Void Space	4.2.5	WA-SRD 3.7.1.2.1.2.1 EM-WAPS 3.6 DOE/RW-0184	3.5	3.5	3.5
Package Labeling	4.2.6	10 CFR 60.135(b)(4) WA-SRD 3.7.1.2.1.2.15 EM-WAPS 2.3.2	2.3	2.3	2.3

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Cross Reference Requirements by Supporting Documents

PWAC Criteria			Waste Acceptance Preliminary Specifications		
Waste Forms					
Solids	43.1	10CFR60.135(C)(1) WASRD 3.7.1.2.1(A)(1)			
Liquids	43.2	10CFR60.135(b)(2) WASRD 3.7.1.2.1(B) EM-WAPS 3.1 DOE/RW-0184	3.1	3.1	3.1
[reserved]	43.3				
Explosiveness, Pyrophoricity &, Combustibility	43.4	10 CFR 60.135 (b)(1),(C)(3) 49 CFR 173(c)(d)(g)(e) 40 CFR 261 (c)(d) 49CFR173.418 EM-WAPS 3.3 WASRD 3.7.1.2.1(A)(3)	3.3	3.3	3.3
Chemically Reactive Species	43.5	40CFR261.23 10CFR60.135(c)(1) WASRD 3.7.1.2.1.2.5 & 6 WASRD 3.7.1.2.1 (C)	1.1, 3.9	1.1, 3.9	1.1
Criticality	43.6	10CFR71.55 10 CFR 60.131(b)(7) WASRD 3.7.1.2.1.4 EM-WAPS 3.5 DOE 5820.2A [3(b)(2)(i)]	3.10	3.10	3.10
Solubilities	43.7	10 CFR 60.135(a)(2)			

Table A-1

Cross Reference Requirements by Supporting Documents

PWAC Criteria			Waste Acceptance Preliminary Specifications		
Leach Rates	4.3.8	10 CFR 60.135(a)(2) WASRD 3.7.1.2.1.2.13(b) DOE/EA-0179			
Corrosion	4.3.9	10 CFR 60.135(a)(2) 40 CFR 261.22 EM-WAPS 3.5 WASRD 3.7.1.2.1.5			
Gas Generation	4.3.10	10 CFR 60.135(a)(2) EM-WAPS 3.2 WASRD 3.7.1.2.1.2.9A			
Mechanical Properties	4.3.11	10 CFR 60.135(a)(2)			
Radiolysis	4.3.12	10 CFR 60.135(a)(2)			
Surface Dose Limits	4.3.13	DOE/WIPP 88-020 49CFR173.441 WASRD 3.7.1.2.1.2.17 EM-WAPS 3.9 DOE/RW-0184	3.8	3.8	3.8
Radionuclide Inventory	4.3.14	40 CFR 191 10 CFR 60.113 WASRD 3.7.1.2.1.2.8 EM-WAPS 1.2	1.2	1.2	1.2
Organics	4.3.15	10 CFR 60.135(a)(2) EM-WAPS 3.4 WASRD 3.7.1.2.1.2.9B	3.4	3.4	3.4

Table A-1

Cross Reference Requirements by Supporting Documents

PWAC Criteria			Waste Acceptance Preliminary Specifications		
Inert Gases	4.3.16	10 CFR 60.135(b)(1) 49 CFR 173.21(c) 49 CFR 173.24(a)(3) 49 CFR 173.412(h) 49 CFR 173.475(h) WASRD 3.7.1.2.1.2.9	3.2	3.2	3.2
Waste Cask/Transportation		10CFR71 49CFR173 49CFR174			
DOT Standards	4.4.1	49CFR173 Subpart I 49CFR174			
Cask Configuration					
-weight	4.4.2.1	49CFR173.411(b)(c)			
-dimensions	4.4.2.2	49CFR173 Subpart I (Type A or B Cask)			
-allowable dose rates	4.4.2.3	49CFR173.441			
-surface contamination	4.4.2.4	49CFR173.411(e)			
Accident Criteria	4.4.3	10CFR71.73 DOE ORDER 5480.3 Subpart 12			
Handling Criteria	4.4.4	49CFR174 Subpart D			
Mtl's of Construction	4.4.5	49CFR178			
Identification	4.4.6	49CFR172 Subpart E			

Table A-1

Cross Reference Requirements by Supporting Documents

PWAC Criteria			Waste Acceptance Preliminary Specifications		
Security	4.4.7	49CFR174.84 10CFR60.31(b)			
Repository Criteria					
Total MTIHM	4.5.1	[TBD]			
Natural Barrier	4.5.2	10CFR60.133(a) 10CFR60.133			
Engineered Barrier Design	4.5.3	10CFR60.113(a)(1) 10CFR60.133(b)			
Ground Water Releases	4.5.4	10CFR60.113(B)(2) 10CFR60.133(f) 40CFR191.16			
50 Year Retrieval	4.5.5	10CFR60.111(a)(1)			
300-1000 Yr Can Integrity	4.5.6	10CFR60.113(a)(1)(ii)(A)			
10,000 Year Releases	4.5.7	40CFR960.4-1 (b)			
Other Criteria					
Canister Fabrication Reporting	4.6.1	10 CFR 60.135(c)(1) 49 CFR 173.412 WASRD 3.7.1.2.1.2.7 EM-WAPS 2.2	2.2	2.2	2.2

Table A-1

Cross Reference Requirements by Supporting Documents

PWAC Criteria			Waste Acceptance Preliminary Specifications		
Canister After Closure	4.6.2	10 CFR 60.135(c)(1) 49 CFR 173.412 WASRD 3.7.1.2.1.2.9	2.2	2.2	2.2
Canister at Delivery	4.6.3	WASRD 3.7.1.2.1.2.18 DOE/RW-0184			
Surface Contamination	4.6.4	49CFR173.411(e) 10 CFR 71.87 49 CFR 173.443 WASRD 3.7.1.2.1.2.10 EM-WAPS 3.7	3.6	3.6	3.6
Consistency Test	4.6.5	WA-SRD 3.7.1.2.1.2.13 10 CFR 60.135(a) EM-WAPS 1.3 DOE/RW-0179		1.3	1.3
Hazardous Waste Determination	4.6.6	40 CFR 261.31-33 40 CFR 261.20-24 40 CFR 262 WA-SRD 3.7.1.2.1.2.13 EM-WAPS 1.5	1.5	1.5	1.5
Can. Impact Characteristics	4.6.7	10 CFR 60.134(c)(1), (c)(2) EM-WAPS 3.12 10CFR71.73 C(1) WASRD 3.7.1.2.1.2.14	3.12	3.12	3.12
Repository Closure	5	10CFR60.51(Licence Requirements) 10CFR960 Subpart C & D			

Table A-1

Cross Reference Requirements by Supporting Documents

PWAC Criteria			Waste Acceptance Preliminary Specifications		
Supporting Documentation					
Records	6.1	EM-WAPS 5.1 & 5.8 WASRD 3.7.1.2.1.2.19 & 20 DOE/RW-0214			
Cert. & Waste Form Apprv'l	6.2				
Waste Volume Minimization	6.3	40CFR265.75(h & i) 40CFR262.41(a)(6) 40CFR264.75(h & i) 40CFR264.73(b)(9) DOE 5480.2A[3b(7)(A)]			
QA Plan	6.4	10CFR60 Subpart G EM-WAPS 4 WASRD 3.9 DOE/RW-0214			
NEPA Documentaion	6.5	[TBD]			
State Documentation	6.6	[TBD]			
NRC Documentation	6.7	[TBD]			

TABLE A-2

Table A-2
Requirements Cross Reference by other Documents

Description (Outline from PWAC)	EM-WAPS Section No.	WASRD Section No. Doc. No. WBS: 9.2.1.1	WIPP Section No. Doc. No. WIPP/DOE-069
1.0 Introduction	N/A	1.0	1.0
2.0 Repository Characteristics	N/A	N/A	N/A
3.0 Responsibilities	N/A	N/A	2.0
3.1 DOE	N/A	N/A	2.1
3.2 NRC	N/A	N/A	2.2
3.3 Repository Offices	N/A	N/A	2.3-2.4
3.3.1 Interim Storage	N/A	Fig.1.1	2.6
3.3.2 Transportation	N/A	3.2.3.2.3	3.1.2
3.3.3 Geological Disposal Site	N/A	N/A	N/A
3.4 Waste Generation Site(s)	N/A	N/A	2.6
3.5 System Definition	N/A	3.1	N/A
3.5.1 Waste Acceptance Systems Functions - Accept Waste	N/A	3.1.1	N/A
3.5.2 Waste Acceptance Functional Relationship	N/A	3.1.2	N/A
3.5.3 System Description	N/A	3.1.3	N/A
3.5.4 Function to Architecture Cross- Reference	N/A	3.1.4	N/A
3.5.5 Major Considerations & Assumptions	N/A	3.1.5	N/A
3.6 Schedules	N/A	3.2.1.4	N/A
3.7 Interface Requirements	N/A	3.2.3	N/A
3.8 Methods & Controls	N/A	3.3.8	N/A
3.8.1 Material Management	N/A	3.3.8.1	N/A
3.8.1.1 Inventory Control	N/A	3.3.8.2	N/A
3.8.1.2 Radioactive Material Inventory	N/A	3.3.8.2.1	N/A
3.8.2 Government Furnished Property	N/A	3.3.9	N/A
3.8.3 Computer Resources	N/A	3.3.10	N/A
3.8.4 Documentation	N/A	3.4	N/A
3.8.4.1 Test Plans & Procedures	N/A	3.4.4	N/A
3.8.4.2 Production Records	N/A	3.7.4.2.3	N/A
3.8.4.3 Quality Assurance Program Description	N/A	3.9	4.0
3.8.4.4 Records Management	N/A	3.4.8	N/A
3.8.4.5 Computer Documentation	N/A	3.4.7	N/A
3.9 Personnel and Training	N/A	3.6	N/A

Table A-2
Requirements Cross Reference by other Documents

Description (Outline from PWAC)	EM-WAPS Section No.	WASRD Section No. Doc. No. WBS: 9.2.1.1	WIPP Section No. Doc. No. WIPP/DOE-069
3.9.1 General Requirements	N/A	3.6.2.1	N/A
3.9.2 Special Requirements	N/A	N/A	N/A
3.10 Human Factors Engineering	N/A	3.3.7	N/A
4.0 Product Criteria	N/A	N/A	3.0
4.1 Summary of Waste Acceptance Criteria and Requirements	N/A	N/A	3.1
4.1.1 Repository Operations and Safety Criteria	N/A	N/A	3.1.1
4.1.2 Transportation: Waste Package Requirements		N/A	3.1.2
4.1.3 RCRA Requirements	N/A	N/A	3.1.3
4.1.4 Performance Assessment Criteria	N/A	N/A	3.1.4
4.2 Package Waste Criteria	N/A	N/A	3.2
4.2.1 Dimensions	2.4 & 3.11.2	3.7.1.2.1.2.1	3.2.2
4.2.2 Canister Weight	3.11.1	3.7.1.2.1.2.1	3.4.1
4.2.3 Canister Material	2.1	3.7.1.2.1.2.7	Table B-5
4.2.4 Heat Generation	3.8	3.7.1.2.1.2	3.4.6
4.2.5 Allowable Void Space	3.6	3.7.1.2.1.2.1	N/A
4.2.6 Package Labeling	2.3.2	3.7.1.2.1.2.15	3.4.8
4.2.7 Canister Handling Features	3.13	3.7.1.2.1.2.16	3.2.3
4.3 Waste Form Criteria	N/A	3.7.1.2.1	3.3
4.3.1 Solids	N/A	3.7.1.2.1(A)(1)	N/A
4.3.2 Liquids	3.1	3.7.1.2.1(B)	3.3.2
4.3.3 Reserved	N/A		
4.3.4 Explosiveness, Pyrophorosity, & Combustibility	N/A	3.7.1.2.1(A)(3)	3.3.3
4.3.5 Chemically Reactive Species	N/A	3.7.1.2.1(C) 3.7.1.2.1.2.5 3.7.1.2.1.2.6	N/A
4.3.6 Criticality Safety	3.10	3.7.1.2.1.2.4	N/A
4.3.7 Solubilities	N/A	N/A	N/A
4.3.8 Leach Rates	N/A	3.7.1.2.1.2.13(B)	N/A
4.3.9 Corrosion	3.5	N/A	N/A
4.3.10 Gas Generation	3.2	N/A	3.4.7
4.3.11 Mechanical Properties	N/A	N/A	N/A
4.3.12 Radiolysis	N/A	N/A	N/A
4.3.13 Surface Dose Limits	3.9	3.7.1.2.1.2.17	N/A
4.3.14 Radionuclide Inventory	1.2	3.7.1.2.1.2.8	N/A

Table A-2
Requirements Cross Reference by other Documents

Description (Outline from PWAC)	EM-WAPS Section No.	WASRD Section No. Doc. No. WBS: 9.2.1.1	WIPP Section No. Doc. No. WIPP/DOE-069
4.3.15 Organics	3.4	3.7.1.2.1.2.9(B)	3.3.5.3
4.3.16 Inert Gases	N/A	3.7.1.2.1.2.9	N/A
4.4 Waste Cask/Transportation	N/A	N/A	N/A
4.4.1 DOT Standards	N/A	N/A	N/A
4.4.2 Cask configuration	N/A	N/A	N/A
4.4.2.1 Weight	N/A	N/A	N/A
4.4.2.2 Dimensions	N/A	N/A	N/A
4.4.2.3 Allowable Dose Rates	N/A	N/A	N/A
4.4.3 Accident Criteria	N/A	N/A	N/A
4.4.4 Handling Criteria	N/A	N/A	N/A
4.4.5 Materials of Construction	N/A	N/A	N/A
4.4.6 Identification	N/A	N/A	N/A
4.4.7 Security	N/A	N/A	N/A
4.5 Repository Criteria	N/A	N/A	N/A
4.5.1 Geological Barrier	N/A	N/A	N/A
4.5.1.1 Total MTHM	N/A	N/A	N/A
4.5.1.2 Backfill Material	Sandia PA	N/A	N/A
4.5.2 Engineered Barrier Design	Sandia PA	N/A	N/A
4.5.3 Ground Water Releases	N/A	N/A	
4.5.4 50 Year Retrieval	N/A	N/A	
4.5.5 10,000 yr Releases	N/A	N/A	
4.6 Other Criteria	N/A	N/A	3.6
4.6.1 Canister Fabrication Reporting	2.2	3.7.1.2.1.2.7	N/A
4.6.2 Canister After Closure	N/A	3.7.1.2.1.2.9	N/A
4.6.3 Canister at Delivery	N/A	3.7.1.2.1.2.18	3.2.2
4.6.4 Surface Contamination on Canister	3.7	3.7.1.2.1.2.10	N/A
4.6.5 Consistency Test	1.3	3.7.1.2.1.2.13	N/A
4.6.6 Hazardous Waste Determination	1.5	3.7.1.2.1.2.12	N/A
4.6.7 Canister Impact Characteristics	3.12	3.7.1.2.1.2.14	N/A
5.0 Repository Closure	N/A	N/A	N/A
6.0 Supporting Documentation	N/A	N/A	N/A
6.1 Records	5.1	3.7.1.2.1.2.19-20	N/A
6.1.1 Waste Form Compliance Plan (WCP)	5.1.1	3.7.1.2.1.2.19.1	N/A
6.1.2 Waste Form Qualification Report (WQR)	5.1.2	3.7.1.2.1.2.19.2	N/A

Table A-2
Requirements Cross Reference by other Documents

Description (Outline from PWAC)	EM-WAPS Section No.	WASRD Section No. Doc. No. WBS: 9.2.1.1	WIPP Section No. Doc. No. WIPP/DOE-069
6.1.3 Production Record	5.1.3	3.7.1.2.1.2.19.3	N/A
6.1.4 Storage and Shipping Record	5.1.4	3.7.1.2.1.2.19.4	N/A
6.1.5 Waste Package Annual Report		3.7.1.2.1.2.20	N/A
6.2 Certification & Waste Form Approval	N/A	N/A	N/A
6.3 Waste Volume Minimization	?	?	?
6.4 QA Plan	4	3.9	?
6.5 NEPA Documentation	?	?	?
6.6 State Documentation	?	?	?
6.7 NRC Documentation	?	?	?
6.8 Annual Capacity Report	N/A	3.7.1.2.4	N/A
6.9 Delivery Commitment Schedules	N/A	3.7.1.2.6	N/A
6.10 Exchange Requests	N/A	3.7.1.2.7	
6.11 Request for Nonstandard or Nonconforming Waste Delivery	N/A	3.7.1.2.8	N/A
6.12 Final Delivery Schedules	N/A	3.7.1.2.9	N/A
6.13 Final Description of Waste Packages	N/A	3.7.1.2.10	N/A
6.14 Shipping Records	N/A	3.7.3.2.1	N/A
6.15 Title Transfer	N/A	3.7.3.2.4	N/A
7.0 Waste Acceptance Management Segment	N/A	3.7.3	
7.1 Waste Acceptance Management Segment Description	N/A	3.7.3.1	N/A
7.1.1 Waste Acceptance Management Segment Functions	N/A	3.7.3.1.1	N/A
7.1.2 Waste Acceptance Management Segment Interfaces	N/A	3.7.3.1.2	N/A
7.2 Waste Acceptance Management Segment Requirements	N/A	3.7.3.2	N/A
7.2.1 Shipping Records	N/A	3.7.3.2.1	N/A
7.2.2 Fee Receipt Determination	N/A	3.7.3.2.2	N/A
7.2.3 Routine Determinations	N/A	3.7.3.2.3	N/A
7.2.4 Title Transfer	N/A	3.7.3.2.4	N/A
7.2.5 Observations by DOE	N/A	3.7.3.2.5	N/A
7.2.6 Notification of Improperly Described Waste Prior to Acceptance into CRWMS	N/A	3.7.3.2.6	N/A
7.3 Support Segment	N/A	3.7.4	N/A
7.3.1 Support Segment Description	N/A	3.7.4.1	N/A

Table A-2**Requirements Cross Reference by other Documents**

Description (Outline from PWAC)	EM-WAPS Section No.	WASRD Section No. Doc. No. WBS: 9.2.1.1	WIPP Section No. Doc. No. WIPP/DOE-069
7.3.2 Support Segment Requirements	N/A	3.7.4.2	N/A
7.3.2.1 Resolution of Improperly Described Waste After Acceptance into CRWMS.	N/A	3.7.4.2.1	N/A
7.3.2.2 Annual Report to Producer	N/A	3.7.4.2.2	N/A
7.3.2.3 Waste Process Records	N/A	3.7.4.2.3	N/A
7.3.2.4 Duplicate Records Storage	N/A	3.7.4.2.4	N/A
7.3.2.5 Records Disposition	N/A	3.7.4.2.5	N/A
8.0 Precedence	N/A	3.8	
9.0 Qualification/Quality Assurance	N/A	N/A	4.0
9.1 Quality Assurance Activities	N/A	N/A	4.0
9.2 Operations and Safety Criteria QA Requirements	N/A	N/A	4.1
9.3 Transportation Packaging QA Requirements	N/A	N/A	4.2
9.4 Waste Characterization Quality Assurance Requirements	N/A	N/A	4.3

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HISTORICAL & CURRENT PERSPECTIVES

The Department of Energy (DOE) has received spent nuclear fuel (SNF) at the Idaho Chemical Processing Plant (ICPP) for interim storage and reprocessing since 1953. Reprocessing of these fuels for uranium and other resource recovery has resulted in the production of 3800 m³ calcine and a total inventory of 2.0 million gallons of radioactive liquids (500,000 gallons destined for immediate calcination and the remaining sodium-bearing waste requiring further treatment before calcination). Also, 343 metric tons (MT) spent graphite fuels, 474 MT spent special fuels, and 240 MT spent Navy fuel are in current inventory at ICPP. Expected continued receipt of fuels, especially Navy and Fort St. Vrain (FSV) fuels, will add to this inventory pending completion and favorable acceptance of a site-wide Environmental Impact Statement (EIS).

Until early 1992, the major activity of ICPP was the reprocessing of spent nuclear fuels to recover fissile (high enriched) uranium. With the changes in world events, the demand to recover and recycle this material has changed, and DOE has discontinued reprocessing fuels for the recovery of uranium. However, the need to properly manage and dispose of spent fuels and high-level waste remains a high priority.

The process and schedule for management and disposal of SNF and HLW wastes were specified initially in the Nuclear Waste Policy Act (NWPA) [1982]. Additionally, a Presidential Memorandum dated April 30, 1985, stated that there was no compelling reason to build a separate repository for defense HLW; therefore, the waste will be placed in a civilian geologic repository. In the Nuclear Waste Policy Amendments Act (NWPAA) [1987], Yucca Mountain, Nevada was designated for characterization as the candidate site for a geologic HLW/SNF repository. However, legislated limits for Yucca Mountain and projections of future commercial SNF, along with timing on the treatment of defense wastes, suggest a second repository will be needed at some time in the future.

The NWPA defines SNF as the fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. As used in this document, SNF is defined to include the nonfuel components and hardware as identified in 10 CFR 961. HLW is defined as the highly radioactive material resulting from the reprocessing of SNF. This includes liquid waste produced directly in reprocessing, any solid material derived from such liquid waste that contains fission products in sufficient concentrations, and other highly radioactive material that has been determined by the Nuclear Regulatory Commission, consistent with the law, as requiring permanent isolation. As used in this document, HLW is defined to include commercial and defense HLW. The Civilian Radioactive Waste Management System (CRWMS) will accept both SNF and solidified HLW. [Note that the 10 CFR 60 definition of HLW includes SNF.]

In the NWPA, Congress identified that long-term storage of SNF in Monitored Retrievable Storage (MRS) facilities is a safe and reliable option for management of SNF. In the

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NWPAA, Congress authorized the Secretary of Energy to site, construct, and operate one MRS, and as stated in 10 CFR 72, the MRS will have an initial 40-year license term with the option for renewal by the NRC. The MRS is to provide temporary storage of SNF until the SNF is shipped to the geologic repository for disposal. HLW will be shipped from the Producer sites directly to the geologic repository.

A pictorial representation of the flow of anticipated SNF/HLW materials specific to the INEL is shown in Figure 1. This illustration covers the INEL materials flow rather than the commercial reactor materials flow directed by Congress to Yucca Mountain.

In accordance with the NWPA of 1982, as amended, DOE plans to dispose of spent fuel and high-level waste in geologic repositories. This disposal must meet the standards issued by the U. S. Environmental Protection Agency (EPA) and must be licensed by the U. S. Nuclear Regulatory Commission (NRC). Federal and state laws, regulations and agreements also exist that require certain action at ICPP. For example, all DOE facilities must meet the requirements of hazardous waste Land Disposal Restrictions (LDR) listed in 40 CFR 268 and DOE Order 5820.2A. Although the continued operation of the New Waste Calciner Facility (NWCF) and calcine production is in violation of LDR after May 8, 1992, the State of Idaho has signed a letter of consent to continue calciner operation as best demonstrated available technology (BDAT) for current liquid wastes in storage. Ultimately, there is a need to provide facilities to vitrify HLW.

Actions are also being taken in the management of radioactive liquid wastes currently stored at ICPP in stainless steel tanks. Such actions are needed to support compliance with the Resource Conservation Recovery Act (RCRA) requirements for secondary containment of hazardous wastes. A Notice of Noncompliance (NON) was issued on January 29, 1990 by the EPA because the secondary containment (concrete vaults) is subject to attack by the acidic solutions stored in the tanks if a leak were to develop. A consent order to resolve this NON has been negotiated between DOE and the State of Idaho. The parties agreed to milestones for removal of liquid waste stored in existing tanks. Final consent order signatures were obtained on April 3, 1992.

Accordingly, the emphasis of ICPP future operations has shifted toward investigating, testing, and selecting technologies to prepare current and future spent fuels and waste as appropriate for geologic disposal. Preparation of spent fuel & high-level waste for disposal may include mechanical, physical and/or chemical processes, and may differ for each of the various fuels and wastes.

The general strategy is to develop and demonstrate processes for preparing spent nuclear fuel (SNF) and high-level waste (HLW) for disposal in a geologic repository. As part of the INEL Spent Fuel and Waste Management Technology Development Plan (SF&WMTDP), the development of a preliminary waste acceptance criteria (PWAC) was identified. Figure 2 shows the hierarchy of the INEL SF&WMTDP documents. As indicated in Figure 2, the PWAC (eventually to become the waste acceptance criteria) is one of many technical development documents that help the program in directing its efforts toward a systematic approach in identifying interim storage and long term disposal options. The PWAC provides program support in three ways. First, it defines the acceptable criteria the INEL SNF and HLW materials need to meet for long term geological disposal. As the

Figure 1
ICPP Spent Fuel and Waste Management
Technical Development Program Interface Diagram

SYSCOM.GCD
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Figure 2: Hierarchy of INEL SF&WMTDP Documentation

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program identifies each of the potential waste forms, they will be evaluated against a set of criteria (derived from various regulatory documents) that must be met. If a given waste form does not meet this set of criteria, the form is either discarded or modified to meet the criteria in the PWAC. (NOTE: The criteria indicated in the PWAC are verified through the performance assessment evaluation of the waste form(s) in a hypothetical repository. Final waste acceptance will have to be determined after an actual disposal site has been designated, where the waste forms can be evaluated against actual repository conditions.) Second, development of the PWAC demonstrates the interrelated aspects of regulatory compliance required to dispose of INEL wastes in a geological repository. And third, the PWAC in conjunction with other Technical Development Documents, provides the basis for the development of the implementation documents indicated in Figure 2. These documents are required to ensure the final product will meet repository requirements.

The following paragraphs attempt to describe the status and explain the steps taken in the development of a waste acceptance criteria to support the development program. It is not the intent of this document to 'select' a process(es); rather, it will focus on the identification of the parameters needed in a waste form(s) that will meet current regulations in a geological repository.

Presently, the two repositories under consideration in the United States are Yucca Mountain Project (YMP) for commercial SNF and HLW, and the Waste Isolation Pilot Plant (WIPP) for transuranic (TRU) waste. The paragraphs below indicate the approach and the responsibilities of the various organizations involved with the development of waste acceptance criteria for the respective repositories.

Yucca Mountain Project Approach

As of January, 1993 (Reference DOE/RW-0351P), for the Yucca Mountain project, the OCRWM office has identified four program-level system requirement documents in their requirement hierarchy (See Figure 3). The Waste Acceptance System Requirement Document (WA-SRD) is one of the program-level requirements documents which A) defines the Waste Acceptance Criteria, B) Establishes Contracts/Agreements, C) Plans for Waste Acceptance, D) Accepts Waste Custody, E) Resolves Improperly Described Waste, and F) Provides Fee Collection (See Figure 4). Prior to the WA-SRD, the OCRWM office issued Waste Acceptance Preliminary Specifications documents to address the waste acceptance criteria for the glass waste forms to be produced by the Savannah River, West Valley and Hanford sites.

At this time, the WA-SRD points to the Office of Environmental Restoration and Waste Management (EM) for furnishing product specifications to the waste producers in support of their qualification programs. Thus, the Waste Acceptance Product Specifications (WAPS) will be developed and provided by DOE-EM. Figure 5 provides a pictorial view of the inter-relationship and responsibilities of the DOE-RW, DOE-EM, and the HLW glass producers.

For commercial SNF, the *purchasers* (owners and generators of SNF from civilian reactors) have a contract with the U.S. Government (reference 10 CFR 961) which states that DOE-RW has the responsibility to receive and dispose of commercial SNF in a geological repository.

FIGURE 3
CRWMS PROGRAM-LEVEL SYSTEM REQUIREMENTS DOCUMENTS

FIGURE 4
CRWMS WA FUNCTIONS

**FIGURE 5 PICTORIAL SUMMARY OF YUCCA MOUNTAIN
DOE-RW/DOE-EM/HLW GLASS PRODUCER INTERACTIONS**

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Waste Isolation Pilot Plant Approach

In the December, 1991, Waste Acceptance Criteria (WAC) for the Waste Isolation Pilot Plant (Reference WIPP/DOE-069 Revision 4 Section 2.0), DOE/EM has delegated authority for all operations involving TRU waste emplacement in the WIPP to the DOE Operations Office, Albuquerque (DOE/AL). The majority of these responsibilities have been delegated to the DOE/AL WIPP Project Integration Office (DOE/WPIO). The DOE WIPP Project Site Office (DOE/WPSO), which reports to the DOE/WPIO, is responsible for all WIPP site activities. The DOE/WPIO has overall responsibilities for the WAC, with concurrence from DOE/WPSO. Note that since the emplacement of TRU waste is not under the jurisdiction of the Nuclear Regulatory Commission (NRC), the NRC license, review, and approval process at YMP is not applicable here.

INEL/ICPP PWAC Approach

In support of the development program, the requirement to establish an acceptance criteria document for SNF and HLW was initiated. This acceptance criteria document has been identified in the development program as the Preliminary Waste Acceptance Criteria (PWAC) to distinguish it from a formalized WAC. The purpose of the PWAC is to establish an initial set of acceptance criteria for SNF and HLW to be processed at the ICPP destined for a hypothetical repository with certain geological features.

However, there are three problems associated with the generation of a PWAC. First, no repository has been identified by DOE to receive the to-be-processed SNF. Although the present law states that all the defense HLW (including the HLW at ICPP) will be destined for the Yucca Mountain repository, it is not clear at this time whether the Yucca Mountain repository will have the capacity to receive all of the defense HLW. Secondly, no performance confirmation or assessment has been completed on the yet-to-be-defined disposal system (i.e. the repository, waste form, and its engineered barriers) to ensure that such a system will meet all the regulatory performance requirements. Third, the combination of wastes from various producers may include commercial materials, and the OCRWM/EM/NRC interface has yet to be identified.

To complete the PWAC document per the program schedule, several areas of development have to be conducted concurrently. These areas of development include: 1) propose and evaluate the potential waste forms, 2) conduct an assessment of the disposal system, 3) identify current regulatory requirements and compliance issues governing a geologic repository, and 4) define and develop the information needed to complete the PWAC.

WINCO will initiate work normally performed by others such as the waste receiving organization or repository operator. This work includes: 1) conducting the performance evaluation of the disposal system based on hypothetical repositories, and potential SNF and HLW forms, and 2) the development of a

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PWAC (WINCO has identified that the PWAC's contents should be consistent with the Yucca Mountain's WA-SRD). Figure 6 portrays the scope of the documentation involved in developing this PWAC. Figure 7 depicts the evaluation process associated with qualifying an ICPP waste form. The results of these efforts provide guidance to the INEL SF&WMTDP. However, the results will have to be confirmed when an actual repository has been identified to receive the processed INEL SNF and HLW.

This PWAC document describes the technical requirements for accepting SNF and HLW into a hypothetical fractured hard rock or salt repository, or a monitored retrievable storage (MRS) facility while awaiting operation of the repository. This PWAC is different from the WAC issued by the WIPP and WA-SRD as issued by the OCRWM in support of the YMP. This PWAC attempts to establish an initial set of acceptance criteria for the SNF and HLW to be processed at the INEL destined for a hypothetical repository. This acceptance criteria defines how the SNF and HLW forms at the INEL need to be processed and packaged before they may be dispositioned into a hypothetical repository. This PWAC does not define the actual acceptance criteria required if a repository is identified to receive the SNF and HLW at a later date; all of the results of this study would have to be confirmed and verified when such a repository is identified. Appendices or otherwise attached documents to this PWAC represent draft copies of what typically might be expected as supporting documents in an actual repository situation. In the time frame expected for an actual repository to come on line, many of the supporting documents needed are expected to be changed, expanded, or replaced.

By necessity, the various wastes at ICPP best lend themselves to different treatment methods or processes. In addition, ICPP has a singular and unique situation in dealing with packaging and disposal of highly enriched uranium. Because of the different forms produced, it is best to address each waste form with a separate product specification. As a result of product composition differences and/or structure, not all product specifications will contain the same details. The hypothetical product specifications supporting this document would necessarily require modification to accommodate mixed waste forms or other form improvements identified during process development.

FIGURE 6 PICTORIAL SUMMARY OF ICCP SF&WMTDP PWAC

AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100

Silver Spring, Maryland 20910

301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

2 of 3

FIGURE 7*
METHODOLOGY FOR SYSTEMS ANALYSIS OF INEL SPENT FUEL & HLW

*This flowsheet is modeled after Figure 3 of SAND91-0047 Report.

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Waste Acceptance Preliminary Specifications for the Idaho Chemical Processing Plant Graphite Based Spent Fuel

INTRODUCTION

Various radionuclide compositions, numerous forms of spent nuclear fuel sent to the Idaho Chemical Processing Plant (ICPP) for reprocessing, and radioactive waste generated directly and indirectly from reprocessing activities are currently located in ICPP facilities at the Idaho National Engineering Laboratory (INEL). In 1992, however, DOE decided that the spent nuclear fuel would no longer be reprocessed to recover usable uranium, but would instead be conditioned for permanent disposal in a geologic repository. A program to initiate development for disposal of the remaining spent fuel and waste forms presently at the ICPP, the Spent Fuel and Waste Management Technology Development Program (SF&WMTDP), has been initiated by DOE to proceed with disposal of the remaining spent fuels and waste forms presently located at ICPP. Part of this program involves defining (to the extent possible) the probable waste acceptance criteria for such a repository.

This document identifies potentially applicable acceptance criteria that will be used to guide development activities so that a complete evaluation of processing alternatives can be made, but should not be confused with the final Waste Acceptance Criteria (WAC) that will be prepared by the repository operator. The criteria proposed in this document, based on present Federal regulations and existing criteria published for other facilities, discusses some implications of spent fuel disposal relative to finalized criteria and identifies issues and concerns that should be resolved prior to disposal in a geologic repository.

Since spent graphite fuels have yet to be fully characterized, nor has a geologic repository been identified, detailed calculations and testing cannot, at this time, be completed to validate any proposed form. Consequently, specifications listed in this report are general, in reference to spent graphite fuels, listing only information that is available from Federal regulations. Other specifications are based on High-level Waste criteria such as those for the Defense Waste Processing Facility (DWPF). As analyses of spent fuel or other forms are completed, changes to the numerical values presented for high-level waste may result. The review and subsequent adjustment of criteria will be a continuing effort for the Spent Fuel Conditioning Development Program.

The EPA (Environmental Protection Agency) has published regulations to assure that high-level waste disposal can be accomplished without undue hazard to the public⁸. The NRC (Nuclear Regulatory Commission), in turn, has published regulations on how they intend to license such a disposal facility. Based on these regulations, criteria have been prepared for each different graphite fuel disposal form. It will be necessary for DOE to prepare a licensing strategy that will demonstrate to the designated regulatory agencies that the repository system, including engineered barriers such as waste containers and the waste forms themselves, will perform in an acceptable manner. Additionally, the producer must meet site-specific repository requirements regarding the limiting rates at which radionuclides can be released. The predicted release rate limits must be

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based on the overall performance of the engineered barrier system. A detailed performance assessment of a chosen spent fuel disposal form in a specified repository medium will be necessary to demonstrate that these release limits can be met. Preliminary studies, based on worst case disposal packages in a typical repository, have begun, and new criteria may be developed as work progresses on the disposal concepts.

1.0 WASTE FORM SPECIFICATIONS

1.1 Chemical Composition

Sufficient chemical and structural data shall be provided, in production records, to characterize the elemental composition for all elements present in the spent graphite fuel greater than {some minimal value} as well as the expected chemical changes of those elements caused by variations in the conditioning process during the life of the facility. A Waste Form Qualification Report (WQR) shall be prepared to document this information, with methods used to make these projections described in an accompanying compliance plan (WCP)^{7,18}.

1.2 Radionuclide Inventory

Estimates, and uncertainties, of the expected total quantity of individual radionuclides to be shipped to the repository shall be provided. Also, inventory estimates, indexed to the year 2030, shall be provided for the individual radionuclides projected for each canistered graphite spent fuel. The method used to make these projections shall be described in the WCP^{5,8,18}.

Production record estimates of inventories of individual radionuclides in each graphite spent fuel canister at the time of shipment shall be provided, along with the expected accuracy of these estimates⁶.

1.3 Fuel Package Conformity

1.3.1 Acceptance Criteria

Measured or projected radioisotope release rates shall be less than or equal to the cumulative release rates identified in 40CFR191. Measured or projected results shall be identified as such, and reported in the Production Records.

1.3.2 Method of Compliance

The capability of a fuel package to meet these specifications shall be derived from production samples and/or process control information.

When using process control information to project results, it shall be demonstrated in the WQR that the method used will provide information equivalent to the testing of actual production samples.

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1.4 **Hazardous Components**

The graphite spent fuel shall be characterized as described in the WCP to determine its hazardous components as stated in 40 CFR 261 and 40 CFR 264.

Characterization will be completed to determine special fuel components that are regulated by RCRA and be reported in the WQR; these components must meet the repository requirements for RCRA permit applications.

2.0 CANISTER SPECIFICATIONS

2.1 **Material**

The disposal canister shall be fabricated from 304L SS and the canister fabrication methods shall be documented in the WCP. The ASTM alloy specification and the composition of all materials used in the welding process shall be compatible with the canister material and reported in the WQR⁵.

2.2 **Fabrication**

The canister shall have an attached grapple (lifting flange) that will allow vertical lifting or horizontal pulling, and fabrication methods shall be identified in the WCP and documented in the WQR.

2.3 **Labeling**

A unique alphanumeric/bar code shall be assigned and two labels shall be permanently affixed to each canister, one visible from the top and one from the side. Additionally, this code shall appear on all documentation pertaining to each individual canister. Labels shall be applied to the exterior of the outermost canister and shall not exceed the required dimensional limits or impair the integrity of the waste package. Label materials and methods of attachment shall be selected to be compatible with the canister material and designed to withstand (1) filling and storage at the conditions present at the conditioning facility, (2) shipment to the repository, and (3) possible lag storage at the repository. The information on each label shall be legible at least to the end of the retrievability period (typically 50 years), and an estimate of the service life of the label and the basis for meeting that estimate shall be provided in the WCP⁵.

2.4 **Canister Dimensions**

The dimensions of the canister should ensure that the canister will stand upright on a flat, horizontal surface without support and will, without forcing, fit into a right circular, cylindrical cavity of the size anticipated for the repository. The overall dimensions of the canister at the time of shipment is dependent on the spent fuel disposal form selected, but shall not exceed 10.2 to 61.0 cm OD x 106.7 to 427 cm long with a nominal canister wall thickness of 0.635 cm. All deviations from the repository approved canister must be reapproved, before being filled, by the repository one year prior to shipment; the quantity and shipment schedule of non-

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standard canisters shall also be furnished.

3.0 PACKAGED WASTE SPECIFICATIONS

3.1 Free Liquids

The canistered graphite spent fuel shall not contain free liquids beyond {amount that could compromise the package integrity - TBD}. The method of compliance shall be described in the WCP and the results shall be reported in the WQR.

3.2 Cover Gas

At closure, the canister shall not contain free gas other than cover gas, if required, or radiogenic gas. Cover gases shall be argon. The maximum internal gas pressure immediately after closure shall be less than or equal to the limit specified by the repository. The method of assuring compliance shall be described in the WCP and the results shall be reported in the WQR.

3.3 Reactive Contents

The package shall not contain explosive, combustible or pyrophoric materials, or chemically reactive materials in any amount that could compromise the ability of the geologic repository to satisfy the performance objectives. The graphite spent fuel contains metal carbides that could react with water to form a mixture of acetylene, hydrogen gas, and other gases. Processing options which convert the carbides to oxides should eliminate concerns for these hazards. An evaluation of the graphite spent fuel(s) shall be required to demonstrate that the package meets established requirements.⁵ The method of evaluation shall be described in the WCP, and the evaluation results shall be documented in the WQR.

3.4 Organic Materials

After closure, the canistered graphite spent fuel shall not contain organic materials like {TBD}. The potential to generate acetylene and other organics from water reaction with heavy metal carbides shall be addressed in the WCP.

3.5 Free Volume

As required by the repository, inert or other relatively dense materials, such as {TBD}, may be added to the canister to minimize the free volume⁷. Typically, at least 80% of the total free volume of the canister will be filled. This requirement is intended to ensure that minimal creep and disruption of the repository occurs after closure. This may pose a problem for graphite fuel disposal since the material is inherently full of voids. Since commercial fuels suffer from a similar problem, it is expected that an acceptable disposal method will be developed which can be adapted to graphite fuels.

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3.6 **External Contamination**

The level of non-fixed (removable) radioactive contamination on all external surfaces of each canister shall not exceed 220 dpm/100 cm² alpha or 2200 dpm/100 cm² beta/gamma⁷. Remote decontamination and contamination monitoring capabilities will have to be developed for all disposal options involving highly radioactive material and is therefore not unique to graphite fuels. Methods for assessing the contamination levels shall be described in the WCP and measured residual contamination levels (after decontamination of canisters) shall be reported in the Production Records.

3.7 **Heat Generation**

Thermal limits for individual spent fuel packages shall not exceed values specified for the shipping cask or by the repository. The heat generation rate and its accuracy for the canistered graphite spent fuel shall be specified (indexed to the year 2030) as required by the repository⁵. The specified value could limit the number of spent fuel elements that can be inserted into the disposal canisters. This information is available as a product of the characterization program and shall be reported in the WQR. No special impacts for this control method are foreseen at this time.

3.8 **Maximum Dose Rates**

At the time of shipment, the canistered spent fuel shall not exceed the maximum surface gamma dose rate and the maximum neutron dose rate set by the repository. The expected dose rates, and expected variations (indexed to the year 2030), shall be specified. The actual dose rates at the time of shipment shall be provided in the shipping records. For the DWPF, these limits have been set at a maximum surface gamma dose rate of 10E⁵ R/hr and a neutron dose rate of 10E³ R/hr⁵.

3.9 **Chemical Compatibility**

The contents of the canistered graphite spent fuel shall not lead to internal corrosion of the canister such that there will be an adverse effect on normal handling during storage, transportation, and repository operation. The method of compliance shall be described in the WCP. Corrosion interactions, capable of occurring until repository closure, shall be evaluated and reported in the WQR⁵.

3.10 **Subcriticality**

The canistered material shall remain subcritical under all credible conditions likely to be encountered. Methods for demonstrating compliance shall be described in the WCP. All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of spent fuel shall be designed, under both normal and accident conditions, 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. The calculated

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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^{5,7}.

Compliance with this requirement will entail detailed safety analysis and the results will be reported in the WQR. Criticality prevention in the repository after closure will need to be addressed by the PA program for spent graphite fuel emplacement and by the repository operator. Depending on requirements of the repository, criticality prevention could have significant impact on the conditioning requirements. Uncertainties as to fissile mass restriction may drive the conditioning program to separation of the fissile material from the fission product fraction of the spent fuel.

3.11 **Weight**

The weight of each disposal canister again is dependent on the spent fuel disposal form selected, but should not deviate from a range of 108 to 3344 kgs.

3.12 **Drop Test**

The canistered graphite spent fuel at the time of shipment shall be capable of withstanding a 7m drop onto a flat, essentially unyielding surface without breaching. The method of compliance shall be described in the WCP, and supporting documentation of analysis and test results shall be contained in the WQR.

3.13 **Handling Features**

The canister shall have a lifting mechanism of the type specified by the repository, and the following shall be furnished to the repository by the producer: (a) a complete set of drawings and operating procedures/instructions and (b) a working duplicate of the grapple device.

4.0 **QUALITY ASSURANCE**

Procedures for sampling, analytical protocols, QA/QC guidelines and other information required for general waste analysis must be documented in a quality assurance plan. This plan shall be established, maintained, and executed for compliance with the repository requirements and shall be applied to all activities that provide information important to the repository. Data generated prior to the inception of the QA program may be utilized as long as the specific QA measures that were in effect when the data were generated are described and appropriately qualified. The quality assurance program shall also be applied to all activities that affect compliance with waste acceptance specifications during graphite spent fuel form production, handling, storage, preparation for shipment, and shipment to the repository. Based on the RCRA applicability determination, appropriate QA/QC requirements (e.g. QAMS-005/80) shall be incorporated into the QA Program for waste analysis.

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5.0 IMPLICATIONS ON GRAPHITE SPENT FUEL DISPOSAL

5.1 Disposal Specifications

Spent graphite fuel shall be disposed of either as assemblies, subassemblies, consolidated materials, or as removed fuel and shall be in a solid form in a sealed container. Particulates (specifically finely-divided fissile material) shall be consolidated in a glass-type matrix to limit unfavorable reactions and/or contamination spread if the canister is breached⁵. All spent graphite fuels shall be reduced to a noncombustible form to eliminate the possibility of a fire during disposal operations, and in all disposal scenarios for graphite fuels, the disposed material will be placed in a nonflammable metal canister, under dry conditions, which will be hermetically sealed with a nonreactive cover gas. Canistered spent fuel shall not contain free liquids in an amount that could compromise the package⁵.

Additionally, the spent graphite fuel shall not be classified as characteristically ignitable, corrosive, or reactive as defined by RCRA¹⁵, meaning that all spent graphite fuel shall not contain explosive or pyrophoric materials or chemically reactive materials that could compromise the ability of the repository to meet its performance objectives.

5.2 Spent Nuclear Fuel Specifications

All spent graphite fuel are nonstandard spent nuclear fuels (SNF) of domestic origin as described in 10 CFR 961.11 Appendix E.B.1 through E.B.5.

5.2.1 Description of the Graphite Spent Fuel

Different types of graphite spent fuels are located at the ICPP. Graphite spent fuels come primarily from the Fort St. Vrain (FSV) and Peach Bottom (PB) High Temperature Gas Reactor facilities. The FSV fuel element consists of an approximately 130-kg hexagonal graphite block, 0.36 meters across the flats and 0.79 meters high. A typical block contains 108 coolant channels and 210 fuel holes. The fertile and fissile materials are present as metal carbide particles coated with layers of pyrolytic carbon, silicon carbide, and another outer layer of pyrolytic carbon; all particles are bonded into fuel assemblies by a carbonaceous material. At fabrication the fuel contains a mixture of fissile (containing thorium and 93.5 % enriched uranium) and fertile (containing only thorium) particles. Each particle is designed to maintain its integrity and contain fission product gases until the particle is deliberately crushed. The silicon carbide layer of the particle is highly resistant to both oxidation and moisture, even at extremely high temperatures. The FSV fuel design, Figure A-1, is such that it would not be classified as combustible or reactive as far as impacts on the repository are concerned.

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Figure 1. Fort St. Vrain Standard Fuel Element

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The Peach Bottom fuel element is approximately 3.6 meters long and 0.08 meters in diameter, is composed largely of graphite, weighs approximately 40 kg, and contains about 1.8 kg of uranium and thorium. A section of a typical Peach Bottom fuel assembly is shown in Figure 2. Two different cores of Peach Bottom fuels have been produced with the principal difference between the two being the fabrication of the fuel particles. Core 1 particles experienced excessive fuel failures; this was attributed to the fuel particle coating system, which consisted of a single pyrocarbon coating with no buffer layer. The system was modified for Core 2 to a two-layer system including a buffer layer. The new design performed satisfactorily.

5.2.2 Summary of Graphite Spent Fuel Classification

Graphite spent fuel is classified as NS-1 and NS-4, according to 10 CFR 961.11 Appendix E.B., meaning that spent graphite fuel may be either (1) disassembled, or (2) processed into fuel pellets or ash and consolidated in a glass-type matrix. In such a condition, the spent fuel would be classified as NS-5.

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ICPP-A-19047
(3-93)

Figure 2. Peach Bottom Fuel Element

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5.3 Disposal System Criteria

The graphite spent fuel, the canister, and the repository all combine to form a disposal system that provides protection for public health and safety, and for the environment by ensuring that the radionuclide and toxic metals are constrained to safe limits. Criteria applying to this overall system are presented below.

5.3.1 Groundwater Protection Requirements

The disposal system for spent nuclear fuel shall, by design, provide a reasonable expectation that undisturbed performance of the disposal system shall not, for a period of 1000 years following disposal, cause the radionuclide concentrations in water withdrawn from any portion of a special source of ground water to exceed a yearly average of:

- (a) Five (5) picocuries per liter of radium-226 and radium-228
- (b) Fifteen (15) picocuries per liter of alpha emitting radionuclide including radium-226 and radium-228 but excluding radon; or
- (c) The combined concentrations of radionuclides that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ greater than 4 millirems per year if an individual consumed 2 l/day of drinking water from such ground sources.

Finely divided fissile material shall be consolidated in a glass-type matrix (for encapsulation and stability) and the encapsulated material must be placed in the specially designed leak-tight canister, per criterion 3.12 of this document.

5.3.2 Total Radionuclide Release Rates

Disposal systems for spent nuclear fuel shall, by design, provide a reasonable expectation, based on a performance assessment covering all events that may affect the system, that the cumulative releases of radionuclides to the accessible environment, for 10,000 years after disposal, shall:

- (a) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Appendix A of 40 CFR 1918.
- (b) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Appendix A of 40 CFR 1918.

Finely divided fissile material shall be consolidated in a glass-type matrix and must be placed in the specially designed leak-tight canister, per criterion 3.12 of this document.

5.3.3 Retrievability

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Disposal systems shall, by design, preserve the option of retrieval for any or all of the canistered spent fuel throughout the emplacement period and for a reasonable period after disposal⁸. Section 122 of the Nuclear Waste Policy Act (1982) provides that DOE shall specify an appropriate period during which spent fuel could be retrieved for any reason pertaining to public health and safety, or the environment, or for the purpose of permitting recovery of the economically valuable components of such spent fuel. This time is assumed to be at most 50 years after spent fuel emplacement operations are initiated⁵.

5.3.4 Dose Rates

The disposal systems shall, by design, provide a reasonable expectation that, for 1000 years after disposal, undisturbed performance of the disposal system shall not cause the annual dose equivalent from the disposal system to exceed 25 millirems to the whole body or 75 millirems to any critical organ for any member of the general public⁸.

5.3.5 Certification for Transport and Emplacement

A repository specific/waste specific plan and detailed procedures required for certifying spent fuel for transport to and emplacement in the repository shall be prepared¹⁸ prior to shipment from the producer. When the graphite spent fuel form and the repository site have been selected and fully characterized, the transport and emplacement plan and procedures shall be finalized and transmitted.

5.3.6 Repository Safety Requirements

Graphite spent fuel shipments must meet all engineered safety requirements identified in the repository Safety Analysis Report (SAR)¹⁸. When the repository site has been selected and the PA program completed, the transport plan and procedures shall be finalized and transmitted.

5.3.7 Performance Assessment

A certification plan shall identify how each shipment will meet the repository criteria to ensure safe handling of wastes at the repository. When the repository site has been selected and the PA program completed, the emplacement plan and procedures shall be finalized and transmitted.

5.3.8 Safe Handling Requirements

Predictions of disposal system performance shall be prepared and incorporated in the NEPA process⁴. To that end, a performance assessment for emplacement of graphite fuels in a geologic repository has been initiated. Typically, this assessment is done by determining the inventory of the

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fission products, and actinides, and other hazardous materials in the disposed fuel by estimating the rate at which these materials are released from the fuel, by analyzing the transport of these materials through the repository environment surrounding the waste, and by determining how quickly and in what amounts the materials of interest could reach a human receptor. Although it will be difficult to adequately evaluate the migration of radioactivity from the waste to the environment without having specific repository data available, preliminary studies to scope this activity are in progress, and preliminary data are expected by the end of FY-1993. When the graphite spent fuel form and the repository site have been selected and fully characterized, the performance assessment shall be finalized and transmitted.

5.3.9 Individual Radionuclide Release Rates

The release rate of any radionuclide from the engineered barrier system during the containment period, excluding any radionuclide that is released at a rate of less than 0.1% of the total release limit^{5,6}, shall not exceed one part in 100,000 per year of the inventory calculated to be present 1000 years following permanent closure, unless specifically approved otherwise. Finely divided fissile material shall be consolidated in a glass-type matrix and must be placed in the specially designed leak-tight canister, per criterion 3.12 of this document.

5.4 Other Criteria

5.4.1 Certification Data Requirement

A data package with certification, and all documentation for certification of such packages^{16,17}, shall be transmitted to the repository prior to shipment.

5.4.2 Waste Minimization Requirement

Spent fuel processing programs shall be developed and implemented to reduce the quantity of waste being sent to storage⁴. The graphite spent fuel form selected shall limit the waste volume to be emplaced to reasonably achievable quantities for each spent graphite fuel type.

Attachment 2

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Waste Acceptance Preliminary Specifications for the Idaho Chemical Processing Plant Special Fuel

INTRODUCTION

At the INEL, DOE has about 730,000 kg total mass of fuel that is collectively called 'special fuel' because specific techniques or facilities are not available to process it; the material is located at the following facilities: the Idaho Chemical Processing Plant (ICPP), the Test Reactor Area (TRA), the Test Area North (TAN), and the Power Burst Facility (PBF). Most of the special fuel was sent to the ICPP with the intent that it would be reprocessed for uranium recovery. However, in 1992 DOE decided that fuel reprocessing for uranium recovery would no longer be conducted at the ICPP and that the spent fuel would be processed, or conditioned, into a form acceptable for disposal in a federal repository. Dispositioning fuel in a safe and controlled manner is especially complex because of the wide variety of fuel types and the many chemical and radionuclide compositions. A program, the SF&WMTDP, was initiated to develop the technology required for disposing of existing special fuel to a federal geological repository. As part of the program, Waste Acceptance Product Specifications (WAPS) must be established.

The waste acceptance process requires demonstration of compliance with the WAPS via four documents, each prepared by the producer, reviewed and accepted by the Office of Environmental Restoration and Waste Management (EM), and available to the Civil Radioactive Waste Management Program (CRWMS). The four documents are:

- (1) the Waste Form Compliance Plan (WCP),
- (2) the Waste Form Qualification Report (WQR),
- (3) Production Records, and
- (4) Storage and Shipping Records.

The WCP is the producer's plan for demonstrating compliance with each specification in the WAPS and is to include detailed descriptions of the testing and analysis to be performed, and the process controls to be applied, by the producer. The WCP will also identify the records that will be provided as evidence of compliance with the specifications.

The WQR is a compilation of the results from testing and analysis that presents the detailed evidence that the canistered waste form will comply with each specification during actual waste form production. Sources of uncertainty in test results and analyses are also provided. In order for EM to accept the WQR, the EM Technical Review Group (TRG) must agree that results from testing and analysis, as described and documented in the WQR, provide a satisfactory demonstration of compliance with each specification. The WQR will be available for CRWMS concurrence.

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Production Records refer to documentation, provided by the producer, that describes the canistered waste forms actually produced. These records will be made available to EM and the CRWMS as soon as possible after production so that non-conformances can be identified and dispositions determined. The content of the Production Records will be specified in the WCP.

Storage and Shipping Records describe the physical attributes of the canistered waste forms and identify any unexpected events, such as thermal excursions, which have occurred during storage at the waste form producer's site. These records will be provided to the CRWMS prior to shipment of the waste forms from the producer's site.

This document is the first attempt to collect potentially applicable acceptance criteria and identify issues and concerns that will be of importance in preparing final specifications for spent fuel emplacement in a Mined Geologic Disposal Site (MGDS). Final specifications will be determined based on appropriate federal regulations in place at the time the fuel is prepared for disposal in a federal repository and will be published in the Waste Acceptance Specifications (WAS) document. The specifications in this document are based on current appropriate federal regulations and existing proposed specifications published for other facilities and are required now for evaluation of various spent nuclear fuel disposal conditioning options. This document will be updated as additional information becomes available.

1.0 Waste Form Specifications

1.1 Chemical Composition

Detailed characterization of the special fuel will be completed to obtain chemical and structural data, namely, the elemental composition, chemical nature of the fuel types and appropriate crystalline phases, for the special fuel waste form. The value ranges for these elements will, likewise, be obtained.

Any chemical additives used during the preparation or processing of the special fuel canistered waste form may not, as shown through qualified process data, increase the chemical reactivity of any species present in the waste.

The special fuel waste form shall be compatible with the canister such that there will not be an adverse effect on its structural integrity.

1.2 Radionuclide Inventories

Estimates of the total quantity, and uncertainties in the expected values, shall be made of individual radionuclides in the special fuels to be shipped to the repository. Also, estimates shall be made of the inventories of individual radionuclides expected to be present in each canistered waste form; this will include the expected range of variations caused by changes in the conditioning process over the life of the facility. The method used to make these projections shall be described in the production records.

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1.3 Fuel Package Conformity

1.3.1 Acceptance Criteria

Measured or projected radioisotope release rates shall be less than or equal to the cumulative release rates identified in 40CFR 191. Measured or projected results shall be identified as such, and reported in the Production Records.

1.3.2 Method of Compliance

The capability of a particular waste form to meet these specification shall be derived from production samples and/or process control information with results being verified in the Production Records.

When using process control information to project results, it shall be demonstrated in the WQR that the method used will provide information equivalent to the testing of samples of actual production waste forms.

1.4 Hazardous Components

The special fuel waste shall be characterized consistent with radiation protection requirements to determine its hazardous components as stated in 40 CFR 261 and 40 CFR 264. Characterization will be completed to determine special fuel components that are regulated by RCRA; these components must meet the repository requirements RCRA permit applications.

1.5 Radionuclide Releases

The special fuel waste form shall be capable of meeting the requirements for radionuclide releases specified in the Table I, Appendix A, "Release Limits for Containment" of 40 CFR 191. The capability of waste to meet the release specification shall be demonstrated by testing actual production samples of the special fuel waste forms. The sampling schedule shall be sufficient to demonstrate at the 95 percent confidence level that 95 percent of the production waste forms would yield leach test results that conform to the criterion. Test samples shall be taken from a convenient location of the waste or waste form canister before the canister is sealed closed. Methods for testing actual/production samples of fuels will have to be determined.

2.0 Canister Specifications

2.1 Material of Construction

The canister material of construction shall be 304L SS.

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2.2 Fabrication and Closure

The canister fabrication methods, as well as those for any secondary canister, shall be documented.

2.3 Identification and Labeling

2.3.1 Identification

A unique metal etched bar-coded alphanumeric identifier shall be attached to each canister and shall be included with all documentation pertinent to that particular canister.

2.3.2 Labeling

Labeling shall meet the repository requirements; namely, each canister shall be labeled in two locations: one visible from the top and one visible from the side of the canister. The identifier shall be printed in a type size of at least 92 points, and the bar code shall be in medium to low density Code 39 bar code symbology per MIL-STD-1189B in characters at least 2 inches high. The materials used to label the canister must be compatible with the canister material, and not impair or degrade the integrity of the canister. Labels shall be applied to the exterior of the outermost canister, and shall not cause dimensional limits to be exceeded.

2.4 Canister Dimensions

The dimensions of the canister shall be controlled so that the canister will stand upright, without support, on a flat horizontal surface and will fit, without forcing, when lowered vertically into a right circular, cylindrical cavity of the size anticipated for the repository.

The overall length and outside diameter of the canister at the time of shipment shall not exceed the repository limits. All deviations from the repository standard canister size must be approved by the repository, before filling, one year prior to shipment; the quantity and shipment schedule of non-standard canisters shall also be furnished.

The physical shape of the canister shall be cylindrical in nature with one end being a reversed dished head and the other attached with a grapple feature (lifting flange) that will allow vertical lifting or horizontal pulling.

2.4.1 Length

The canister length may vary from, but not exceed, 160 to 477 cm.

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2.4.2 Diameter

The canister diameter may vary from, but not exceed, 16 to 66 cm.

2.4.3 Wall Thickness

The wall thickness of the canister shall normally be 0.635 cm, and the wall thickness of the inner canister and all over packs shall be 0.9525 cm.

3.0 **Packaged Waste Form Specifications**

3.1 Free Liquids

Canistered waste shall not contain free liquids in an amount that could compromise the waste package.

3.2 Gas and Maximum Internal Pressure

At closure of the canister, the waste shall not contain free gas other than cover gas, if required, or radiogenic gas. Cover gas shall be argon. The maximum internal gas pressure immediately after closure shall be 7 psig at 25 °C unless specified otherwise by the repository.

3.3 Contents (explosive, combustible or pyrophoric)

The waste package shall not contain explosive, combustible, 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. Non-radionuclide pyrophoric material is not allowed. Any material in pyrophoric form is limited to less than 1% by weight in each waste package. An evaluation shall be presented of the canistered waste form to demonstrate that the waste meets this requirement.

3.4 Organic Materials

At canister closure, the waste shall not contain detectable organic materials.

3.5 Free Volume

The free volume shall be minimized. Inert or other material may be added to the canister to fill empty space to minimize the free volume to no less than 80% of the total volume capacity.

3.6 External Contamination

The level of removable contamination on all external surfaces of each canister shall not exceed 220 dpm/100 cm² alpha or 2200 dpm/100 cm² beta/gamma.

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3.7 Heat Generation

The heat generation rate at the time of shipment and its accuracy to $\pm 15\%$ shall be supplied for the special fuel canistered waste forms, and the plan for compliance shall be described. Additionally, the expected thermal output and range of expected variations shall be documented, along with the method used to make the projections, and shall not exceed values specified for each individual waste package or by the repository.

3.8 Gamma and Neutron Dose Rates

At the time of shipment, the canister waste shall not exceed a maximum surface gamma dose rate of 10^5 R/hr and a maximum neutron dose rate of 10^3 R/hr or other limits set by the repository. The actual doses at the time of shipment, the expected values of those rates, and expected variations shall be specified.

3.9 Chemical Compatibility

The contents of the canistered waste form shall not lead to internal corrosion of the canister such that there will be adverse effect on normal handling during storage, transportation, and repository operation. Corrosion interaction capable of occurring shall be evaluated, and the method of compliance shall be described.

3.10 Subcriticality

The producer shall ensure that the canistered material will remain subcritical under all credible conditions likely to be encountered. All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste or fuel shall be designed, under normal and accident conditions, 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. The calculated effective multiplication factor (k_{eff}) must be 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.

Waste packages shall not exceed fissile material limits based on criticality calculations for spacing at the recipient repository.

3.11 Weight and Overall Dimensions

3.11.1 Weight

The weight of the shipping cask/waste canister shall not exceed the repository limits (6000 kg).

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3.11.2 Overall Dimensions

The overall dimensions of the shipping cask/waste canister (with overpack) shall not exceed 477 cm in length and 67 cm in diameter.

3.12 Drop Test

The canistered waste form shall be capable of withstanding a 7m drop onto a flat, essentially unyielding surface without breaching, and the method of compliance shall be described in the WCP. Supporting documentation of analysis and test results shall be contained in the WQR.

3.13 Handling Features

The canister shall have a lifting mechanism of the type specified by the repository. The following shall be furnished to the repository: 1) a complete set of drawings and operating procedures/instructions and 2) a working duplicate of the grapple device.

4.0 Quality Assurance

The producer shall establish, maintain, and execute a quality assurance program for demonstrating compliance with the repository requirements. This program shall be applied to all activities that provide information of importance to the repository. The quality assurance program shall also be applied to all activities that affect compliance with waste acceptance specifications during waste form production, handling, storage, preparation for shipment, and shipment to the repository.

4.1 Data Package

A data package, with certification plan, shall be transmitted to the repository prior to shipment. The certification plan shall be repository-specific/waste-specific for the transport and emplacement of each waste type to the repository and shall be prepared, with detailed procedures, to identify how each waste shipment will meet the repository criteria to ensure safe handling of wastes at the repository.

4.2 High-level Waste Fuel Fraction

The high-level waste fuel fraction (if separated) of special fuel shall be disposed of in a geologic repository.

4.3 QA Documentation

The following procedures shall be documented in a Quality Assurance Plan: sampling, analytical protocols, QA/QC guidelines, and any other pertinent regulatory information. The quality assurance program shall be applied to all testing and analysis activities that provide information to be required by the

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repository.

4.4 Safety Assessment Report

Waste shipments must meet all engineered safety requirements identified in the repository SAR.

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Implications on Special Fuel Disposal

General

Various options for disposing of special fuel exist, including: disposal of the entire intact fuel pieces with little conditioning, disposal of only the actual fuel after it has been mechanically separated from the cladding material, disposal of the radioactive fuel material after it has been chemically separated, and other methods. Selection of the final method will depend on the results of the fuel characterization studies and the ability of the fuel to meet the disposal criteria. If extensive tests are required to guarantee that the fuel for direct disposal meets the criteria, it may be more economical to process the fuel to prepare it for disposal. Another item which may necessitate processing the fuel, is the criterion for fissile material content and the ramifications of meeting this criterion. Other considerations which may drive the selection of a fuel disposal method are the ability of fuel residues to meet Low-Level Waste (LLW) requirements, economics, risks and other items not yet defined.

A facility will be required for in-depth examination and characterization of the Special Fuel so that decisions may be made concerning its disposition. Presently, required information on some of fuel characterization is lacking; this prevents determining the best packaging and storage methods. Much of the fuel has been stored underwater for a long time period and has severely deteriorated, and, in some cases, has biological organisms growing on it. A facility will be required to determine the extent of this deterioration and to establish a method for removing the living matter.

Following the fuel characterization, the best processing option will be chosen to meet shipping, handling and storage criteria; the processing option may be different for different fuel types, i. e. it may be best to direct dispose of one type of fuel, mechanically disassemble another, and chemically separate still another. Facilities would be required to test the proposed action for each fuel type and perform acceptance testing on the methods used.

Efforts are on-going at the ICPP to address the appropriate methods of fuel disposal. This program will complete research activities that will establish the applicability of existing criteria and provide information for more specific criteria.

Description of Special Fuel

Information gathering for the special fuel is continuing; of the information gathered thus far, the special fuel varies widely in characteristics. There are individual rods stored in buckets, fuel assemblies, canned fuel, fuel test assemblies, etc. The condition of fuel cladding also varies, with some fuel being intact and capable of continued storage as is and other fuels reduced to debris in buckets. The length varies from 6 to 160 inches and effective diameter from 0.5 to 18 inches. Enrichments and burn-ups also vary widely.

It is necessary to know all the characteristics of the fuel including its components, properties, and content to determine short storage method and also final disposition preparation for storage in a geological repository. The needed information will be obtained in a phased program: the first

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phase consists of obtaining all of the known information about each of the special fuel types and placing it into a computerized database so it will be readily available; The next phase will consist of visual inspection of fuel that is moved to new storage locations. The fuel stored in the north and middle basins of CPP-603 will be moved to the south basin of CPP-603 or to CPP-666 basin storage. During the fuel moving operation most of the fuel will be visually inspected to note its general condition and any other items of note, and some of the fuel may be canned or recanned to maintain a safe configuration. The third and final phase of the characterization will consist of physical inspection and examination of the fuel. This phase will require a facility that will contain all the needed remote examination equipment as well as access to laboratory analyses (probably including neutron interrogation for determining fissile material content).

Once the fuel is characterized, the methods of disposal may be evaluated in depth to determine the best method proposed for each fuel type.

Direct Disposal of the Fuel

Direct disposal of the fuel consists of minimum processing to prepare the intact fuel pieces for disposal. It may also consist of studies on the behavior of the intact fuel in the repository storage, including: water leaching studies, long term oxidization effects, the degradation/stability of the fuel components for several types of conditions proposed for the repository, and the reactivity of the fuel in the repository.

Mechanical Treatment For Disposal

For some fuels it may be possible to mechanically separate the fuel containing components from the rest of it, primarily the fuel cladding. The cladding should meet the requirements for low level near surface disposal while the other components would be processed for repository disposal.

Chemical Processing For Disposal

Chemical processing would consist of chemical treatment to separate fissile and radioactive waste portions of the fuel; then the liquid waste product could then be converted into a glass or glass-ceramic form for the repository. It may be advantageous to reduce the amount of waste which must be converted by separating the fission products and actinides in the liquid waste product. The non-bearing actinide fission product waste would be processed sufficiently so that it would qualify to be low-level waste and may be sent to near-surface waste storage. Processing the fuel and converting the waste to a glass or glass-ceramic form may have certain advantages over direct fuel disposal. The glass waste form has been studied and characterized extensively, and research indicates that disposing of this waste form could reduce the complexity of modeling for repository releases since it is a more standard form. This may simplify the process for meeting repository requirements and possibly increase public acceptance.

Radioactivity Releases

The release of fission products and actinides from the spent fuel are important especially in fuel which has had its cladding breached. Fuel types with intact cladding may be an acceptable waste form for a repository. Specific data on water leaching is not readily available and would have to be obtained.

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Canister Size

Most fuel would fit into the reference container for spent fuel, larger fuel pieces may require processing or cutting.

Criticality Concerns

The requirements to prevent a nuclear criticality from occurring in a repository are obviously more difficult to meet with spent fuel than processed waste. Criticality during the years of disposal storage may be met by spacing within the repository, inclusion of nuclear poisons within the fuel package, structural spacing mechanism, or other methods as long as such methods are verifiable. The ability to meet this criterion for geological time periods will depend on the guidance or more specific regulations that are developed in the future. The criticality impacts of fuel disposal, assuming more reactive configurations as fuel elements degrade, also must be evaluated. Probabilities and implications of increased moderation from water intrusion, concentration of fissile material following leaching from fuel, or elective leaching of nuclear poison require further studies.

Fuel Characterization

Detailed characterization of both the chemical and nuclear properties of the special fuel will be required prior to placing waste of any form into a repository. Samples will have to be obtained, and research performed, to prove these samples are representative of the waste. Alternately, it may be possible to establish nuclear characteristics through analysis of the irradiation history of the fuel. Methods for sampling the somewhat heterogeneous fuel elements to assure that a homogeneous sample is obtained also must be evaluated. Obtaining a representative sample from a batch of molten glass or from a glass-ceramic is easier than demonstrating that a representative sample of a fuel element has been obtained.

Attachment 3

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Attachment 4

Waste Acceptance Preliminary Specifications for the Idaho Chemical Processing Plant High-Level Waste Form

Introduction

The INEL is currently developing a process to immobilize high-level waste (HLW) in a glass-ceramic waste form. These Waste Acceptance Preliminary Specifications (WAPS) specify properties and requirements potentially applicable for acceptance of the glass-ceramic waste form into the Civilian Radioactive Waste Management System (CRWMS). These WAPS are intended to be used to help guide development activities, and to help identify those items that will be important in preparing the final specifications. Results from the development program will be used to refine the WAPS. Final specifications will incorporate the results of development activities and the repository site selection, design, and licensing processes, thereby evolving into the Waste Acceptance Specifications (WAS) document.

The specifications presented in this document are based on existing Federal Regulations, and requirements established in the Waste Acceptance - Systems Requirements Document (WA-SRD)(1). Attachment A presents the regulatory drivers and rationale behind the WAPS indexed to level two headings. While the WAPS is intended to serve as a stand-alone document to support waste form development, it is also incorporated into the INEL Preliminary Waste Acceptance Criteria (PWAC)(2) as Attachment 4, the description of the INEL immobilized high-level waste form. As such, these WAPS also reflect conceptual INEL site-specific requirements as detailed in the INEL PWAC.

Wherever possible, the WAPS reflect generic requirements. In some cases, specific requirements have been derived from best available data, or in response to requirements in higher-tiered documents. For example, the requirements in 2.1 Canister Material and 2.4 Canister Dimensions were dictated by specific requirements in the INEL PWAC. The specific requirements which appear in these WAPS will be revised as new information or requirements become available. Because of the nature of the specific requirements contained in these WAPS, revisions to those requirements are not expected to have major impacts on development activities.

The waste acceptance process requires demonstration of compliance with the WA(P)S via four different documents, each prepared by the producer, reviewed and accepted by the Office of Environmental Restoration and Waste Management (EM), and available to the CRWMS. These four documents are:

- (1) the Waste Form Compliance Plan (WCP),

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- (2) the Waste Form Qualification Report (WQR),
- (3) Production Records, and
- (4) Storage and Shipping Records.

The WCP is the producer's plan for demonstrating compliance with each specification in the WA(P)S. The WCP is to include detailed descriptions of the testing and analysis to be performed, and the process controls to be applied by the producer. The WCP will also identify the records that will be provided as evidence of compliance with the specifications.

The WQR is a compilation of the results from testing and analysis that presents detailed evidence that the canistered waste form will comply with each specification during actual waste form production. Sources of uncertainty in testing results and analysis are also provided. In order for EM to accept the WQR, the EM Technical Review Group (TRG) must agree that results from testing and analysis, as described and documented in the WQR, provide a satisfactory demonstration of compliance with each specification. The WQR will be available for CRWMS concurrence.

Production Records refer to documentation, provided by the producer, that describe the canistered waste forms actually produced. These records will be made available to EM and the CRWMS as soon as possible after production so that non-conformances can be identified, and dispositions determined. The content of the Production Records will be specified in the WCP.

Storage and Shipping Records describe the physical attributes of the canistered waste forms and identify any unexpected events, such as thermal excursions, which have occurred during storage at the waste form producer's site. These records will be provided to the CRWMS prior to shipment of the waste forms from the producer's site.

1. Waste Form Specifications

The waste form consists of crystalline oxide phases bound together in an amorphous matrix, and is referred to as a glass - ceramic. The waste form is produced by hot isostatic pressing (HIP) in which the waste, and any necessary additives, are blended as granular solids and placed into a container called a HIP can. The HIP can is then evacuated and sealed. The waste then reacts with the additives and densifies within the HIP can at elevated temperatures and pressures. The HIP can is retained as part of the stabilized waste form.

1.1 Chemical Composition

1.1.1 Chemical Composition Projections

In the WQR, the producer shall provide the elemental and phase compositions for all elements in concentrations >0.5 weight %, and for all phases >10 volume % for each waste type. The anticipated elemental and phase composition ranges shall also be reported for each waste type, with the elemental composition being reported as oxides. The method(s)

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to be used to demonstrate compliance shall be described by the producer in the WCP. Waste form compositions not available for reporting in the initial WQR shall be included as addenda to the WQR.

1.1.2 Chemical Composition During Production

In the Production Records, the producer shall report the elemental (as oxides) and phase composition for production runs of the waste form. The reported composition shall include elements present in concentrations >0.5 weight %, and phases present in concentrations >10 volume %. The producer shall describe the method to be used for compliance in the WCP and an estimate of the error of the reported composition and the basis for the estimate shall be included in the Production Records. If a statistical sampling approach is used to determine the composition, confidence intervals shall be at least 90%. Statistical process control data can be used to assist in establishing composition.

1.2 Radionuclide Inventory

In the production records, the producer shall report [indexed to the year 2030] the inventory of radionuclides (in Curies) that have half-lives greater than 20 years and that are or will be present in concentrations greater than 0.05% of the total radioactive inventory for each waste type.

1.2.1 Radionuclide Inventory Projections

In the WQR the producer shall provide estimates of:

- (a) the total quantities of individual radionuclides to be shipped to the repository for each waste type,
- (b) the upper limit of all radionuclides for any canistered waste form, and
- (c) an average calculated radionuclide inventory per canister for each waste type.

The producer shall describe the method to be used for demonstrating compliance in the WCP. Radionuclide estimates not available for reporting in the WQR shall be included in an addendum as those estimates become available.

1.2.2 Radionuclide Inventory During Production

In the Production Records, the producer shall provide estimates of the inventories of individual reportable radionuclides for each canister and for each waste type. Error associated with estimates of radionuclide inventories shall be reported in the WQR.

1.3 Product Consistency

The producer shall demonstrate control of waste form production by comparing (either directly or indirectly) the normalized release rates of matrix elements from production samples to the normalized matrix element release rates of the benchmark glass established

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in the Environmental Assessment (EA) for the vitrified high-level waste form. The producer shall describe the method for demonstrating compliance in the WCP, and shall provide verification in the Production Records. The producer shall also demonstrate the ability to comply with the specification in the WQR.

1.3.1 Acceptance Criterion

Measured or projected normalized release rates of matrix elements shall be less than or equal to the normalized release rates of matrix elements of the benchmark glass established in the EA for the vitrified high-level waste form. Measured or projected results shall be identified as such, and reported in the Production Records.

1.3.2 Method of Compliance

The capability of the waste form to meet this specification shall be derived from production samples and/or process control information.

Production Records shall contain results derived from actual samples using the product consistency test, as well as process control information used for verification. When using process control information to project results, the producer shall demonstrate in the WQR that the method used will provide information equivalent to the testing of samples of actual production waste forms.

1.4 Phase Stability

1.4.1 Phase Stability Information

The producer shall provide the following data for each projected waste type:

- (a) the lowest phase transition temperature for the phases reported in response to specification 1.1, and
- (b) a time-temperature-transformation (TTT) diagram that identifies the duration of exposure at any temperature that causes significant changes in the phase composition.

The method to be used to obtain the required data shall be described in the WCP, and the data shall be provided in the WQR.

1.4.2 Control of Temperature for Phase Stability

At the time of shipment, the producer shall certify in the QA records that after initial cool-down, the waste form temperature has not exceeded the lowest phase transition temperature. The producer shall describe the method of compliance in the WCP.

1.5 Hazardous Materials

In the WQR, the producer shall determine, quantify, and report the presence of hazardous materials in the waste as defined in 40 CFR 261.31 through 40 CFR 261.33.

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The producer shall perform the "Toxicity Characteristic Leaching Procedure" (TCLP - 56 Federal Register 26986) and other RCRA characteristic test(s) (40 CFR 261.20 through 40 CFR 261.24) as appropriate, using prototypical specimens of the projected bounding waste form compositions. The method to be used must be described in the WCP, and results documented in the WQR. The producer shall also specifically report, in the WQR, whether the canistered waste forms are hazardous.

1.6 Product Dimensions

1.6.1 Length

The length of the HIPed waste form shall be established such that when stacked on end in the waste canister described in 2.0 Canister Specifications, an integral number of HIPed waste forms will fill the canister to meet the fill height specification in 3.5. The producer shall describe the method to be used to demonstrate compliance in the WCP and shall document the ability to comply with the specification in the WQR.

1.6.2 Diameter

The diameter of the HIPed waste form shall be established such that the HIPed waste form will fit completely and without forcing when lowered vertically into the waste canister described in 2.0 Canister Specifications. The producer shall describe the method to be used to demonstrate compliance in the WCP and shall demonstrate the ability to comply with the specification in the WQR.

1.6.3 Out-of-Roundness

Out-of-roundness of the HIPed waste form shall be controlled so that each HIPed waste form will fit completely and without forcing when lowered vertically into the waste canister described in 2. Canister Specifications. The producer shall describe the method to be used to demonstrate compliance in the WCP and shall demonstrate the ability to comply with the specification in the WQR.

1.7 HIP Can Material

The HIP can material shall be selected to be compatible with the waste canister as described in 3.9 Chemical Compatibility. The producer shall describe the method of demonstrating compliance in the WCP. The producer shall document the ability to meet this specification in the WQR.

2.0 Canister Specifications

2.1 Material

The waste form canister shall be fabricated from 304L SS. Detailed welding procedures, including filler and other materials specifications, shall be included in the WCP, with documentation of compliance being included in the Production Records.

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2.2 Fabrication and Closure

Canister fabrication methods shall be identified in the WCP and documented in the WQR. The canister shall be leak tight to 1×10^{-4} atm-cc/sec helium. The method for demonstrating compliance shall be described in the WCP, and documented in the Production Records.

2.3 Identification and Labeling

2.3.1 Identification

The producer shall assign a unique metal etched bar code accompanied by a unique alphanumeric identifier to label each outermost canister. This bar code and alphanumeric identifier shall appear on the canistered waste form and all documentation pertinent to that particular canistered waste form.

2.3.2 Labeling

Each canister shall be labeled in two locations: one visible from the top and one visible from the side of the canister. Information shall be recorded on the label as a bar code primary identifier, and an alphanumeric back-up identifier. The alphanumeric identifier shall be printed in a type size of at least 92 points using a sans serif type face (or equivalent). The bar code shall be in medium to low density Code 39 bar code symbology per MIL-STD-1189B in characters at least 2 inches high. The layout, as well as the method and materials of application, shall be described in the WCP. Materials used to label the canister must be compatible with the canister material, and not impair or degrade the integrity of the canister. The label must be an integral part of the canister, and remain legible for a period of at least 10 years under the conditions anticipated in interim storage. Labels meeting the requirements shall be applied to the exterior of the outermost canister, and shall not cause the dimensional limits (Specification 3.11) to be exceeded.

2.4 Canister Dimensions

2.4.1 Length

The overall length of the canister shall be 3.00 m (+0.005 m, -0.020 m), including the neck and handling flange and the measured lengths and estimated errors shall be reported in the Production Records.

2.4.2 Diameter

The outer diameter of the canister shall be 61 cm (+1.5 cm, -1.0 cm). The measured diameters and estimated errors shall be reported in the Production Records.

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2.4.3 Wall Thickness

The wall thickness of the canister shall be 0.95 cm (+0.05 cm, -0.0 cm) and the measured diameters and estimated errors shall be reported in the production records.

3.0 Canistered Waste Form Specifications

3.1 Free Liquid

The producer shall ensure that the canistered waste form does not contain detectable free liquids. The producer shall describe the method of compliance in the WCP, and provide documentation of the ability to comply in the WQR. Administrative controls, process knowledge, and other factors may be used to demonstrate compliance.

3.2 Gases

The producer shall ensure that the canistered waste form does not contain detectable free gas other than air, noble, or radiogenic gases. The internal gas pressure immediately after closure shall not exceed 150 kPa (absolute) at 25 °C. The producer shall describe the method of compliance in the WCP and shall document compliance in the WQR. The producer shall also document, in the WQR, the quantities and compositions of cover gases and any gases that might accumulate inside the canister after the canister has been subjected to temperatures up to 500 °C for up to two hours.

3.3 Explosiveness, Pyrophoricity, and Combustibility

The producer shall ensure that the canistered waste form does not contain detectable explosive, pyrophoric, or combustible materials. The producer shall describe the method of compliance in the WCP. The producer shall present in the WQR an evaluation of the waste form to demonstrate by administrative controls, process knowledge, and/or other factors that, for the range of anticipated material compositions, the waste form remains nonexplosive, nonpyrophoric, and noncombustible after having been subjected to temperatures up to 500° C for up to two hours.

3.4 Organic Materials

The producer shall ensure that the canistered waste form does not contain detectable free organic materials. The producer shall describe the method for compliance in the WCP, and document the basis for compliance in the WQR. The producer shall also present, in the WQR, an evaluation of the canistered waste form to demonstrate by administrative controls, process knowledge, and/or other factors, that for the anticipated range of compositions, the canistered waste form does not contain free organic materials after final closure.

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3.5 Fill Height

The producer shall fill the canister to a height equivalent to at least 80% of the volume of the empty canister. The producer shall report this height in the Production Records, and describe the method of compliance in the WCP.

3.6 Removable Radioactive Contamination on External Surfaces

The level of removable radioactive contamination on all external surfaces of each canistered waste form shall not exceed the following limits at the year of shipment to the repository:

Alpha radiation: 220 dpm/100 cm²

Beta and Gamma radiation: 2200 dpm/100 cm²

In addition, the producer shall visually inspect each canistered waste form and remove visible debris from the exterior surface prior to shipment. The producer shall provide in the WQR an estimate of the amount of canister material removed during any decontamination operations, and the basis for that estimate. If decontamination procedures remove canister material, the wall thickness of the decontaminated canister must remain within the specifications given in 2.4.3. The producer shall describe the method of compliance in the WCP, and provide contamination level results in the shipping records.

3.7 Heat Generation

The heat generation rate for each canistered waste form shall not exceed 1500 watts per canister at the year of shipment.

3.7.1 Heat Generation Projections

The producer shall provide in the WQR an estimate of the projected heat generation rate of the canistered waste forms and the range of expected variation for each waste type indexed to the year 2030. The producer shall describe the method of compliance in the WCP. Projections for compositions not available for reporting in the initial WQR shall be included as addenda to the WQR.

3.7.2 Heat Generation at Year of Shipment

The producer shall provide an estimate of the heat generation rate at the year of shipment for each canistered waste form in the shipping records and shall describe the plan for compliance in the WCP.

3.8 Maximum Dose Rates

The canistered waste form shall not exceed a maximum surface gamma dose rate of 1×10^5 R/hr and a maximum neutron dose rate of 1×10^3 R/hr.

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3.8.1 Projections of Dose Rates

The producer shall provide in the WQR an estimate of the projected gamma and neutron dose rates of the canistered waste forms and the range of expected variations for each waste type indexed to the year 2030. The producer shall describe the method of demonstrating compliance in the WCP.

3.8.2 Dose Rates at Year of Shipment

The producer shall provide an estimate of the gamma and neutron contact dose rate at the year of shipment for each canistered waste form in the shipping records and shall describe the plan for compliance in the WCP.

3.9 Chemical Compatibility

The contents of the canistered waste form shall not lead to internal corrosion of the internal canister which will have an adverse effect on normal handling during storage, or during an abnormal occurrence such as a canister drop accident. The producer shall describe the method of demonstrating compliance in the WCP. Interactions between the canister and its contents, including any reaction products generated within the canistered waste form after exposure to temperatures up to 500° C for two hours shall be discussed in the WQR.

3.10 Subcriticality

The producer shall ensure that the canistered waste form will remain subcritical under all credible conditions likely to be encountered at the producer's site, including the proposed interim storage array. The calculated effective neutron multiplication factor, k_{eff} , must be shown to be less than 0.95 after allowing for bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation. The producer shall describe the method of demonstrating compliance in the WCP, and provide supporting documentation demonstrating compliance in the WQR. The WQR shall also contain sufficient information on the nuclear characteristics (such as fissile density of the canistered waste form) to enable subcriticality to be confirmed under repository storage and disposal conditions.

3.11 Weight and Overall Dimensions

The configuration, dimensions, and weight of the canistered waste form shall not exceed the maximum size and weight which can be received, handled, and emplaced in the repository. The overall shape of the canistered waste form shall be cylindrical in nature. Closures shall consist of a reversed dish head, which will allow the canister to stand on end unsupported, and a head with a grappling feature (lifting flange) that will allow vertical lifting or horizontal pulling. These parameters shall be controlled as indicated below, and shall be documented at the time of shipment. The producer shall describe the method of compliance in the WCP and the basis for compliance in the WQR.

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3.11.1 Weight

The total weight of the individual canistered waste form shall not exceed 3000 Kg. The measured weight and estimated error shall be reported in the Shipping Records.

3.11.2 Overall Dimensions

The dimensions of the canistered waste form shall be such that, at the time of shipment, the canistered waste form will stand upright without support on a flat horizontal surface, and will fit completely and without forcing when lowered vertically into a right circular cylindrical cavity 64.0 cm in diameter and 3.01 m in length.

The producer shall state in the WQR the minimum wall thicknesses of the inner and outer canisters, along with their technical basis. The producer shall document the wall thicknesses in the Production Records.

3.12 Drop Test

The canistered waste form shall be capable of withstanding a 7 m drop onto a flat, essentially unyielding surface (such as concrete) without breaching (leak rate $< 1 \times 10^{-4}$ atm-cc/sec helium). The producer shall describe the method of compliance in the WCP, and present supporting documentation of analysis and test results in the WQR. The test results shall include information on measured canister leak rates and canister deformation after the drop.

3.13 Handling Features

The canistered waste form shall have a concentric neck and lifting pintle. The lifting pintle geometry and maximum loading capacity shall be described in the WCP.

The producer shall design the lifting pintle and a suitable grapple, which can be used at the repository. The grapple and pintle shall be designed to satisfy the following requirements:

- (a) The grapple shall be capable of being remotely engaged and disengaged from the pintle.
- (b) The grapple, when attached to a suitable hoist, and when engaged with the pintle, shall be capable of raising and lowering a canistered waste form in a vertical direction.
- (c) The grapple shall be capable of engaging and disengaging a canister within a right circular cylindrical cavity with a maximum diameter of 62.5 cm.
- (d) The grapple shall be designed to prevent an inadvertent release of a suspended canistered waste form when the grapple is engaged with the pintle.

The producer shall describe the method used for demonstrating compliance in the WCP and provide the designs in the WQR.

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4.0 Quality Assurance

The producer shall establish, maintain, and execute a quality assurance (QA) program that applies to all testing and analysis activities that affect compliance with these WAPS during waste form production, handling, storage, and preparation for shipment. The producer shall impose a QA program consistent with the QA requirements that govern HLW as identified in the EM-QAPD and the Civilian Radioactive Waste Management System's Waste Acceptance Systems Requirements Document (WA-SRD).

References

- (1) U. S. Department of Energy, Waste Acceptance Systems Requirements, CRWMS M&O Document Number TSO.920908.0496.
- (2) Idaho National Engineering Laboratory, Preliminary Waste Acceptance Criteria, WINCO-1157, December 1993.

Attachment 4

Attachment A.

Rationale for the Waste Acceptance Preliminary Specifications for the Idaho Chemical Processing Plant High-Level Waste Form

The rationale behind the specifications for the Idaho Chemical Processing Plant high-level (glass-ceramic) waste form is derived largely from the Civilian Radioactive Waste Management System's Waste Acceptance - Systems Requirements Document (WA-SRD)(1). Additionally, some specifications are also determined, in whole or in part, by requirements found in various parts of the Code of Federal Regulations (CFR). This information is summarized for general reference purposes in Table A-1 of the PWAC. While the WA-SRD and the CFR largely determine these specifications, some other documents also contain information pertinent to the specifications. These documents are also referenced in Table A-1. Because of the unique nature of the glass-ceramic waste form, a few of the specifications in these WAPS are also unique, and therefore have no directly corresponding driver in the existing literature. The rationale behind these specifications are discussed below.

1.1 Chemical Composition

Since the glass-ceramic waste form is a complex assemblage of crystalline and amorphous phases, this specification was modified to include an assessment of the phase composition (crystalline and amorphous) of the waste form.

1.4 Phase Stability

Because the glass-ceramic waste form consists of a complex mixture of crystalline and amorphous phases, the glass transition temperature of the amorphous matrix may not be the lowest, or most critical, phase transition temperature. This specification calls for the producer to determine the lowest phase transition temperature for the glass-ceramic waste form, and references the maximum allowable storage temperature to the lowest phase transition temperature. This specification thereby assures that the product will not undergo any changes due to thermally-induced phase transitions between the time it is produced and the time it is shipped to the repository.

1.6 Product Dimensions

This specification is unique to the glass-ceramic waste form. The HIP process which is used to fabricate the glass-ceramic waste form produces a solid product which must be inserted into the waste canister. This specification assures that the product from the HIP process will fit into the specified waste canister.

1.7 HIP Can Material

The glass-ceramic waste form is encapsulated in a metallic "can" for processing at elevated temperatures and pressures in the HIP. The can remains part of the waste form after processing. This specification is an extension of specification 3.9 Chemical Compatibility,

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in that it guides selection of the can material to ensure compatibility with the canister material.

3.2 Gases

This specification contains time and temperature limits for assessing gas generation to allow quantification of test results.

3.3 Explosiveness, Pyrophoricity, and Combustibility

This specification contains time and temperature limits for assessing explosiveness, pyphoricity, and combustibility to allow quantification of test results.

3.9 Chemical Compatibility

This specification contains time and temperature limits for assessing interactions between the canister and its contents to allow quantification of test results.

Attachment 5

Summary of Key Directives

**Governing Permanent Disposal
in a Geologic Repository**

Prepared By:

Stephen C. Sands II

Revision: 0
November, 1993

Westinghouse Idaho Nuclear Company, Inc.
Spent Fuel and Waste Management Technology Development Program
System Analysis/Performance Assessment

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EXECUTIVE SUMMARY

This document was developed in support of the Idaho National Engineering Laboratory (INEL) Spent Fuel and Waste Management Technology Development Program (SF&WMTDP). It is largely comprised of flow diagrams summarizing the key regulatory requirements which govern permanent disposal in a geologic repository. The key purposes are (1) to provide an easy and effective tool for referencing or cross referencing federal directives (i.e., regulations and orders), (2) to provide a method for examining the requirements in one directive category against the requirements in another, and (3) to list actions that must be taken to ensure directive compliance. The document is categorically broken down into a Transportation section and a Mined Geologic Disposal System (MGDS) section to ensure that the interrelationship of the entire disposal system is considered.

The Transportation section describes the transportation packaging requirements, testing methods, and safety requirements imposed on fissile material shipments.

The MGDS section encompasses technical aspects involved in siting, licensing, waste interaction with the container, container design features, physical characteristics of the surrounding environment, facility design features, barrier systems, safety features, criticality considerations, migration restrictions, implementation guidelines, and so forth. Whether the hazardous waste requirements of 40 CFR 260-270 will apply to geologic disposal of some materials is not clear at this time; as this issue is developed, this summary will be revised accordingly. For purposes of illustration, the worst case scenario (i.e., that a permit and a variance will be required for disposal) is outlined (a discussion of the permitting process is not included).

It is important that the approaches and considerations contained in this document be integrated into the efforts of the SF&WMTDP so that every applicable aspect of the regulatory requirements can be evaluated to avoid investing large sums of money into projects that do not take into account all of the aspects of permanent waste disposal. Not until an overall picture and clear understanding of these regulations is established can a basis be developed to govern the direction of future activities of the SF&WMTDP.

1.0 General Introduction

This document summarizes federal directives impacting disposal at a geologic repository. The intention here is three-fold: (1) to provide a tool for referencing current directive requirements, (2) to provide a method for examining the requirements in one directive category against the requirements in another, and (3) to list actions that must be taken to ensure directive compliance. This document will require periodic reviews and updates to reflect changes in applicable directives. The directives discussed herein have been divided into Transportation Requirements and Mined Geologic Disposal System (MGDS) Requirements. Figure 1 provides a visual summary of the requirements necessary for the permanent disposal in a geologic repository.

Flow diagrams, comprising the bulk portion of this document, have been prepared on various levels of detail; the objective is to provide sufficient detail in the flow diagrams so that they can stand alone from the sources of the requirements in most instances. For directives containing large amounts of detailed information, several flow diagrams have been prepared. These descriptions include a summary sheet outlining the information found in the particular regulation or DOE Order. Whenever possible, detailed flow diagrams are developed for all of the subparts contained in each directive.

Each flow sheet is organized into a series of columns: Compliance Approach (listing overall methods for assessing compliance with a particular regulatory requirement); Compliance Support (listing the specific items or topics addressed in that regulation); and Considerations, Information Needs, and Activities (summarizing the significant details covered by that specific regulation or section). Suppose, for example, it is necessary to find applicable directives pertaining to transportation. The Compliance Approach and Support columns would be scanned for transportation related issues resulting in a listing of specific information and directives applicable to the transportation.

It is important that these approaches and considerations be integrated into the activities of the SF&WMTDP so that every applicable requirement can be evaluated to avoid investing large sums of money into projects that do not take into account the long term goal of permanent waste disposal. Not until an overall picture of the applicable directives is established can a basis be developed to govern the direction of future activities of the SF&WMTDP.

Figure 1
Pictorial Summary of
Requirements Developed

1.1 Congressional Actions Impacting Geologic Disposal

In 1954, Congress passed the Atomic Energy Act (AEA) to assure proper management of source, special nuclear, and byproduct material. Section 161 of AEA provided the authority to establish "by rule, regulation, or order, such standards and instruction to govern the possession and use of special nuclear material, source material, and byproduct material as the Atomic Energy Commission may deem necessary or desirable to promote the common defense and security or to minimize danger to life or property." As a result, subsequent Congressional actions have been taken to address the long-term disposal of high-level radioactive waste, resulting in the establishment of such rules, regulations, and orders necessary to ensure compliance with federal legislation. Actions dealing with high-level waste (HLW) disposal include:

Energy Reorganization Act of 1974;

Nuclear Waste Policy Act (NWPA) of 1982;

Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments, which include Land Disposal Restriction (LDR), of 1984;

Nuclear Waste Policy Amendments Act (NWPAA) of 1987;

Federal Facilities Compliance Act (FFCA) of 1992; and

Energy Policy Act of 1992.

1.2 Key Provisions of Applicable HLW Laws

Energy Reorganization Act

Nuclear Regulatory Commission (NRC) licenses DOE HLW disposal.

Nuclear Waste Policy Act and Amendments

Yucca Mountain site is the only one to be characterized to determine suitability.

Capacity of first repository limited to 70,000 metric tonnes of heavy metal for *spent fuel* and equivalent DOE HLW.

Monitored Retrievable Storage (MRS) Facility cannot be constructed until after the NRC has issued a license for the repository.

Congress to evaluate after 2007 of the need for a second repository.

NRC 10 CFR 60 to establish the licensing requirements for the repository.

EPA 40 CFR 191 to establish the standard for HLW and *spent fuel* disposal.

NRC Regulation 10 CFR 60

Waste retrievability during operation and 50 yrs after repository closure.

Pre-emplacement groundwater travel time of > 1000 yrs to accessible environment.

Substantially complete containment of HLW in waste package for 300-1000 yrs.

Limited release rate of radionuclides from waste package after 1000 yrs not to exceed 1 part in 100,000 per year of inventory at 1000 yrs.

Other waste package criteria to avoid in-situ chemical, physical or nuclear interactions which could compromise the performance of the repository.

EPA Standard 40 CFR 191 (Under re-evaluation for HLW by NAS)

Disposal system shall not cause annual dose equivalent to any person in the accessible environment to exceed 25 mrem whole body or 75 mrem critical organ.

Release of radionuclides to accessible environment over 10,000 yrs limited to prescribed values given in paragraph 13 of standard.

Additional requirements to provide additional assurance that standard will be met including institutional controls, monitoring, permanent markers and records, engineered and natural barriers, and avoidance of areas with mined resources.

1.3 Regulation Development

Under the NWPA, a process for the selection of sites for HLW repositories is established, and the DOE is charged with the responsibility of locating, constructing, operating, closing, and decommissioning repositories. This Act also stipulates that the disposal of waste be governed by an environmental standard established by the EPA. Responsibility for assuring that the DOE repository meets this EPA established standard is delegated to the NRC.

In 1983, the NRC developed a procedure for assuring that future repository

investigations and developments are in compliance with the requirements of the NWPA. This procedure was documented under Title 10 of the Code of Federal Regulations, Chapter 60 (10 CFR 60). This regulation currently requires that the standard established in 40 CFR 191 must be met and, in addition, sets numerical requirements for the performance of some repository elements. In the license application, DOE must illustrate that the repository will comply with both of the above regulations.

Because of the requirements placed on the DOE by 10 CFR 60, DOE established a regulation to provide general guidelines for the recommendation of sites for nuclear waste repositories. This regulation was documented in 1984 under Title 10 of the Code of Federal Regulations, Chapter 960. This regulation established procedural guidelines for implementing the requirements set forth in 10 CFR 60, including siting evaluation, nomination, and characterization; filing recommendations for repository development; and preclosure and postclosure guidelines.

The Department of Transportation (DOT) has also established regulations imposed on the DOE pertaining to the safe transportation of radioactive material. As a practical matter, these regulations become valid compliance issues influencing the development of the repository investigations required by the NWPA. Regulations stipulating that a package meeting repository requirements will automatically satisfy applicable transportation requirements do not exist; therefore, a repository packaging must be evaluated against both sets of regulations.

The EPA standard referred to above was promulgated in 1985 under Title 40 of the Code of Federal Regulations, Chapter 191 (40 CFR 191). This standard requires that any repository must protect the public from significant radiation doses for at least 10,000 years after permanent closure by releasing less than a predetermined amount of each radionuclide to the biosphere.

The regulatory requirements relating to the permanent disposal of HLW in a geologic repository are illustrated in Figure 2 and are listed according to the agency which imposes those regulations.

Figure 2
Regulations Affecting Repository Development
by Imposing Agency

Note: The dashed line going to the DOT regulations indicates their indirect nature.

In an effort to assure compliance with these, and any other requirements (including requirements existing prior to the NWA) having applicability to the permanent geologic disposal of HLW, the DOE imposes specific requirements and procedures in the form of DOE Orders. Applicable DOE Orders have been explained in the flow diagrams contained in their respective sections of this document.

In addition to Regulations and Orders, various guidance exists outlining specific procedures and practices for ensuring compliance with requirements of these directives. These guidance consist of notices, guidelines, memoranda, internal procedures, and implementation procedures. Because this document is a summary, only applicable Regulations and Orders have been summarized in the flow diagrams.

However, a brief listing of some potentially applicable Regulatory Guides is included in Appendix A. The words "potentially applicable" are used here because no detailed investigation into the applicability of these guides has been conducted.

2.0 Transportation Requirements

Although it is the responsibility of the individual shipper to verify compliance with packaging and shipping regulations and to ensure that waste disposal canisters meet MGDS requirements, understanding these requirements will help ensure that the waste canisters that we produce or purchase are in compliance with applicable regulations. Section 2 focuses on analyzing the packaging requirements, package testing methods, and safety requirements imposed on fissile material shipments.

The type of package used is dependent on the activity of the radioactive material being considered. Type A packages cannot exceed A1 or A2 activity limits and are subject only to normal conditions of transport testing. Type B packages may exceed A1 or A2 activity limits and, therefore, require additional hypothetical accident conditions of transport testing. A table of these activity limits for single radionuclides and methods for calculating these activity limits for radionuclides not listed in the table (or for radionuclide mixtures) are contained in subsections 173.435 and 173.433, respectively, of Title 49 of the Code of Federal Regulations, subpart I of Part 173. According to the INEL Roadmap document, SNF will always contain fissile material in excess of these activity limits, thus requiring Type B packaging.

2.1 Listing of Regulations and Orders Developed

- 10 CFR 71 - Packaging and Transportation of Radioactive Material
 - Subpart E - Package Approval Standards
 - Subpart F - Package and Special Form Tests
- 49 CFR 173 - Shippers - General Requirements for Shipments and Packages (flow diagram listing sections developed)
 - Subpart I - Radioactive Materials (Summary)
 - Sections: - Type A or B Package Classification Method
 - Cask/Canister Requirements & Material Specific Restrictions
 - Limitations and Transportation Requirements
 - Fissile Material Requirements
 - Testing Requirements
- 49 CFR 174 - Carriage by Rail
 - Subpart K - Detailed Requirements for Radioactive Materials
- 40 CFR 263 - Standards Applicable to Transporters of Hazardous Materials
- DOE Order 1540.1A - Materials Transportation and Traffic Management

**DOE Order 1540.2 - Hazardous Materials Packaging for Transportation -
Administrative Procedures**

**DOE Order 5480.3 - Safety Requirements for Packaging and Transportation
of Hazardous Materials, Substance, or Waste**

**DOE-ID 5480.3 - Hazardous Materials Packaging and Transportation
Safety Requirements
Attachment 1 - Chapter I - Off-site Shipments
Attachment 1 - Chapter II - On-site Shipments**

2.2 Flow Diagrams for Regulations and Orders

Flow diagrams are in the order listed in section 2.1.

10 CFR 71 Packaging and Transportation of Radioactive Material

10CFR71.600
rev. 10/77/88

GOVERNING REGULATION

Subparts

* Indicates that a flow diagram for this subpart has been developed.

10 CFR 71 Subpart E Package Approval Standards

10CFR71.600
Rev. 10/17/88

10 CFR 71 Subpart F Package and Special Form Tests

10CFR71.F.600
rev. 10/17/88

**49 CFR 173 Shippers - General Requirements
for Shipments and Packages
Subpart I - Radioactive Materials
Flow Diagram Listing**

49CFR173
101 10/7/96

49 CFR 173 Shippers - General Requirements for Shipments and Packages Subpart I - Radioactive Materials (Summary)

4007255-000
rev. 12/99/00

49 CFR 173 Shippers - General Requirements for Shipments and Packages

Subpart I - Radioactive Materials

Type A or B Package Classification Method

49CFR173.435
rev 12/29/93

NOTE: SNF will always be a greater than Type A quantity and contain fissile materials, thus requiring Type B shipping container.

49 CFR 173 Subpart I Cask/Canister & Content Specific Requirements

49 CFR 173
Subpart I

49 CFR 173 Subpart I Limitations and Transportation Requirements

49CFR173.600
rev 10/17/98

49 CFR 173 Subpart I Fissile Material Requirements

49CFR173.459
Rev 11/07/98

49 CFR 173 Subpart I Testing Requirements

49 CFR 173
Rev. 10/2000

49 CFR 174 - Carriage by Rail

Subpart K - Detailed Requirements for Radioactive Materials

49CFR174.200
and 174.201

40 CFR 263 - STANDARDS APPLICABLE TO TRANSPORTERS OF HAZARDOUS WASTE

40CFR263.GCD
rev 11/17/99

GOVERNING REGULATION

Subparts

DOE Order 1540.1A - Materials Transportation and Traffic Management

DOE-1540.1A-02
rev 11/17/93

DOE Order 1540.2 - Haz. Mat. Packaging for Transport - Administrative Procedures

DOE 402.000
rev 10/17/98

GOVERNING REGULATION

Subparts

DOE Order 5480.3 - Safety Requirements for Packaging & Transportation of Hazardous Material, Substance, or Waste

DOE-4026.002
Rev. 10/07/98

DOE-ID 5480.3 - Haz. Mat. Packaging and Trans. Safety Req.

Attachment 1 - Chapter 1: Off-site Shipments

DOE-4003.0-02
REV 11/17/99

DOE-ID 5480.3 - Haz. Mat. Packaging and Trans. Safety Req.

Attachment 1 - Chapter II: On-site Transfers

DOE-000002.BCD
rev 11/17/98

3.0 MGDS Requirements

Under Title 40 of the Code of Federal Regulations, section 191 (40 CFR 191), all Mined Geologic Disposal Sites (MGDS) "shall be designed to provide a reasonable expectation, based on performance assessments (PA), that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal" will not exceed the release limits outlined in 40 CFR 191.13. A Performance Assessment, as defined, "(1) identifies the processes and events that might affect the disposal system; (2) examines the effects of these processes and events on the performance of the disposal system; and (3) estimates the cumulative releases of radionuclides, considering the associated uncertainties, caused by all significant processes and events." With this in mind, section 3 summarizes the regulatory requirements for conducting a PA and outlines the nuclear waste packaging requirements that will ensure compliance with both the transportation requirements (discussed in Section 2.0) and MGDS restrictions.

A summary of general aspects that must be accounted for in the development of PA models (or other analysis methods) has been included as the first flow diagram in section 3.2; this is an overall summary of the key performance factors that are addressed throughout the regulations in this section. Other flow diagrams encompass the technical aspects involved in siting, licensing, release limits, waste interactions with the container, container design features, physical characteristics of the surrounding environment, facility design features, barrier systems, safety features, implementation guidelines, migration restrictions, criticality considerations, model verification methods, and so forth.

Since many of the factors influencing the long-term performance of a MGDS are site-specific, a complete assessment of the long-term performance of waste in the MGDS cannot be conducted until after an actual site has been selected and fully characterized for repository development. This section is intended to aid in the modeling development for a hypothetical geologic repository, accounting for as many factors as possible, until such time when an actual MGDS is identified.

3.1 Listing of Regulations and Orders Developed

Summary of General Aspects Implied by Performance Assessment Modeling & Analysis Compliance Approach

- 10 CFR 60 Disposal of High Level Radioactive Waste in Geologic Repositories
- Subpart B - Licenses (Summary)
- Sections: - Licenses Compliance Structure
 - Construction Authorization & Permanent Closure Compliance Structure

Subpart E - Technical Criteria (Summary)

**Sections: - Performance Objectives & Waste Package Design
Compliance Structure**

**- Operations Area Design Specifications Compliance
Structure**

**10 CFR 960 General Guidelines for the Recommendation of
Sites for Nuclear Waste Repositories**

Subpart B - Implementation Guidelines

Subpart C - Postclosure Guidelines (flow diagram)

- Postclosure Technical Guidelines Table

Subpart D - Preclosure Guidelines (flow diagram)

- Preclosure Technical Guidelines Table

**40 CFR 191 Subpart B - Environmental Standards for the Uranium Fuel
Cycle Compliance Structure**

40 CFR 264 Subpart X - Permit for Misc. Unit Compliance Structure

40 CFR 268.6 Land Disposal Restriction Compliance Structure

10 CFR 20 Standards for Protection Against Radiation

DOE Order 5820.2A - Radioactive Waste Management (Update in process):

Chapter I - High Level Waste;

Section 3d - Disposal Requirements

3.2 Flow Diagrams for Regulations and Orders

Flow diagrams are in the order listed in section 3.1.

Summary of General Aspects Implied by Performance Assessment Modeling & Analysis Compliance Approach

PASUM-002
Rev. 10/19/98

NOTE: Performance Assessment Modeling & Analysis, when used as a Compliance Approach in flow diagrams indirectly implies all of the above aspects. Supporting requirements in these areas are covered by the flow diagrams for the specific regulations in which these aspects are contained.

10 CFR 60 DISPOSAL OF HIGH LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES

10CFR60.600
rev 11/21/99

* Indicates that a flow diagram for this subpart has been developed.

10 CFR 60 Subpart B Licenses Compliance Structure (Summary)

NOFPA-500
REV 10/2000

10 CFR 60 Subpart B Licenses Compliance Structure

10 CFR 60

10 CFR 60 Subpart B Construction Authorization & Permanent Closure Compliance Structure

10 CFR 60 Subpart E Technical Criteria Compliance Structure (Summary)

100-113-01

10 CFR 60 Subpart E Technical Criteria - Performance Objectives & Waste Package Design Compliance Structure

NOV 1988

10 CFR 60 Subpart E Technical Criteria - Operations Area Design Specifications Compliance Structure

10 CFR 960 General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories

10000.000
100 00000

* Indicates that a flow diagram for this subpart has been developed

10 CFR 960 Subpart B Implementation Guidelines

WORKFLOW
- 10/1/2000

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10 CFR 960 Subpart C Postclosure Guidelines

10CFR960.1.600
Rev. 10/21/98

10 CFR 960 Subpart C Postclosure Technical Guidelines Table

Worksheet
by DOE

Technical Guideline	Qualifying Condition	Favorable Condition	Potentially Adverse Conditions	Disqualifying Conditions
Geohydrology 960.4-2-1	The present and expected geohydrologic setting compatible w/ waste containment & isolation. Must comply w/ requirements of section 960.4-1 for radionuclide accessible environment releases & 10 CFR 96.113 for releases from engineered-barrier system.	Pre-waste emplacement ground water travel time from disturbed zone to accessible environment < 10,000 yrs; Hydrologic processes during Quaternary Period not affect repository during next 100,000 yrs; stratigraphic, structural & hydrologic features easily & accurately modeled; Saturated & Unsaturated zone disposal reqs.	Geohydrologic changes such as changes in hydraulic gradient, hydraulic conductivity, effective porosity, ground-water flux w/in host rock; Ground-water source for irrigation or untreated human consumption along flow paths from host rock; Presence of geologic setting of stratigraphic features - difficulty in modeling	Disqualified if pre-waste-emplace. ground-water travel time from disturbed zone to accessible environment expected to be < 1,000 yrs along any pathway of likelihood & significant radionuclide travel
Geochemistry 960.4-2-2	Above condition w/ consideration of likely chemical interactions among radionuclides, host rock, & ground-water	Nature & rates of geochemical processes during Quaternary Period not affect repository in next 100,000 yrs; Geochem. cond. promoting precipitation, etc.; While trace of radionuclides by particulate etc.; Water flow allowing < 0.001 %/yr total radionuclide inventory @ 1,000 yrs decay; process dec. probab. cum. rel. by factor of 10	Ground-water cond. in host that could affect solubility or chem. reactivity of engineered-barrier; Geochem. processes reducing sorption of radionuclides or degrade the rock; Pre-waste-emplacement ground-water cond. in host that are chemically oxidizing	none
Rock characteristics 960.4-2-3	Present & expected character of host rock & surrounding units accommodate thermal, chemical, mechanical, & radiation stresses induced by const. operation, & closure by expected interactions among waste, host, engineered components, & ground-water; Must also comply w/ above restrictions on releases	Host sufficiently thick & laterally extensive to allow flexibility in selecting depth, configuration, & location of repository to ensure isolation; Host with high thermal conductivity, low thermal expansion coeff., or sufficient ductility to seal fractures induced by repos. construal, operation, & closure or waste interaction	Rock cond. requiring measures beyond available technology to ensure waste containment; Potential for phenomena such as thermally induced fractures, brine migration, etc. affecting isolation; Combination of geologic structural, geochem., & thermal properties, & hydrologic cond. in host so waste heat gen. dec. isolation	none
Climatic changes 960.4-2-4	Future climatic changes not likely to lead to radionuclide releases < allowable in above; DOE will consider global, regional, & site climatic patterns during Quatern. Period considering geomorphic evidence of climatic conditions in geologic setting	Surface-water system such that expected climatic cycles over next 100,000 yrs not affect waste isolation; Geologic setting in which climatic changes during Quaternary Period had little effect on hydrologic system	Evidence that water table could rise sufficiently over next 10,000 yrs to saturate facility in previously unsaturated host; Evidence that climatic changes in next 10,000 yrs could cause perturbations in effect. porosity, hydraulic gradient/conductivity, or ground-water flux in host increasing transport of radionuclides	none
Erosion 960.4-2-5	Facility placed at depth so that surface erosion not likely lead to releases < above restriction; DOE will consider climatic, tectonic, & geomorphic evidence of rates & patterns of erosion during Quaternary Period	Site cond. that permit waste emplacement at depth at least 300 m below directly overlying surface; Geologic setting where processes during Quaternary Period have < 1 chance in 10,000 over next 10,000 yrs of leading to radionuclide releases; Site cond. so waste exhumation not expect to occur in first million yrs	Geologic setting shows evidence of extreme erosion during Quatern. Period; Geologic setting where nature & rates of geomorphic processes during Quaternary Period could affect ability to isolate waste for first 10,000 yrs after closure	Disqualified if site conditions do not allow portions of underground facility to be situated at least 300 m below directly overlying surface
Dissolution 960.4-2-6	Site located so any subsurface rock dissolution will not lead to releases > restriction above; In predicting likelihood of dissolution w/in setting during Quaternary Period, including dissolution fronts or other identified features	No evidence that host rock w/in site was subject to significant dissolution during Quaternary Period	Evidence of dissolution w/in geologic setting - such as breccia pipes, dissolution cavity, significant vol. reduction of host or surrounding strata, or any structural collapse - such that a hydraulic interconnection leading to a loss of waste isolation could occur	Disqualified if it is likely that active dissolution would result in a loss of waste during the first 10,000 yrs after closure
Tectonics 960.4-2-7	Future tectonic processes not likely lead to releases < allowed above; In predicting likelihood of disruptive events, DOE will consider structural, stratigraphic, geophysical, & seismic evidence for nature & rates of tectonic processes during Quaternary Period	Nature & rates of igneous activity & tectonic processes during Quaternary Period would, if continued, have < 1 change in 10,000 of leading to radionuclide releases in the first 10,000 yrs after closure	Evidence of active folding, uplift, faulting, etc. during Quaternary Period; Historical earthquakes w/ in geologic setting of magnitude affecting isolation upon recurrence; Evidence of increase in freq. of magnitude of future earthquakes; Potential for natural phenomena such as landslides, volcanic ash; Potential for tectonic deformation	Disqualified if, based on recording during Quaternary Period, the nature & rates of fault movement or other ground movement are such that loss of isolation is likely to occur
Human Interference 960.4-2-8	Site located such that activity of future generations at or near the site will not likely affect the waste containment/isolation; DOE will consider estimated effectiveness to permanent markers & records required by 10 CFR 96 taking into account below two considerations (resources & ownership)	none	none	none
Natural resources 960.4-2-9-1	Considering permanent markers & records, & reasonable projection of value, scarcity, & technology, the natural resources (including water used for irrigation or human consumption w/o treating) would not give rise to interfering activity leading to releases < specified above	No unknown natural resources that have or are projected to have foreseeable value great enough for commercial extraction; Ground water w/ 10,000 ppm or more dissolved radionuclides along any path of likely travel from host rock to accessible environment	Indications that site contains naturally occurring materials identified as feasible for future economic extraction; Evidence of subsurface mining/extraction for resources, or drilling other than for evaluating depth w/in site; Evidence of significant conc. of naturally occurring material not widely avail. from other sources	Disqualified if prev. exploration, mining, or extraction activities for resources of commercial importance have created paths between projected facility & accessible environment; Ongoing or future activities to recover mineral resources outside controlled areas expected to lead to loss of isolation
Site Ownership & Control 960.4-2-9-2	Site located on land which DOE can obtain in accordance w/req. 10 CFR 96, ownership, surface & subsurface rights, and control access required in order that surface & subsurface activities will not likely allow releases < specified above	Pre-set ownership and control of land and all surface and subsurface rights by the DOE	Projected land ownership conflicts that can't successfully be resolved through voluntary purchase-sell agreements, non-disputed agency-to-agency transfer of title, or Federal condemnation proceedings	none

NOTE: Additional information in all of these areas located in Appendix IV.

10 CFR 960 Subpart D Preclosure Guidelines

FOUO 021500
rev. 01/05/00

10 CFR 960 Subpart D Preclosure Technical Guidelines Table

Technical Guideline	Qualifying Condition	Favorable Condition	Potentially Adverse Conditions	Disqualifying Conditions
Population density and distribution 960.5-2-1	During repository operation and closure, the expected average radiation dose to public w/in any highly populated, or dose rate to any member, not likely exceed a fraction of the limit specified in 960.5-1(a)(1)	Low pop. density in general region of the site; remoteness of site from highly populated areas	Highly residential, seasonal, or daytime population density w/in projected site boundaries; any surface facility located adjacent to area 1 square mile having population not < 1,000 members enumerated by most recent U.S. census	Disqualified if any surface facil. located in highly pop. area or adjacent to 1 square mile area w/ pop. > 1,000; DOE could not develop emergency preparedness prog. set in DOE Order 5600.5
Site ownership and control 960.5-2-2	Located on land which DOE can obtain ownership, surface & subsurface rights, & control of access required so that surface & subsurface activities not likely to lead to releases in restricted area > restrictions 960.5-1(a)(1) (10 CFR 960.121 - obtaining land)	Present ownership & control of land & all surface & subsurface mineral & water rights by DOE	Projected land-ownership conflict that cannot be successfully resolved by voluntary purchase-sell agreement, Federal condemnation proceedings, or agency-to-agency title transfer	none
 Meteorology 960.5-2-3	Located so expected meteorological conditions during operation & closure not lead to releases to unrestricted areas > specified in 960.5-1(a)(1)	Prevailing meteorological cond. so radioactive releases to atmosphere during operation & closure effectively dispersed, reducing likelihood of unaccept. exposure to any member in area	Prevailing meteorological cond. so radioactive emissions from repository operation or closure could preferentially transport to areas w/ higher pop. densities than average for the region; History of extreme weather phenomena significantly affecting repos. during operation & closure	none
Offsite installations and operations 960.5-2-4	Located so projected effects of nearby industrial, transportation, & military installation & operation will not affect repository from siting-decommissioning or when considered together, emissions operations & closure not likely to be > req. of 960.5-1(a)(1)	Absence of contributing releases from other nuclear installation & operations considered under req. of 40 CFR 161, subpart A	Presence of nearby potentially hazardous installations or operations adversely affecting repos. operation & closure; Other nuclear operations present w/ releases near max value permitted by 40 CFR 160-161	Disqualified if atomic energy defense activities in proximity to site expected to conflict w/ repos. from siting-decommission.
Environmental quality 960.5-2-5	Quality of the environment in the affected area during this and future generations is adequately protected from siting through decommissioning; projected environmental impacts can be mitigated to an acceptable deg. taking into account programmatic, technical, social, economic, & environmental factors	Projected ability to meet, w/in time constraints, all Federal, State, & local procedural & substantive environmental factors; and the release requirements of 960.5-1(a)(2) can be met	Projected conflict w/ Federal, State, or local environmental req.; Projected adverse environmental impacts on State or regionally protected areas; or a component to National Park, Wildlife, or Wilderness Protect. System; or a Native American resource; or proximity to any the above	Disqualified if quality of environment in affected area could not be adequately protected or unable to comply with favorable or overcome potentially adverse conditions
Socioeconomic impact 960.5-2-6	Located so any signif. adverse social &/or economic impacts induced in community & surrounding regions can be offset by reasonable mitigation/compensation; the requirements of 960.5-1(a)(2) can be met	Ability to absorb project-related pop. changes w/o significantly impacts on housing supply & demand; Availability of adequate labor force in affected area; Projected net increases in employment & business sales, improved community services, & increased government revenues; no disruption of primary sectors	Significant impacts on community services, housing supply and demand, and finances of State & local agencies; Lack adequate labor force; Need for repository related purchase/acquisition of water rights, if such rights adversely impact present/future development; potential for major disruptions of primary sectors	Disqualified if repository would significantly degrade or reduce the quality of water from major water sources, or from offsite supplies for human consumption/irrigation
Transportation 960.5-2-7	Located so the access routes from existing local highways & railroads to site will not conflict w/ the previously designated use of any resource; can design & construct using av. technology; not required transportation components to meet performance standards more stringent than DOT or HRC regulations	AVAIL. & PROXIMITY of access routes from local existing roads & highways that provide access to regional highways & rails that are adequate to serve repos.; Regional railroad w/ min 6 inter-change points; Total risk for transportation < than comparable siting operations; Availability of waste carriers capable & willing	ACCESS ROUTES to existing roads highways and railroads that are expensive to construct relative to siting options; Terrain- steep grades, sharp switchbacks, lake, river, landslides, or potential hazard to incoming waste ship; Existing highway/rail requiring sig. reconstruction/upgrades; any cond. causing cost/impact/risk	none
Surface Characteristics 960.5-2-8	Considering surface characteristics & cond. of site and surrounding area, including surface-water & terrain, req. of 960.5-1(a)(3) met	Generally flat, well-drained terrain	Surface characteristics that could lead to flooding the surf. or underground facilities	none
Rock Characteristics 960.5-2-9	Located so the thickness and lateral extent & characteristics and composition of host rock suitable for underground facility; Repository construct., operation, & closure not cause undue hazard to personnel; must meet req. of 960.5-1(a)(3)	Host sufficiently thick & laterally extensive to allow significant flexibility in depth selection & configuration, and characteristics that require minimal/no artificial support for underground opening to ensure safe repository construction, operation, & closure	Suitable host rock, but too thin or too laterally restricted; in situ characteristics & cond. that could require engineer measures beyond avail. technology; Geomechan. prep. requiring extens. maintenance; Potential for phys., chem., or radioactive-induced phenomena leading to safety hazard; Stratigraphic problems	Disqualified if rock characteristics are such that activities assoc. w/ repository construction, operation, or closure are predicted to cause significant risk to safety to personnel
Hydrology 960.5-2-10	Located such that geohydrologic setting will be compatible with repository activities; not hinder intended functions of the shaft liners & seals; meet requirement of 960.5-1(a)(3)	Absence of aquifers between between host rock & land surf.; Absence of surface-water sys. that could potentially cause flooding; Availability of the water required for repository construction, operation, or closure	Ground-water conditions that could require complex engineering measures that are beyond reasonably available technology for repository construction, operation, and closure	Disqualified if, based on expected ground water conditions, it is likely that engineering beyond available technology required for exploratory-shaft or repository construction, operation, or closure
Tectonics 960.5-2-11	Located in geologic setting in which projected effects of expected tectonic phenomena or igneous activity on repository construction, operation, & closure will meet the req. in 960.5-1(a)(3)	The nature and rates of faulting if any, w/in geologic setting are such that the magnitude & intensity of associated seismicity are significantly < those generally allowable for construction & operation of nuclear facilities	Evidence of active faulting w/in geologic siting; Historical earthquakes or past man-induced seismicity that could produce ground motion at site in excess of reasonable design limits; Evidence that magnitude of earthquakes at the site during construct., operation, and closure will be > predicted by past act.	Disqualified if, based on nature & rates of fault or other ground motion, it is likely that engineering measures beyond available technology will be required

NOTE: Additional information in all of these areas located in Appendix IV.

40 CFR 191 Subpart B Environmental Standards for the Uranium Fuel Cycle Compliance Structure

W-7300

40 CFR 264 Subpart X Permit for Misc. Unit Compliance Structure

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40 CFR 268.6 Land Disposal Restriction Compliance Structure

40 CFR 268.6
101 W2008

10 CFR 20 Standards for Protection Against Radiation

10CFR20.600
for 10/1/99

DOE Order 5820.2A - Radioactive Waste Management:

Chapter I - High Level Waste;

Section 3d - Disposal Requirements

DOE5820.2A.0CD
rev 11/21/88

ACRONYMS

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
CFR	Code of Federal Regulations
COC	Certificate of Compliance
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration
HLW	High-level Waste
INEL	Idaho National Engineering Laboratory
MGDS	Mined Geologic Disposal System
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act
PA	Performance Assessment
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act
SAR	Safety Analysis Report
SNF	Spent Nuclear Fuel
TRU	Transuranic Waste

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DOE/ID-10405, Idaho National Engineering Laboratory Installation Roadmap Document, DRAFT, May 1993.

ORNL/M-1717, Hazardous Materials Transportation Act, Revision 5, October 15, 1991, Oak Ridge National Laboratory.

ORNL/M-1900, Atomic Energy Act and Related Legislation, Revision 6, September 1, 1992, Oak Ridge National Laboratory.

SAND86-0121, Assessing Compliance With the EPA High-Level Waste Standard: An Overview, October 1986, Sandia National Laboratories.

Training Seminar Manual, Environmental Regulations Overview, July 1992, WINCO Environmental Training Personnel.

APPENDIX A

This Appendix provides potentially supplemental information for ensuring compliance with the requirements summarized in this document. It contains two letters reporting the results of an investigation of criticality issues related to the direct disposal of fuel in a geologic repository conducted by R.L. Nebeker, of WINCO.

Attachments to the letters outline and summarize various NRC Regulatory guides and ANSI standards. These summaries provide additional information relating to criticality safety. Attachment 1 of Neb-03-91 and Attachment 3 of Neb-04-91 summarize the content of various Regulatory Guides, ANSI Standards, and Regulations; Attachment 2 of Neb-03-91 gives impacts, proposed resolutions, and long term implications of specific requirements set forth in 10 CFR 60, 40 CFR 191, and DOE Order 5480.5. These two regulations, 10 CFR 60 and 40 CFR 191, have been summarized in more detail in the MGDS section. Attachment 2 of Neb-04-91 does the same for various Regulatory guides; however, no flow diagram summaries for Regulatory guides are prepared in this document.

Other potentially applicable federal directives are contained in DOE Order 5480.4 - Environmental Protection, Safety, and Health Protection Standards. This Order categorically lists directives and reported procedures to be followed when conducting activities outlined in the various sections of this document. For example, under the Radioactive Material Packaging and Transportation Safety section (Page 12 of Attachment 3 of this Order), references such as *ORNL-NSIC-68, 1970, "Cask Designers Guide"* (ORNL) and *NRC Guide 7.4, "Leakage Tests for Shipment of Radioactive Materials"* (NRC) are listed.

No detailed investigation into the applicability of the references in this appendix has been conducted. However, it is believed that some of these referrals will contain useful information as new operations and activities at the INEL relative to the SF&WMTDP are developed.

Idaho National Engineering Laboratory

Neb-03-91

From R. L. Nebeker

Phone 6-3578

Date October 22, 1991

Subject: Criticality Implications of Direct Disposal of Fuel

To N. A. Chipman, Fellow Engineer
New Business and Special Studies

cc: G. B. Frandsen
R. N. Henry
G. W. Hogg

V. C. Maio
B. R. Wheeler
R. L. Nebeker - 2

As you requested, I have reviewed various regulations and standards concerning criticality issues related to the direct disposal of fuel in a geological repository. A list of these regulations and their highlights are provided in Attachment 1.

In general, the regulations do not specifically apply to repository disposition, but to other aspects of fuel handling. However, regulations for repository disposition of fuel would be expected to contain the general restrictions shown in these regulations.

Attachment 2 summarizes the requirements of these regulations as well as other regulations concerning fuel disposition in a repository (mainly concerning the stability of the repository package) which indirectly impact criticality control.

For direct disposal of fuel, two time periods are of concern: "short," corresponding roughly to the length of time a canister must retain its integrity and "long," when container integrity cannot be guaranteed. The need for criticality control in a repository is discussed in 10CFR60.131(7), but nothing is said regarding the time periods for which the criticality control requirements must be met. The NRC staff has identified this as an "uncertainty", and the issue is presently being studied by NRC personnel.

Rick Weller of the High-Level Waste Program for the NRC was contacted regarding the time periods for which criticality control requirements in 10CFR60 must be met. He indicated that a staff position is being developed and an NRC Guidance Document on the subject will be issued in the next several months. Most likely, the guidance will require that criticality control be considered in both the preclosure and post closure periods. Analyses must be completed to evaluate criticality impacts in meeting performance criteria for the duration of the period of interest, which is assumed to be 10,000 years, based on EPA requirements in 40CFR191.

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N. A. Chipman
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October 22, 1991

While it appears that criticality could be controlled with adequate design in the "short" time period, it also appears that there is absolutely no way to guarantee that a criticality will not occur over the time the fissile material in the spent fuel would remain in the repository.

Obviously, disposing of the fuel directly instead of removing the fissile material (uranium and plutonium) increases the care and attention that must be given to the waste package because of criticality concerns. Some of the additional concerns are:

1. Each "package" must be assured to be critically safe. For HEU fuel, this could involve additional fuel disassembly steps prior to packaging or adding nuclear poisons to the package.
2. The spacing within the repository would have to be analyzed to determine that the array of spent fuel is subcritical for all possibilities. This spacing may be more or less restrictive than spacing for heat removal.
3. The intrusion of water into the repository over long time periods would adversely affect the fuel reactivity and would have to be considered in all criticality analyses.
4. Over long periods, movements through faulting or other earth shifting methods might change the geometry of the fuel array or damage the package and reduce its lifetime, making it more reactive.
5. Over long periods, nuclear poisons could conceivably be selectively leached from the fuel package, resulting in higher reactivities. The decay of fission product poisons in the fuel would also increase the reactivity in the fuel, even in the "short" term.
6. Selective movement of uranium is conceivable over the long term if the uranium is dissolved and reprecipitated. This also might increase the reactivity within the repository.
7. Typically, inspections are required to verify that any nuclear poisons used for criticality control remain in place and are not removed. Inspection to assure canister arrays and the integrity of the canister may also be an issue. Inspection after placement in a repository might be impossible or would require extensive fuel handling.
8. Intrusion to prevent diversion of HEU is not addressed in existing regulations but would be a logical safeguard issue that would be expected to arise during the public review process. Unlike commercial fuel, HEU fuel would require less refining to prevent an SNM threat.

N. A. Chipman
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October 22, 1991

In summary, it would appear that confinement of fission products via engineered barriers (canister and repository) is feasible, but assurance of criticality safety cannot be demonstrated for geologic time.

In addition to these criticality issues there are other issues concerning fuel configuration that indirectly affect criticality control that must be resolved if fuel is disposed of directly. Among these are:

1. Elimination of combustibles/reactives will be required of fuels containing graphite or carbides before they can meet today's requirements. This could require extensive pretreatment prior to disposal.
2. Solidification of particulate matter would be required for any powdered fuel or fuel residue, again requiring a type of pretreatment.
3. Fuels would have to be characterized to demonstrate their ability to retain fission products and to assure regulators that material going to the repository is known and understood. Because of the many types of fuel (over 30 general types at the ICPP alone), this would require an extensive amount of time and money (probably over a billion dollars over many years).

It is doubtful that these issues can be analyzed in a manner that would convince the public that HEU type fuel or even commercial LEU fuel can be disposed of directly to a repository without generating a criticality safety risk. Whether or not the issues are really problems may be immaterial; if they are perceived as problems by the public, it will be impossible or difficult to get public acceptance. While it may be technically acceptable to say that the risk of a criticality deep underground in a geological repository is acceptable and can be analyzed based on data from the Oklo Natural Reactor, it is doubtful that the general public would accept such a risk. Furthermore, failure to remove the fissile material (the technology does exist) casts doubt on DOE's commitment to make nuclear safety their number one priority.

Obviously, this issue will have to be developed further over a period of time. If I can be of any further help, or supply further information, let me know.

R. L. Nebeker
Fellow Engineer

Attachments

/rg

Attachment 1

Summary of Guidance Documents Pertaining to Criticality and Fuel Storage

Document	Title	Summary of Contents
10CFR60	Disposal of High-Level Radioactive Wastes in Geologic Repositories	This regulation lists general provisions for disposal of HLW and describes license application requirements. It contains performance objectives and design criteria.
10CFR60.113	Performance of Particular Barriers After Permanent Closure	Requires HLW containment during fission product decay time. Requires gradual release of radionuclides from barrier system. Requires containment for 300-1000 years.
10CFR60.131	General Design Criteria for the Geologic Repository Operations Area	Requires radiation doses, levels and concentrations to be within established levels. Lists design criteria for repository. Requires steps to minimize possibility of a criticality.
10CFR60.135	Criteria for the Waste Package and Its Components	Requires package for HLW to be able to withstand environmental attacks. Lists criteria to be met by waste forms.
40CFR191	Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste	Lists standards for radiation doses received by public as a result of management and disposal activities. Discusses radioactive material releases as a result of disposal.
40CFR191.03	Standards	Gives dose limits to public for disposal activities.
40CFR191.13	Containment Requirements	Provides standards for design of containment and lists release likelihoods to be obtained.

Document	Title	Summary of Contents
40CFR191.14	Assurance Requirements	Discusses institutional controls, monitoring, marking, barriers, mining, and waste removal.
40CFR191 Appendix A	Table for Subpart 13	Lists cumulative releases to the accessible environment for 10,000 years after disposal for specific nuclides and groups.
DOE Order 5480.5	Safety of Nuclear Facilities	Describes basic requirements for DOE's environment, safety and health program. Basic elements of nuclear criticality safety are presented along with Nuclear criticality safety control parameters.
NRC Regulatory Guide 1.13	Spent Fuel Storage Facility Design Basis	Presents methods for assuring that fuel storage and handling system are designed for adequate safety under normal and postulated accident conditions.
NRC Regulatory Guide 3.4	Nuclear Criticality Safety in Operations with Fissionable Materials at Fuels and Materials Facilities	Describes procedures for preventing accidental criticality in operations with fissionable materials at fuel cycle facilities other than reactors. Refers to ANSI/ANS-8.1-1983.
NRC Regulatory Guide 3.33	Assumptions used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Fuel Reprocessing Plant	Provides methods and equations for determining the impacts of a criticality on the public health and safety. Describes how to estimate the consequences of an accidental criticality as it applies to a fuel reprocessing plant.
NRC Regulatory Guide 3.34	Assumptions used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant	Provides methods for determining the impacts of a criticality on the public health and safety as it applies to a uranium fuel fabrication plant.

Document	Title	Summary of Contents
NRC Regulatory Guide 3.43	Nuclear Criticality Safety in the Storage of Fissile Materials	Provides guidance for procedures to avoid accidental criticality during storage of fissile materials. Refers to ANSI N16.5-1975.
NRC Regulatory Guide 3.57	Administrative Practices for Nuclear Criticality Safety at Fuels and Materials Facilities	Provides guidance for safety procedures which are part of a nuclear safety program. Refers to ANSI/ANS 8.19-1984.
NRC Regulatory Guide 3.58	Critical Safety for Handling, Storing, and Transporting LWR Fuel at Fuels and Materials Facilities	Provides guidance for preventing criticality accidents during handling, storage, and transporting of LWR fuel outside of nuclear reactors. Refers to ANSI/ANS-8.17-1984.
NRC Regulatory Guide 3.60	Design of an Independent Spent Fuel Storage Installation (Dry Storage)	This document provide guidance for use in the design of a dry storage independent spent fuel storage installation. It refers to ANSI/ANS-57.9-1984.
NRC Regulatory Guide 8.12	Criticality Accident Alarm Systems	This guide describes a system for meeting requirements for a criticality accident alarm system. it refers to ANSI/ANS-8.3-1986.
ANSI/ANS-8.1-1983	American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors	This standard provides guidance for the prevention of criticality accidents in the handling, storing, processing, and transporting of fissionable material.
ANSI/ANS-8.3-1986	Criticality Accident Alarm System	This standard provides guidance for the establishment and maintenance of an alarm system to initiate personnel evacuation in the event of inadvertent criticality.

Document	Title	Summary of Contents
ANS-8.7/ANSI N16.5-1975	Guide for Nuclear Criticality Safety in the Storage of Fissile Materials	This guide provides orientation and direction to nuclear safety practices.
ANSI/ANS-8.17-1984	American National Standard, Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors	This standard provides basic requirements that address the criticality safety aspects of a facility or operation that can be referenced or used in conjunction with other safety standards or regulations.
ANSI/ANS 8.19-1984	American National Standard - Administrative Practices for Nuclear Criticality Safety	This standard presents a codification of certain common safety elements related to criticality safety.
ANSI/ANS-5.79-1984	American National Standard - Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)	This standard provides design criteria for an Independent Spent Fuel Storage Installation for LWR spent fuel which incorporates one or more of the dry storage concepts.

Attachment 2

Criticality and Other Requirements for Spent Fuel Disposal

Assumption/ Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Containment until fission products decay (300-1000 years)	10CFR60.113	Extensive fuel characterization required for many different fuel types.	Repository to be constructed to provide containment: characterize fuel.	Probably attainable for required time.
Slow release of radionuclides (1/100,000 per year)	10CFR60.113	Must demonstrate for fuel inventory as well as criticality fission products. Must show slow release of gaseous fission products from criticality.	Characterize fuel, perform analyses.	Probably obtainable for many fuels.
Maintain air concentrations below 10CFR20 limits	10CFR60.131	Retention of fission products required.	Canister should be adequate if it remains intact.	Release of gaseous fission products from criticality must be analyzed.
Double contingency to prevent criticality	10CRF60.131(7) DOE 5480.5, ANSI/ANS-8.1- 1983	May require extensive spacing, use of poison, or other requirements.	Various solutions possible for short term.	Unable to demonstrate compliance in long term.
Keff to have a 5% margin	10CFR60.131(7)	May limit spacing/ packaging of fuel.	Spacing, poisons, disassembly or other methods.	Unable to demonstrate compliance in long term.

Assumption/ Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
In-situ chemical reactions do not compromise package	10CFR60.135	Must show that poisons remain in place; that uranium is not concentrated by chemical action.	Canister will provide protection during "short" term.	Long term compliance will be difficult to demonstrate.
In-situ physical properties do not compromise package	10CFR60.135	Physical movement of fuel leading to criticality must be prevented.	Repository geology will demonstrate short-term compliance.	Long-term stability will be difficult to demonstrate.
In-situ nuclear properties do not compromise package	10CFR60.135	High radiation, criticality must not impact package.	Short term compliance by spacing, poisons, etc.	Long-term demonstration of lack of damage from criticality difficult to demonstrate.
Consider solubility	10CFR60.135	Poisons could be lost or uranium concentrated by solubility.	Container will provide protection in short term.	Cannot demonstrate compliance in long term.
Consider oxidation/reduction reactions	10CFR60.135	Poisons could be lost or uranium concentrated by Redox reactions.	Containers will provide protection in short term	Cannot demonstrate compliance in long term.
Consider corrosion	10CFR60.135	Poisons could be lost or uranium concentrated by corrosion of container and fuel.	Containers will provide protection in short term.	Cannot demonstrate compliance in long term.
Consider hydriding	10CFR60.135	May result in more reactivity of fuel, excessive corrosion.	Containers will provide protection in short term.	Cannot demonstrate compliance in long term.

Assumption/ Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Consider gas generation	10CFR60.135	Criticality, reactive fuels can create gas.	Pretreat reactive fuels, fuels will be protected against criticality in short term.	Long term compliance difficult to demonstrate.
Consider thermal effects/loads	10CFR60.135	Overheating will increase fission product release migration.	Spacing, fuel disassembly can limit thermal effects.	Criteria can probably be met.
Consider mechanical strength	10CFR60.135	Mechanical failure could position fuel in more reactivity geometry.	Containers will be mechanically stable in short time.	Cannot demonstrate compliance in long term.
Consider mechanical stress	10CFR60.135	Mechanical stress may deform fuel into more reactive configuration.	Canister will provide protection in short term.	Long term compliance may be difficult to demonstrate.
Consider radiolysis	10CFR60.135	May result in gas generation.	Short term compliance built into design.	Evaluate effect of long-term radiation exposure.
Consider radiation damage	10CFR60.135	Could result in higher radionuclide release.	Package will be designed for calculated radiation dose.	Must show that fuel is not significantly different from waste in terms of radiological source form. Alpha activity will last for long term.

Assumption/ Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Consider radionuclide retardation	10CFR60.135	Fuel must be as good as waste form for fission product acceleration.	Characterize fuel to demonstrate ability to retain radionuclides.	Characterization will be expensive, time consuming; must retain radionuclides from a criticality.
Consider leaching	10CFR60.135	Leaching may remove poison or concentrate uranium. Water will increase fuel reactivity. Fuel must be as resistant as waste form.	Short term compliance will be provided by package.	Long-term compliance will be difficult to demonstrate.
Consider fire and explosion hazards	10CFR60.135	Some fuels may be combustible/reactive.	Pretreat combustible/reactive fuels prior to disposal.	Pretreatment will require extensive facilities.
Consider synergistic interaction	10CRF60.135	Criticality control requires added dimension of requirements.	Adequate plans, calculations and methods can be prepared.	Increased time and effort will be required.
No pyrophoric materials	10CFR60.135 DOE 5480.5	Pyrophoric fuel would have to be pretreated.	Pretreat required fuel.	Pretreatment facility would be costly.

Assumption/Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
No chemically reactive materials	10CFR60.135	Combined fuels would require pretreatment.	Pretreat fuel as necessary.	Pretreatment facility would be costly.
Consolidate Particulates	10CFR60.135	Powdered fuel or residue would have to be consolidated.	Pretreat fuel as necessary.	Pretreatment facility would be costly.
Reduce to noncombustible form	10CFR60.135	Certain fuels would require pretreatment.	Pretreat fuels as necessary.	Pretreatment would be costly.
Maintain dose to public below 25 mr whole body	40CFR191.03	None for short term.	Provide adequate packaging/ shielding.	Difficult to demonstrate for long term.
Releases to have less than 1/1000 chance of exceeding release limits	40CFR191.13	Fuel must be as good a form as waste.	Characterize fuel; preprocess if required	Long-term compliance difficult to prove.
Monitor disposal systems	40CFR191.13	Install monitoring system.	Monitoring practical in short term.	Cannot verify compliance in long term.
Do not preclude removal of waste	40CFR191.14	Design for removal.	Repository/package design in short term.	Cannot verify in long term.

Assumption/ Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Consider all potential criticality hazards	DOE 5480.5	Criticality prevention adds additional requirements and care.	Repository design, fuel size.	Cannot verify in long term.
Ensure process is subcritical under both normal and abnormal operating/credible conditions	DOE 5480.5 ANSI/ANS 8.1-1983 ANSI/ANS 8.19-1984	Extra care required in handling/storage.	Spacing, poisoning, etc. may be required in package.	Long term compliance cannot be guaranteed.
Avoid entry of water into storage area	DOE 5480.5	Fuel reactivity will be increased in wet environment	Repository construction will provide compliance for short term.	Difficult to demonstrate for long term.
Poisons can be used if available data assures presence and reliability	DOE 5480.5	Loss of poison will result in increased fuel reactivity.	Container will provide assurance in short term but cannot inspect to assure presence.	Long-term presence of poison cannot be demonstrated. Cannot inspect to guarantee presence.
Assure prescribed extent of moderation remains unchanged	DOE 5480.5	Increased moderation will increase fuel reactivity.	Container/repository design will provide assurance in short term.	Long term changes are likely but cannot be specified.
Reflection based on result of credible accident	DOE 5480.5	Increased reflection will increase fuel reactivity.	Repository design will provide assurance in short term.	Long-term geological events may change dimensions/spacing.

Assumption/Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Maintain all dimensions and nuclear properties relied on for geometry control	DOE 5480.5	Change in geometry may increase fuel reactivity.	Original spacing can be relied on for short term.	Long-term geological events may change dimensions/spacing.
Periodic inspections, insitu tests, and preventive maintenance needed for criticality control	DOE 5480.5	Inspection cannot easily be made after installation in repository.	None	Inspection, etc. impossible in long term.
Control spacing, mass, density and geometry under normal and abnormal conditions	ANSI/ANS-8.19 1984	Control is lost after placement in repository.	None	Physical changes to repository, fuels, etc. possible in long term.
Spent fuel storage facility to meet Category I seismic requirements	RG 1.13	Seismic events could rearrange fuel, resulting in criticality.	Repository design will provide protection in the short term.	Demonstration of long term compliance is difficult.
Obviate concern for criticality in event of fire, flood, earthquake, or other natural calamities.	ANS-8.7/ANSI N16.5-1975	Natural phenomena may result in increased fuel reactivity.	Repository design should meet standard in short term.	Demonstration of long term compliance is difficult.

Idaho National Engineering Laboratory

Neb-04-91

From R. L. Nebeker
Phone 6-3578/MS 5219
Date October 29, 1991
Subject Review of Task Team 12 Criticality Information

To N. A. Chipman, Fellow Engineer
New Business and Special Studies

cc: G. G. Frandsen V. C. Maio
R. N. Henry B. R. Wheeler
G. W. Hogg R. L. Nebeker - 2

Reference: R. L. Nebeker, Letter Neb-03-91, to N. A. Chipman, "Criticality Implications of Direct Disposal of Fuel," dated October 22, 1991.

At your request, the information submitted by Task Team 12 concerning criticality implications of direct fuel disposal was reviewed. In that submittal, various regulations were referenced which apply to criticality prevention. All of these references except two were described earlier in the reference to this letter. Task Team 12 referred to two NRC Regulatory Guides not included in Letter Neb-03-91: Reg Guide 3.41 and Reg Guide 3.48.

NRC Regulatory Guide 3.41 was withdrawn by the NRC on March 20, 1986 and has been replaced with NRC Regulatory Guide 3.4 (see Attachment 1). Consequently, it was not included in Neb-03-91. NRC Regulatory Guide 3.48 describes the format and contents for safety analysis reports (SARs) for fuel storage. It lists certain information to be included in the SAR which indirectly impacts criticality prevention during fuel storage. For completeness, these requirements, and implications of meeting the requirements, are shown in Attachment 2. A summary of both regulatory guides is shown in Attachment 3 in the same format as originally shown for other regulations in Neb-03-91.

If further information is needed, please let me know.

R. L. Nebeker
R. L. Nebeker
Fellow Engineer

/t1

Attachments

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

March 20, 1986

REGULATORY GUIDE DISTRIBUTION LIST (DIVISION 3)

SUBJECT: ISSUANCE OF REVISION 2 TO REGULATORY GUIDE 3.4 AND
WITHDRAWAL OF REGULATORY GUIDE 3.41

With the issuance of Revision 2 to Regulatory Guide 3.4, "Nuclear Criticality Safety in Operations with Fissionable Materials at Fuels and Materials Facilities," the NRC staff is withdrawing Regulatory Guide 3.41, "Validation of Calculational Methods for Nuclear Criticality Safety."

Revision 2 to Regulatory Guide 3.4 endorses ANSI/ANS-8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," which is a consolidation of ANSI N16.1-1975/ANS-8.1 (endorsed by Revision 1 of Regulatory Guide 3.4) and ANSI N16.9-1975/ANS-8.11 (endorsed by Regulatory Guide 3.41). Regulatory Guide 3.41 is therefore obsolete. However, withdrawal of Regulatory Guide 3.41 is in no way intended to alter any prior or existing licensing commitments based on its use.

Regulatory guides may be withdrawn when they are superseded by the Commission's regulations, when equivalent recommendations have been incorporated in applicable approved codes and standards, or when changes in methods and techniques or in the need for specific guidance have made them obsolete.

Robert B. Minogue

Robert B. Minogue, Director
Office of Nuclear Regulatory Research

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Attachment 2

Criticality and Other Requirements for Spent Fuel Disposal

Assumption/ Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Evaluate fuel storage sites for: vulnerability to accidents from natural phenomena, radiation shielding, confinement, and control of radioactive materials, etc.	Reg Guide 3.48	Significant analyses required prior to fuel placement.	These items will be analyzed as part of repository preparation.	Long-term analyses require making assumptions without fully understanding future events.
SAR should discuss flood history, flood design considerations, local intense precipitation losses, run off model, probable maximum flood flow, water level determinations, ice flooding, dam failures, and other potential flooding mechanisms.	Reg Guide 3.48	Significant analyses of past and predicted future events required. Flooding could adversely affect reactivity of fuel.	These items, based on past events, will be analyzed in detail for repository.	Long-term analyses will require making assumptions without fully understanding future events.

Assumption/ Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Describe earthquake history, identify and describe capable faults, determine maximum earthquake, describe surface faulting, geologic features, properties of underlying materials, ground water conditions, etc.	Reg Guide 3.48	Significant analyses of past and predicted future events required. Geologic change could adversely affect reactivity of fuel.	These items, based on past events, will be analyzed in detail for geologic repository.	Long-term analyses will require making assumptions without fully understanding future events.
Provide a detailed description of material to be stored, including physical, thermal, and radiological characteristics. Include specific power, burnup, decay time, heat generation rates, etc.	Reg Guide 3.48	Significant characterization required.	Detailed characterization work will be completed prior to placement of fuel in repository.	Information for some fuels will be lacking even in short term.

Assumption/ Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Provide information concerning tornado missiles, floods, flood elevations, flood force, flood protection, seismic design, snow and ice loadings, etc.	Reg Guide 3.48	Significant analyses required. Flooding or fuel movement could adversely affect fuel reactivity.	Analyses will be completed at time of repository construction.	Long-term analyses will require making assumptions without fully understanding future events.
Describe control methods for prevention of criticality and error contingency criteria. Describe the design features, procedures, and special techniques to preclude criticality.	Reg Guide 3.48	Significant analyses required.	Analyses will be completed at time of repository construction.	Certain control methods cannot be guaranteed to be viable for long terms.
Describe systems for providing safety under normal and abnormal conditions.	Reg Guide 3.48	Extensive descriptions will be required.	Description will be required when repository is built.	Facility and system will not remain in original configuration for long periods.

Assumption/Requirements	Reference	Impact	Proposed Resolution	Comments/Long Term Implications
Analyze potential accidents, including causes, detection, effects and consequences, corrective actions, etc.	Reg Guide 3.48	Extensive analyses will be required.	Analyses will be part of geologic repository SAR.	Long-term analyses must be based on inadequate information.
Conduct of Operation items to be described.	Reg Guide 3.48	Descriptions will be prepared.	These conditions will be followed during storage of fuel.	These conditions cannot be guaranteed for long time periods.

Attachment 3

Summary of Guidance Documents Pertaining to Criticality and Fuel Storage

Document	Title	Summary of Contents
NRC Regulatory Guide 3.41	Validation of calculational methods for nuclear criticality safety.	Withdrawn 3/20/86 and replaced by Regulatory Guide 3.4.
NRC Regulatory Guide 3.48.	Standard format and content for the Safety Analysis Report for an independent spent fuel storage installation or monitored retrievable storage installation (dry storage).	This guide presents a standard format that is acceptable to the NRC staff for the SAR required for a license application to store spent fuel in an independent spent fuel storage installation or to store spent fuel and high-level radioactive waste in a monitored retrievable storage installation.

Attachment 6

RELEASE LIMITS and CALCULATING UNIT WASTE FACTORS

Background

Disposal of high-level radioactive wastes, including spent fuels, is governed predominantly by 40 CFR 191 regulations. Working to those requirements, in relation to disposal of both the spent nuclear fuels and high-level waste products from prior processing, may dictate use of calculated values for the 'Units Waste Factor'.

Past reprocessing of spent fuels may have resulted in combined waste streams from various fuel dissolution campaigns. Blending aqueous waste streams from fuel dissolution loses the characteristic information of the individual fuel elements and the information needed to calculate the unit of waste, typically 1,000 metric tons initial heavy metal (MTIHM). For the blended high-level waste, alternative calculations are identified in 40 CFR 191 that allow for an equivalent unit waste factor.

Calculating MTIHM Equivalents

The 40 CFR 191 Release Limits are found in Appendix A Table 1 of the code. The table provides for release limits per 1,000 metric tons of (initial) heavy metal or other unit of waste. This table and the notes have been reproduced as follows.

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40 CFR 191 Appendix A - Table for Subpart B

Table 1 Release Limits for Containment Requirements

[Cumulative releases to the environment for 10,000 years after disposal]

Radionuclide	Release limits Per 1,000 MTHM or other waste units of waste (see notes) (Ci)
Americium (Am) -241 or -243	100
Carbon (c) -14	100
Cesium (Cs) - 135 or -137	1000
Iodine (I) -129	100
Neptunium (Np) -237	100
Plutonium (Pu) -238, -239, -240, or -242	100
Radium (Ra) -226	100
Strontium (Sr) -90	1000
Technetium (Tc) -99	10000
Thorium (Th) -232	10
Tin (Sn) -126	1000
Uranium (U) -233,-234,-235,-236, -238	100
Any other α -emitting radionuclide with $t_{1/2} > 20$ yrs	100
Any other non α -emitting radionuclide with $t_{1/2} > 20$ yrs .	1000

Application of 40 CFR 191 Appendix A-Subpart B Table 1

Note 1: Units of Waste. The release limits in Table 1 apply to the amount of wastes in any one of the following:

- (a) An amount of spent nuclear fuel containing 1,000 MTHM exposed to a burnup between 25,000 megawatt-days per metric ton of heavy metal (MWd/MTHM) and 40,000 MWd/MTHM;
- (b) The high-level radioactive wastes generated from reprocessing each 1,000 MTHM exposed to a burnup between 25,000 megawatt-days per metric ton of heavy metal (MWd/MTHM) and 40,000 MWd/MTHM;
- (c) Each 100,000,000 curies of gamma or beta-emitting radionuclides with half-lives greater than 20 years but less than 100 years (for use as discussed

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in Note 5 or with materials that are identified by the commission as high-level radioactive waste in accordance with part B of the definition of high-level waste in the NWPA);

- (d) Each 1,000,000,000 curies of other radionuclides (i.e. gamma or beta-emitters with half lives greater than 100 years or any alpha-emitters with half-lives greater than 20 years (for use as discussed in Note 5 or with materials that are identified by the commission as high-level radioactive waste in accordance with part B of the definition of high-level waste in the NWPA); or
- (e) An amount of transuranic (TRU) wastes containing one million curies of alpha-emitting transuranic radionuclides with half lives greater than 20 years.

Note 2: Release Limits for Specified Disposal Systems. To develop release limits for a particular disposal system, the quantities in Table 1 shall be adjusted for the amount of waste included in the disposal system compared to the various units of waste defined in Note 1.

Note 3: Adjustments for Reactor Fuels with Different Burnup. For disposal systems containing reactor fuels (or high-level wastes from reactor fuels) exposed to average burnup of less than 25,000 MWd/MTHM or greater than 40,000 MWd/MTHM, the units of waste defined in (a) and (b) of Note 1 shall be adjusted. The unit shall be multiplied by the ratio of 30,000 MWd/MTHM divided by the fuel's actual average burnup, except that a value of 5,000 MWd/MTHM may be used when the average fuel burnup is below 5,000 MWd/MTHM, and a value of 100,000 MWd/MTHM shall be used when the average fuel burnup is above 100,000 MWd/MTHM. This adjusted unit of waste shall then be used in determining the Release Limits for the disposal system.

Note 4: Treatment of Fractional High-Level Wastes. In some cases, a high-level waste stream from reprocessing spent nuclear fuel may have been (or will be) separated into two or more high-level waste components destined for different disposal systems. In such cases, the implementing agency may allocate the Release Limit multiplier (based on the original MTHM and the average fuel burnup of the high-level waste stream) among the various disposal systems as it chooses, provided that the total Release Limit multiplier used for that waste stream at all of its disposal system may not exceed the Release Limit multiplier that would be used if the entire waste stream were disposed of in one disposal system.

Note 5: Treatment of Wastes with Poorly Known Burnup or Original MTHM. In some cases, the records associated with particular high-level waste streams may not be adequate to accurately determine the original metric tons of heavy metal in the reactor fuel that created the waste, or to determine the average burnup that the fuel was exposed to. If the uncertainties are such that the original amount of heavy metal of the average fuel burnup for particular high-level waste streams cannot be quantified, the units of waste derived in (a) and (b) of Note 1 shall no longer be used. Instead, the units of waste defined in (c) and (d) of Note 1 shall be used for such high-level waste streams. If the uncertainties in such information allow a range of values to be associated with the original amount of heavy metal of the average fuel burnup, then the calculations described in the previous Notes will be conducted using the values that result in the smallest Release Limits, except that the Release Limits need not be smaller than those that would be calculated using the units of waste defined in (c) and (d) of Note 1.

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Note 6: *Use of Release Limits to Determine Compliance with 191.13.* Once release limits for a particular disposal system have been determined in accordance with Notes 1 through 5, these release limits shall be used to determine compliance with the requirements of 191.13 as follows. In cases where a mixture of radionuclides is projected to be released to the accessible environment, the limiting values shall be determined as follows: For each radionuclide in the mixture, determine the ratio between the cumulative release quantity projected over 10,000 years and the limit for that radionuclide as determined from Table 1 and Notes 1 through 5. The sum of such ratios for all the radionuclides in the mixture may not exceed one with regard to 191.13(a)(1) and may not exceed ten with regard to 191.13(a)(2).

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DATA PACKAGE REQUIREMENTS

Data Package Requirements

This section specifies the arrangement of data which must be reported to the repository for all waste packages to be received. These instructions have been prepared as a reference guide for those personnel responsible for transmission of the data package to the repository offices.

Prior to shipment, the shippers computer system must retrieve the required information for all package information associated with that shipment and write the information in an ASCII file format in the Record and File Layout Format detailed in Table 1. The data package will be transmitted in the ASCII format over a specified communications system to the repository via Ethernet on the Internet. Therefore, these instructions are primarily for use by the data processing personnel to aid them in programming the system to provide the transmittal information in the data package format.

Transmission of Data to the Repository

The MIS specialist at the repository will provide the liaison between the shippers and the repository. Individual shippers will contact the repository offices to obtain the necessary password and identification (ID) code to transmit the data to the repository.

The shipper must format the data package as described in this section, convert it to ASCII, and transmit it to the host computer at the repository. The repository will provide the software and the node address to allow access to the host computer. The shipper must retain the electronic file information of the data package for 30 days after initial transmittal.

Record and File Format

Table 1 shows the Record and File Format for shippers to use in transmitting the data package to the host computer. Each record is xxx bytes long, and begins with a field identifying the record type. Record types to enter are : shipment "S", package "P", hazardous "H", and radionuclide "R". Empty fields and unused bytes in a record are filled with blanks. The sequential file will contain one shipment record, 1-~~tbd~~ package records, 0-1 hazardous records per waste package, and 1-3 radionuclide records per waste package. After a package record, provide the associated radionuclide record(s) and hazardous record before the next package record. If fewer than three radionuclide records are needed, or if no hazardous record is needed, omit the unneeded records, and proceed to the next package record.

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Transmission of Data

The user at the shipping site will log on and transmit the data package as described in the repository host computer user's manual. Based on the error report returned to the shipper's printer by the host computer, determine whether all the records in the data package passed the host computer's edit and range checks. In accordance with the shipper's procedures, an authorized person will determine the correct data and modify rejected records accordingly until the data packages pass the edit checks.

NOTE: If the shipper experiences problems getting data to pass the edit and range checks, the MIS specialist at the repository can help the shipper. However, because of the differences in assigned security categories, the MIS specialist cannot change the shippers data in the temporary data base.

If it is necessary to change a shipment number, package ID, assembly number, Waste Acceptance Criteria (WAC) exception number or other protected field, it will be necessary to delete the entire package, change the data at the shipping site, and retransmit the data package.

When the data package has passed all edit and range checks, and the shipment date and shipment certification date are known, the shipment is considered to be complete. The shipper must then change the shipment ready field on the shipment screen to "Y". If the entire package has passed the edit and range checks, the "Y" will be accepted, and the shipper will be denied all further access to that data package on the host computer. Otherwise, the shipper will have to resolve the error message before the "Y" will be accepted.

The host computer data base, to which the shipper transmits the data package, is a shared data base. Several shippers may be logged on simultaneously, but each will have their own account file so that no shipper will have access to another shipper's data. In addition to being able to access a data package record-by-record via menu options for the shipment data base, rejected package data base, or accepted package data base, the shipper will also have three report options: (1) the error list, (2) the shipment summary, and (3) the package data [by shipment].

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Table 1

Record	Field	Field Format
1	Shipment Data Format	S
1	Shipment Number	A8
1	Shipment Date	A6 'YYMMDD'
1	Vehicle Type	A1
1	Waste Type	A2
1	Shipment Certification Date	A6 'YYMMDD'
1	Cask Type/Number	A3
1	Approved Payload Compliance Certifier	A25
2	Waste Package Data Format	P
2	Package ID Number	A13
2	Container Code	A3
2	Shipment Number	A8
2	Closure Date	A6 'YYMMDD'
2	Cask Type/Number	A3
2	Package Certification Date	A6 'YYMMDD'
2	Weight	A7 (9.9E+99)
2	Surface Dose Rate	A7 (9.9E+99)
2	Neutron Contribution	A7 (9.9E+99)
2	Thermal Power	A7 (9.9E+99)
2	U-235 Fissile Grams (or equivalent)	A9 (9.9E+99)
2	Gas Generation (moles/yr)	A7 (9.9E+99)
2	Content Code	A3
2	Certifying Site	A2
2	Miscellaneous	A35
2	WAC Exception Number	A7
2	Certification Official's Name	A25
3	Radionuclide Data	R (11 per record (25 total))
3	Radionuclide Symbol	A7
3	Radionuclide Quantity	A9 (9.9E+99)
3	Radionuclide Units	A1
4	Hazardous Material Data Format	H (14 per record (14 total))
4	Hazardous Material ID Code	A4
4	Hazardous Material Quantity	A9 (9.9E+99)
4	Hazardous Material Quantity Units	A1

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Amending Data

If data in the data package requires modification any time after the 'shipment ready' field has been set to "Y", the shipper must notify the MIS specialist in writing, and identify all required changes and the reason(s) why those changes are necessary. The MIS specialist will then extract the shipment record data back into an active data base, that will allow replacement of the data, and identify the reason for the change(s). The host computer audit data base tracks all additions, deletions, and changes to the production data base.

Shipment Data Format

The shipper shall provide the shipment data described in Table [tbd]. A shipment is defined as one railcar or one truck.

Shipment Number

Each shipment shall have a unique number. The shipment number consists of a two digit alpha code identifying the shipping site, followed by the last two digits of the shipping year, and the next four consecutive digits represent the shipment number for the site.

Shipment Date

The 6-digit shipment date is entered in YYMMDD format.

Vehicle Type

The vehicle is either "R" for railcar or "T" for truck.

Shipment Certification Date

The shipment certification date is the date when the entire shipment was certified to transport as opposed to the dates of individual canister certification, or actual transit date.

Cask Type/Number

For each waste package, the shipper shall provide an x-character alphanumeric identifier of the cask or container used to transport the shipment.

Approved Payload Compliance Certifier

The name of the official who certified that shipment requirements were met shall be entered as follows: last name, first name, and (if available) middle initial.

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Waste Package Data Format

The shipper shall provide the waste package data in the format specified (found in Table 1) for each canister in the shipment

Package ID Number

Each canister shall have a unique package identification number. This number will consist of a 2-letter site identification (alpha) code listed in Table 1 followed by the 11-character (maximum) numerical package identifier.

Container Code

A 3-digit code shall be entered to identify the type of canister used. The codes listed in Table [tbd] are the containers currently approved for use. Any container not on the approved list must first be certified as acceptable; only then will an approved container code be issued to the shipper.

Shipment Number

The shipper shall assign a unique shipment number to each shipment. The shipment number consists of the 2-letter shipping site identification code specified in Table 1, followed by the last two digits of the year of transport to the repository, and the next consecutive 4-digit shipment number from that site.

Closure Date

The shipper shall provide the date when the waste container was closed in a YYMMDD format.

Cask Type/Number

For each waste shipment, the shipper shall provide a four-character alphanumeric identifier for the cask or other container used to transport the shipment.

Package Certification Date

The date when the certifying official signed the certification statement for this package shall be entered in a YYMMDD format.

Weight

Each waste canister shall be weighed, and the gross weight (in kilograms) shall be entered into the data field using scientific notation.

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Surface Dose Rate

The maximum surface dose rate reading, including the neutron contribution (in mR/hr) shall be entered in scientific notation.

Neutron Contribution

The neutron contribution to the maximum surface dose rate (in mR/hr) shall be entered if it exceeds the reportable limits as specified in Section 4.3.13 of this PWAC.

Thermal Power

The total thermal generating capacity (in watts) must be entered for all canisters. It shall be entered using two significant figures and scientific notation. If the thermal power is less than the reportable limits identified in Section 4.2.4, then the field may be left blank.

U-235 Fissile Grams (or equivalents)

The U-235 fissile gram equivalent of each waste canister must be reported if it is known to contain more than 400 gms of fissile material.

Gas Generation

The repository will retain a field for reporting gas generation rates. The numerical value (if any) shall be reported in moles/yr and entered in scientific notation.

Content Code

A content code shall be used to record the contents in each canister. These content codes will be prepared by each site as a three-digit code. Once approved in the waste package certification plan, they will be added to the host computer database as a viable code number.

Certifying Site

The site where the waste package was certified shall be identified by the 2-character site code. The repository needs this information for use with (1) the name of the official who certified the waste package, and (2) the content code to ensure the waste package is certifiable for storage within the repository.

Miscellaneous

This 30-character field is a free field for the shipper to enter additional information deemed useful or necessary for the repository.

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WAC Exception Number

If a shipper has been granted an exception to the WAC on a case-by-case basis, that exception number shall be entered into the data package.

Certification Official's Name

The name of the official who certified the waste package shall be entered as follows: last name, first name, and (if available) middle initial.

Radionuclide Data

The radionuclide fields shall be entered to reflect the curie content of each canister with regard to the radionuclide species identified in 40 CFR 191 governing release limits from the repository.

Radionuclide Symbol

The radionuclide field is a 7-character field, and data entry shall follow the format:

PU-239 (xx-nnn)

Radionuclide Quantity

Radionuclide quantities shall be entered in scientific notation to two significant digits.

Radionuclide Units

Radionuclide units of measure shall be reported as "C" for curies. Standard units for MAP (mixed activation products) or MFP (mixed fission products) shall be denoted in the same manner.

Hazardous Material Data Format

The hazardous material fields can accommodate from 0-14 different species.

Hazardous Material ID Code

Hazardous materials shall be identified by entering the 4-character code for the hazardous material present in the package. The codes can be found in 40 CFR 261, Subparts C and D. If no hazardous material is present, the field is left blank.

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Hazardous Material Quantity

Hazardous material quantities are not currently reported to the agencies that regulate the repository. If data exists to substantiate an actual hazardous material quantity, then the generator should report that quantity for future information purposes. Entering a 0.0E+00 in this field (in conjunction with an ID code entry) signifies presence of a material in an unknown or unmeasured quantity.

Hazardous Material Quantity Units

All hazardous materials will be entered in gram quantities in scientific notation to two significant digits.

DATE

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8/17/94

END