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Waste Form Product Characteristics

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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 1992 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 m^3 calcine and a total inventory of 7600 m^3 of radioactive liquids (1900 m^3 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) Sec.8,(b) para(3)) [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 put into 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 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 . Treatment of liquid wastes now 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 and 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. Continued operation of the New Waste Calciner Facility (NWCF) for calcine production and storage is based on a letter from the State of Idaho concerning compliance with land disposal and storage restrictions (LDR). The relief in that letter is contingent on DOE's continued good-faith negotiations to establish treatment facilities for its wastes. Ultimately, there will be a need to provide facilities to treat 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 identification of a geologic disposal site.

Determining a proper direction for the development program and a basis for future waste form evaluation suggested the need for Preliminary Waste Acceptance Criteria (PWAC). A WAC normally would be the responsibility of the repository operator; however, since a repository for all of the INEL wastes has not been identified, the SF&WMTDP developed a PWAC to guide technology development. In 1993, this PWAC was written to define the waste package characteristics and criteria necessary to assure compliance with applicable regulations and DOE orders.

This Waste Form Product Characteristics (WFPC) document extracts the waste form/package details from the earlier PWAC. Performance of waste form/packages, while dependent on the geologic media, do not depend on the extraneous details found in a WAC, which is the sole province of the repository operator. The intended nature of this document is to capture the detailed findings of the PA work and provide information toward the development of waste forms/packages that are predicted to meet regulatory release limits for radionuclides in certain geologic media. To confirm that the established criteria are sound and have a high probability of meeting these requirements, performance assessment (PA) studies were conducted by constructing computer models of waste form placement in hypothetical repositories. The characteristics of the various repositories used in the PA model(s)and identified in this document reflect known, or in some cases generic, attributes or set of conditions known to occur in a given type geology.

Note: *A performance assessment is an internationally accepted method required by the Code of Federal Regulations (CFR) to analyze engineered disposal systems for proper isolation of radioactive waste. PA's quantify aspects of waste disposal decisions by identifying and examining the effects of various processes and events on the performance of the disposal system and estimating the cumulative releases of radionuclides and hazardous materials as agreed with appropriate regulatory agencies. For further details concerning the PA for INEL materials, please refer to the "Initial Performance Assessment of the Disposal of Spent Nuclear Fuel and High-Level Waste Stored at Idaho National Engineering Laboratory - Vol 1 & 2" (SAND93-2330 [published 12-93] and " Performance Assessment of the Disposal in Unsaturated Tuff of Spent Nuclear Fuel and High-Level Waste owned by U.S. Department of Energy - Vol 1&2" (SAND94- 2563-1[to be published 1/95]).*

Throughout the SF&WMTDP, various program documentation (i.e., planning, technical development, and implementation documents) will be developed and distributed to identify and present program criteria, plans, reports, etc. This document is one of several technical development documents required to support the INEL SF&WMTDP Program. The preparation of the WFPC fulfills an agreement between DOE and the State of Idaho that identifies waste form(s) and options that would be followed by DOE in preparing the materials for final disposal. It also identifies the allowable characteristics a waste form must have to meet current regulatory requirements associated with geologic waste disposal.

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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, granite, or tuff) 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 satisfied[1,2], 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 along 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, Sandia National Laboratories (SAND93-2330) December 1993.

2 Reference: Chapter 4. "Hypothetical Disposal Systems in Geological Media", Proposed Description of the Geological Barrier Surrounding Tuff Repositories (draft), Sandia National Laboratories (SAND94-xxxx) December 1994.

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 ($CaSO_4 \bullet xH_20$), anhydrite ($CaSO_4$), limestone ($CaCO_3$), and dolomite ($Ca \bullet Mg(CO_3)_2$). 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 waste package with negligible risk of criticality . One disadvantage is the increased corrosion rates of typical waste package materials in a salt environment. While water migration toward a heat source in a salt repository has been postulated, modelling to date indicates a water enhanced corrosion reaction is actually deficient of water.

Granite Repository

Igneous rock formations such as basalt, granite, or tuff offer favorable 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 a presumed 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 presence and accumulation is a significant concern due to moderation when dealing with HEU materials.

Tuff Repository

The potential repository at Yucca Mountain is in a devitrified, partially saturated, welded tuff. Work to date suggests that it has a mean matrix porosity of 14% and a mean water saturation of 65%. Therefore, the rock mass consists of host rock with pore spaces filled with air and water. The repository area is 300 m below the surface and ~200 m above the water table.

3.0 Responsibilities/Organization

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 initiate any arrangements for individual shipments.

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.*

Tuff Repository

The generic tuff repository for this PA was modeled on the site characterization of the Yucca Mountain site in Nevada. A detailed description of the characteristics for this type repository can be found in the *Performance Assessment of the Disposal in Unsaturated Tuff of Spent Nuclear Fuel and High-Level Waste Owned by U.S> Department of Energy, Volume 1: Methodology and Results.*

3.4 Waste Generation Site(s)

Waste producer 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 producer 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/RPO 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 producer 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.

3.5 Waste Acceptance (WA) Overview

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

3.5.1 WA Background

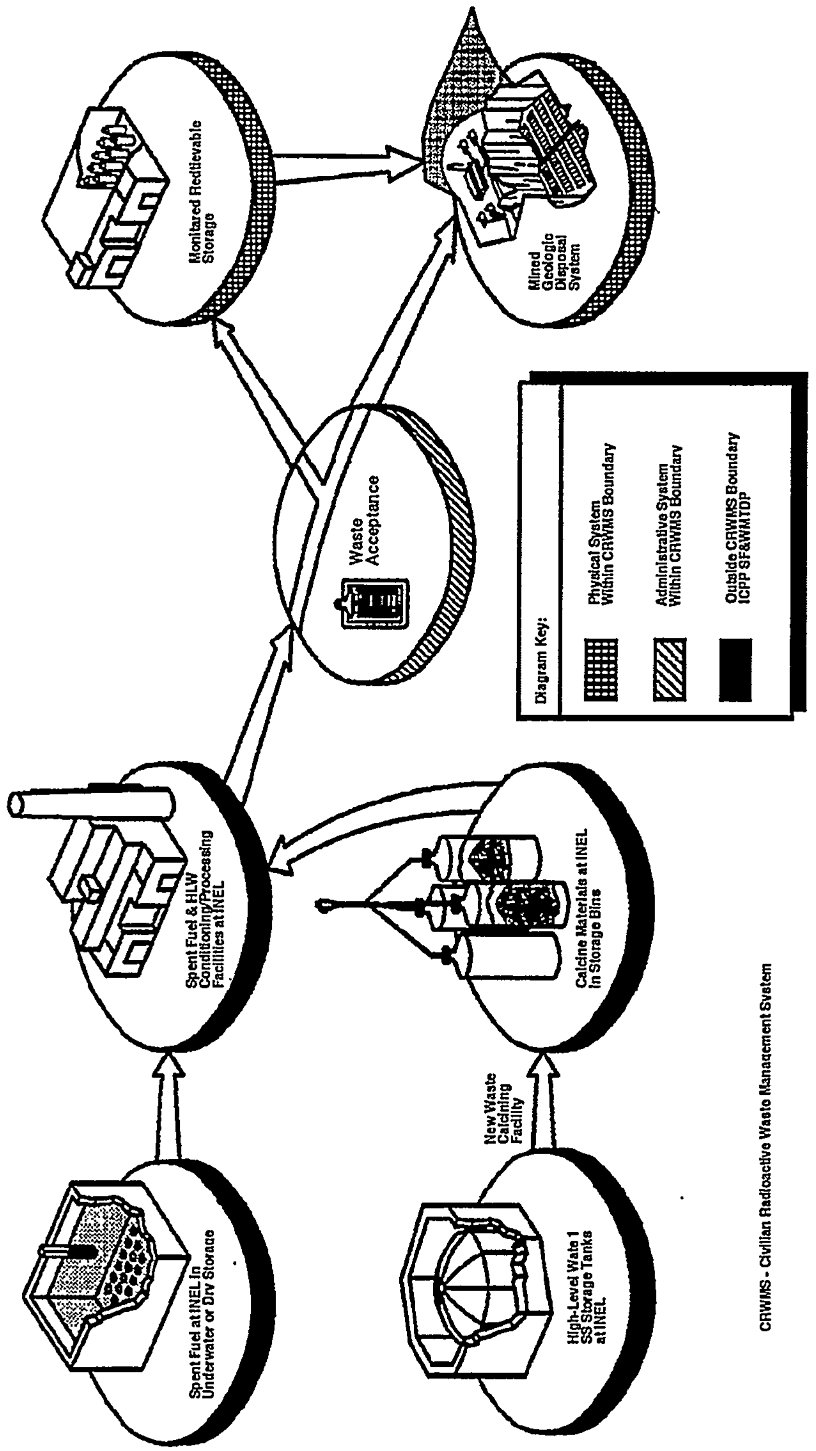
The process and the schedule for management and disposal of SNF and HLW wastes were specified initially in the NWPA (1982). Additionally, a Presidential Memorandum dated April 30, 1985, stated that there was no compelling reason to build a separate repository for defense HLW; therefore, the waste will 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 the first repository 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, or legislated relief will be sought to expand the first repository.

The NWPA defines SNF as commercial 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 NWPAA, Congress authorized the Secretary of Energy to site, construct, and operate one MRS facility. 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.

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

Figure 3.5-1
ICCP Spent Fuel and Waste Management
Technical Development Program Interface Diagram



CRWMS - Civilian Radioactive Waste Management System

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3.5.2 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 waste form accepted into the repository will be : (1) HLW immobilized in 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 associated with the MGDS 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 any stand alone 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 container and Multi-Purpose Canister (MPC) that take place in the 10 CFR 50 licensed fuel building are required by 10 CFR 71 (for transportation containers) and 10 CFR 72 (for storage containers) to have Certificates of Compliance or license. These activities include closing and sealing of the container or MPC. Nothing in this requirements document should be construed to countermand any provision of a purchaser license.

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. Approved 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 container systems. In the event some purchasers cannot use MPCs due to weight limitations, the CRWMS will maintain the capability to handle Legal Weight Truck (LWT) canisters at the MRS facility and the MGDS.

3.5.3 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.

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.

4.0 Product Criteria

4.1 Summary of Waste Acceptance Criteria and Requirements

The DOE Order 5820.2A (process of being rewritten under 5820.2B), "Radioactive Waste Management" requires that the waste producer and/or storage sites must comply with consolidated criteria and requirements for waste to be transported and placed within [**TBD**].

4.1.1 Repository Operations

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

4.1.2 Transportation: Waste Package Requirements

4.1.2.1 Ground Transport

Both producer(s) and the repository site are expected to be equipped with railhead capabilities. Any highway transport will be limited to special tractor/trailer transporters for local transport (likely) only to the nearest available railhead.

4.1.2.2 Waste package/Container System

The transport container will be designed specifically for an over-length canister (see Section 4.2.1) of the standard diameter. Non-standard waste package shipment will require producer supplied inserts to assure necessary restraint of the waste packages inside the container during transport.

Container design will require certification by Department of Transportation (DOT) personnel in addition to any other certification requirements established by DOE/NRC. Container design and testing shall consider containment under the maximum credible events for the design accident scenario. Surface exposure rates for loaded containers shall not exceed 200 mR/hr on any package surface, from any source. [10 CFR 71]

4.1.3 RCRA Requirements

Radioactive waste, that is also RCRA hazardous, is designated mixed waste and is subject to dual regulation under the Atomic Energy Act (AEA) and RCRA. Where defense wastes contain hazardous materials, they will be regulated under RCRA. A 'path forward' relating to treatment and handling of mixed hazardous wastes associated with nuclear facilities is depicted in Figures 4.1.3-1 and 4.1.3-2 for HLW and spent fuels respectively.

Future regulatory requirements, as applicable to this WFPC, 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. Producers 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 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. State regulations may vary.

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Figure 4.1.3-1 GENERAL RCRA REGULATORY ISSUES FOR HLW (GLASS AND/OR GLASS-CERAMIC)

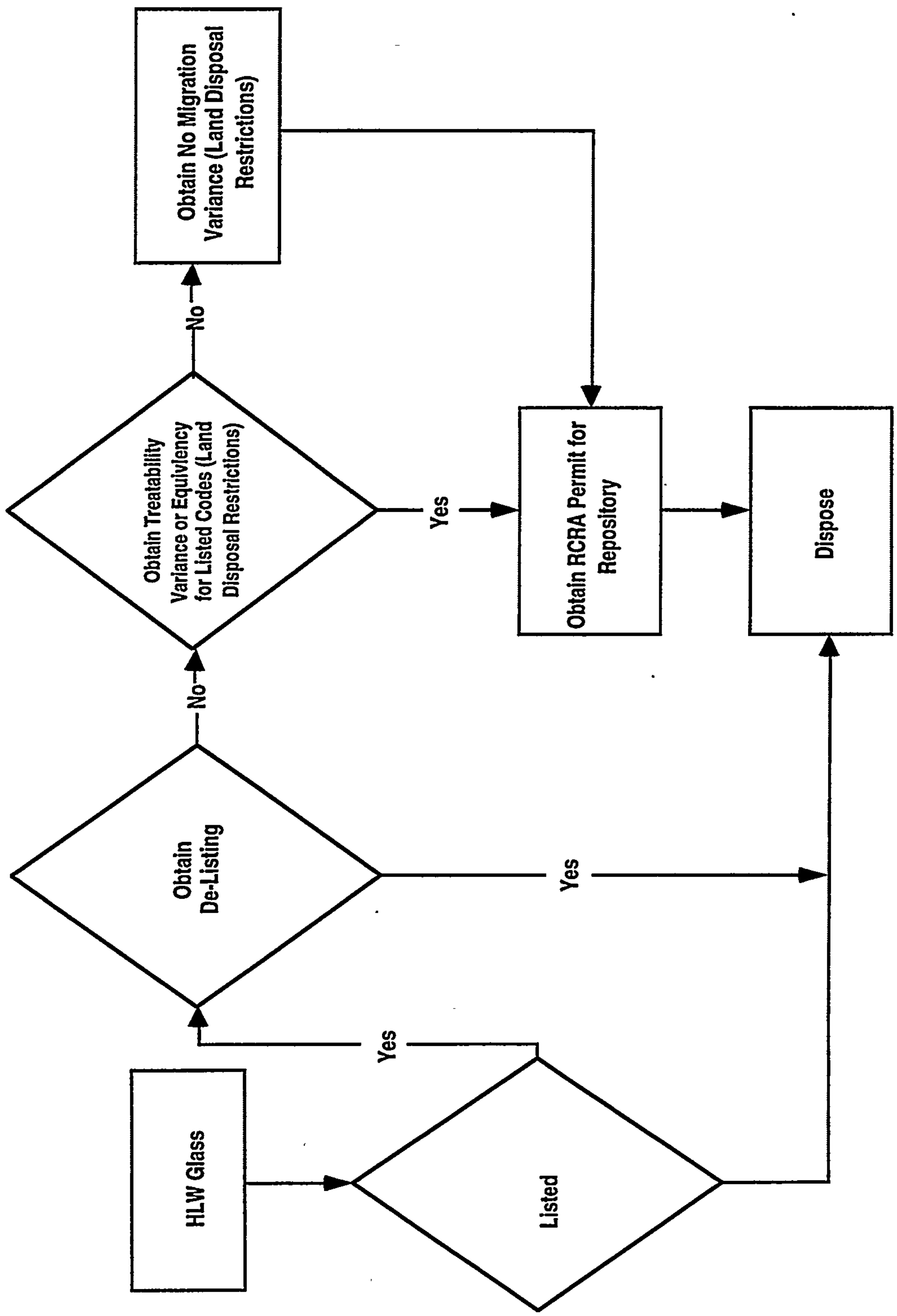
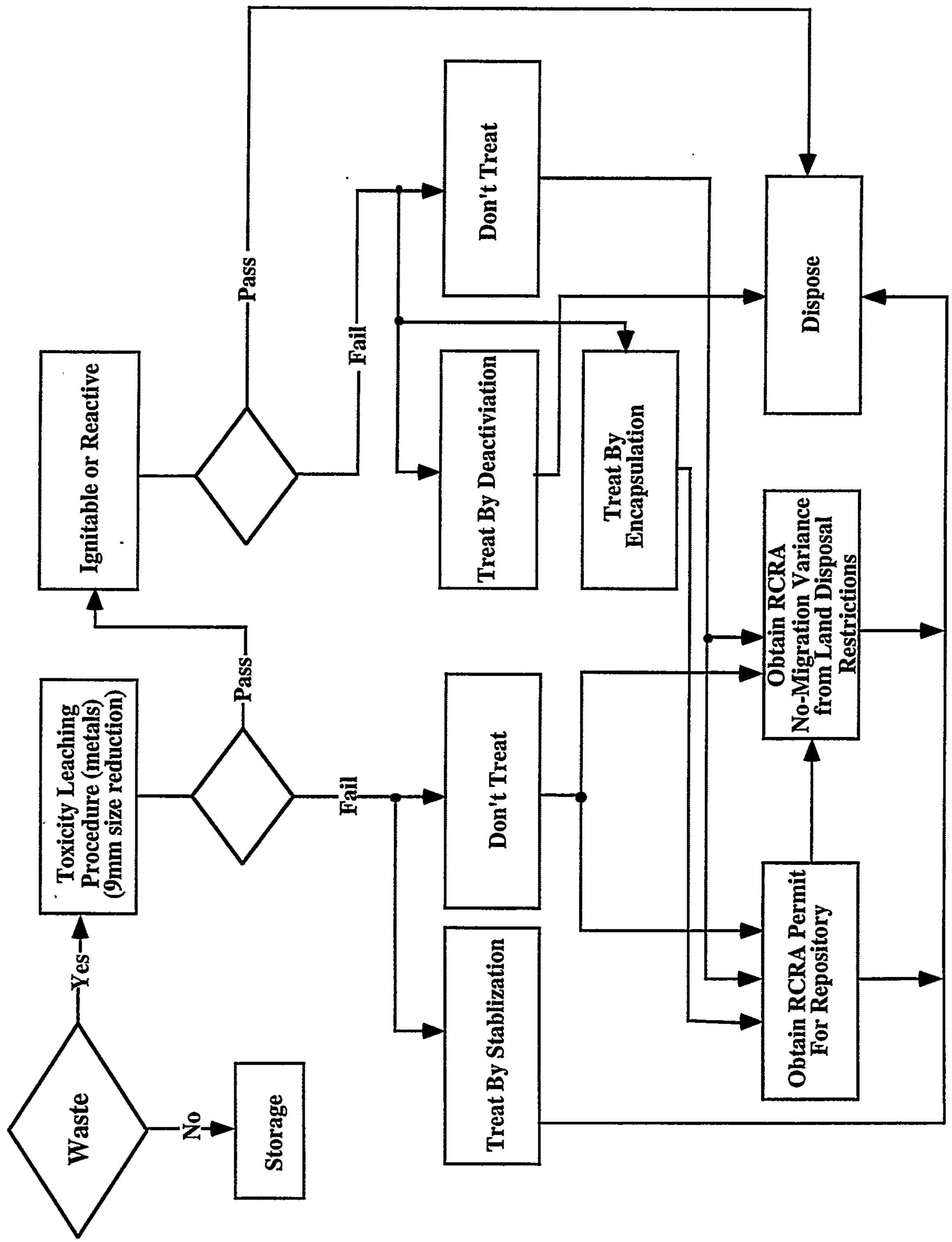


Figure 4.1.3-2 General RCRA Regulatory Issues for Spent Fuel



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4.1.4 Performance Assessment Criteria

Performance Assessment Criteria characterize the 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.

For waste generated and/or shipped from storage, one or more of the following requirements 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 Packaged Waste Criteria

4.2.1 Materials Considerations

The canister material shall consist of 304L stainless steel Material composition and construction, when installed in conjunction with an engineered barrier system (EBS) will be such that waste package integrity is guaranteed to meet the 50-year retrievability requirement following permanent closure of the Mined Geologic Disposal System (MGDS).

4.2.1.1 LWT Canister (proposed)

The Legal Weight Truck Canister (LWT) construction will consist primarily of varying-thickness layers of Incoloy 825 and 516 carbon steel. See Figure 4.2-1.

The 25-ton LWT is designed to contain 4 PWR or 9 BWR fuel assemblies, but the waste package length and fuel support structure (FSS) configuration can be changed to handle a variety of fuel dimensions. Instead of a cylindrical geometry, the LWT will have a square cross section with each side being 47 cm as shown in Figure 4.2-1. The square geometry allows higher packing

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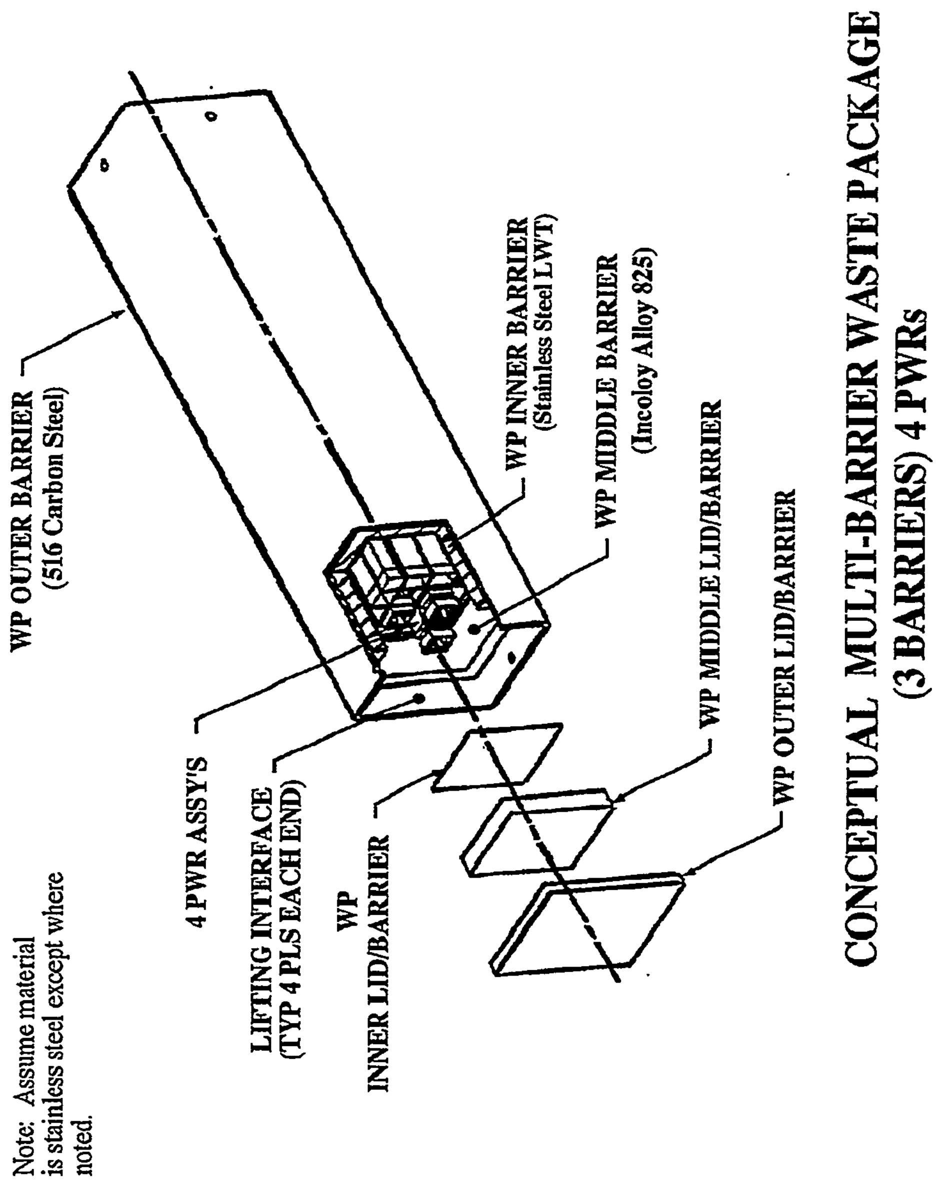


Figure 4.2-1
Legal Weight Truck (LWT) Canister

densities and increased efficiencies for weight and volume limited systems, which further improve the economics. The waste package has a welded, shielded closure which includes a grapple and fill and vent openings. The bottom shielded end has a drain opening. The waste package will use a basket or FFS containing neutron absorbers to maintain nuclear subcriticality. The waste package will enable the use of material filler for final disposal of Spent Nuclear Fuel (SNF).

4.2.1.2 MPC Canister (proposed)

The MPC construction will consist primarily of varying-thickness layers of Incoloy 825 and 516 carbon steel. See Figure 4.2-2.

MPC internals will be customized to accommodate the requirements of the individual waste components being loaded into the larger container.

The basic characteristics of a 125 ton MPC disposal container are:

1) Drift emplacement
2) Multi-composition metallic barriers
3) May attempt to minimize ionizing radiation from the SNF
4) Filler materials as buffers an/or barriers
5) May take advantage of drift backfill performance.

The Multi-Purpose Canister (MPC) concept is a set of SNF assemblies or HLW canisters inside a package or may be a set of individual sealed SNF canisters bundled into a disposal container as shown in Figure 4.2-2. In either case, the packaged waste would be placed in a containment barrier at the MGDS for final disposal. Figure 4.2-2 shows the MPCs as they would be received at the MGDS, before the final containment barrier is installed.

MPCs are relatively thin-walled packages designed to provide a relatively clear outer surface for handling SNF. From the perspective of the MGDS, the point at which the

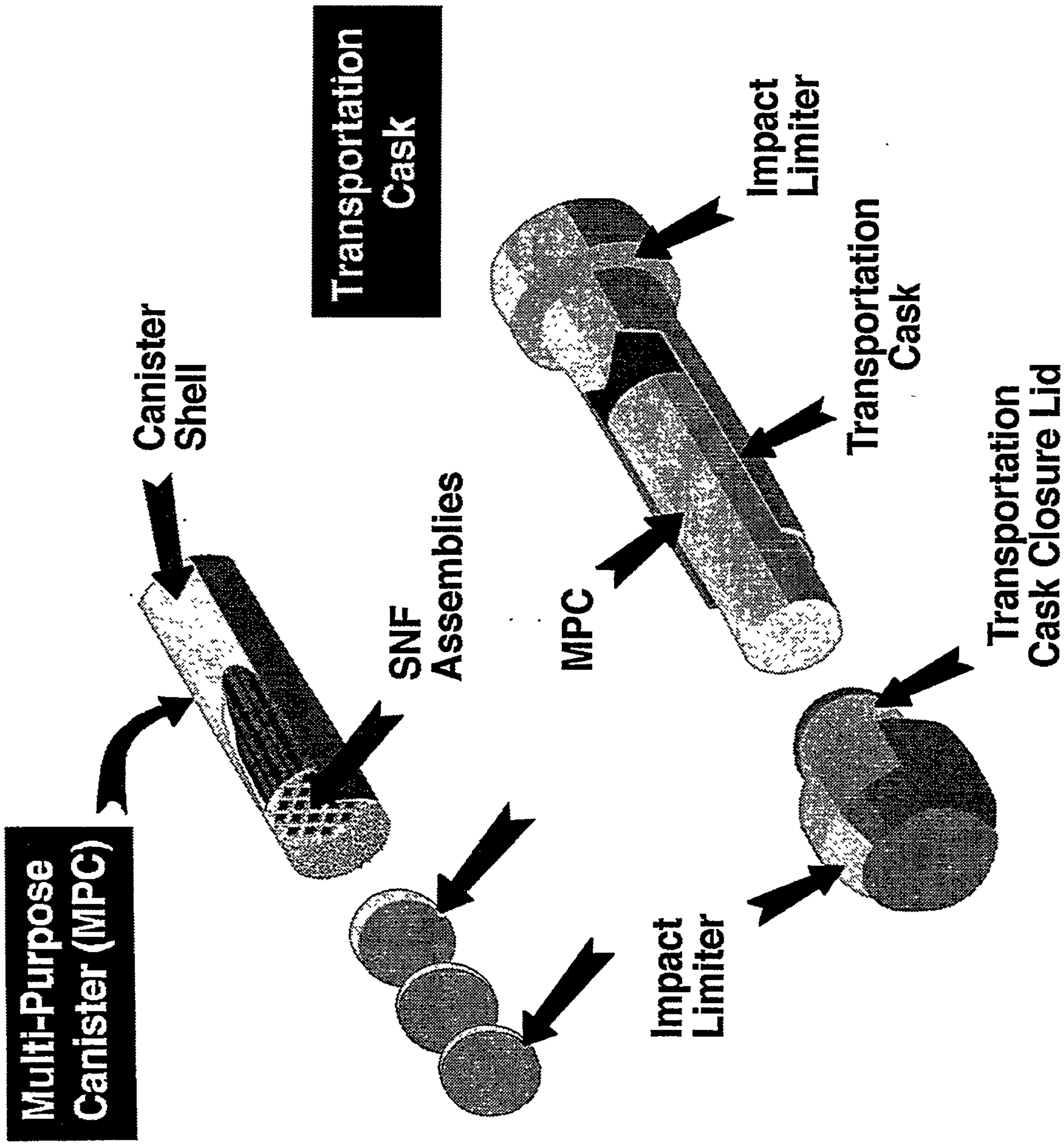


Figure 4.2-2
Multi-purpose Canister (MPC)

MPCs are loaded is not as important as how the 'Universal Basket' or 'Kernel' (EPRI terminology) is designed and fabricated. The MPC acts like a universal SNF basket. The universal basket may be part of an on-site dry storage device, then loaded into a transportation overpack and shipped to the MGDS. For the MGDS to accept a universal basket, the sealed thin-walled basket must provide neutron criticality control, per Title 10 CFR 20, 60, 71, and 72.

Ensuring that the MPC has long term performance credit is important to the success of the MPC design. The MPC basket will be overpacked at the MGDS surface facilities. Depending on the size and constance of the as-received MPC the dose rate at the surface of the overpacked MPC will vary. The MPC is anticipated to provide no shielding. Filler materials inside of the MPC may be part of the MPC design.

4.2.2 Canister/Waste Package Weight

4.2.2.1 An individual waste (HLW) canister w/o overpack or super-canister construction shall not exceed a weight of 6 metric tons.

4.2.2.2 A loaded waste package/shipping container combination shall not exceed 125 metric tons.

4.2.3 Canister Configurations

The recommended size of a standard canister size is 61 cm (+1.5 cm, -1.0 cm) O.D. and 300 (+5.0 cm, - 20 cm) in length. See Figure 4.2-3. Typical canister materials will consist of 304L stainless steel. This also applies to structural internals (for fuel compartments) within larger containers. Allowances for other materials will be considered on a case-by-case evaluation and approval by the repository.

Overall size of a canister shall not exceed an outer diameter of 62.5 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. Under no circumstances may a canister exceed 458 cm in overall length.

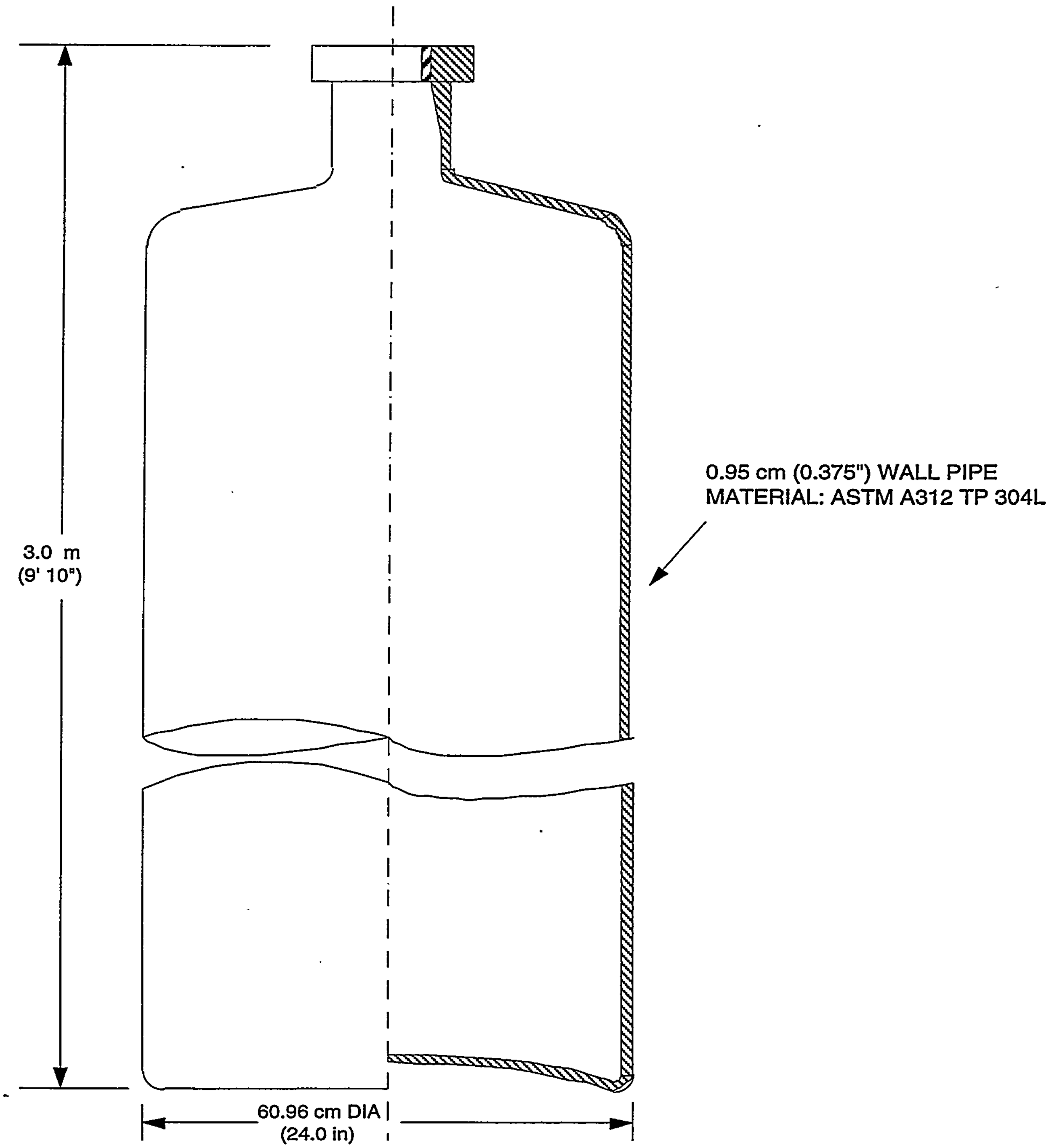


Figure 4.2-3
Standard HLW Canister

4.2.3.1 Vertical Placement

Typical individual waste package placement will rely on placement within vertical boreholes in the various drifts within the repository.

LWT's may be oriented in either a vertical or horizontal position. A horizontal orientation implies merely 'parking' the waste package in the drift rather than placement in a vertical borehole.

4.2.3.2 Horizontal Placement

MPC's are limited to this orientation due to handling/transport issues within the confines of the repository drifts.

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.

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 4.2.8 for specific details).

4.2.4 Heat Generation

There are two thermal limits for decay heat within the repository: 1) the total heat from the radioactive decay of the radioisotopes within an individual waste package and 2) the total decay heat from all waste packages within the repository itself.

The thermal power generated by the waste materials in any single waste package shall be calculated based on the known contents and shall not exceed **[TBD]** watts without approval from the repository operators; that information is to be included in the data package. Additionally, the waste package design must provide for a heat flow rate per unit (external surface) area of **[TBD]** cal/sec$\cdot$m^2. [NOTE: this value will be repository specific.] In determining whether or not a waste package or group of waste packages meets the established limits, any error or measurement uncertainty must be added to the calculated value.

The calculated maximum allowable heat generation rate of less than **[TBD]** watts per typical waste package will allow for a small number packages generating the maximum watts without exceeding the design heat load of the repository. The producer must check with the repository to determine the allowable percentage of waste packages with maximum heat output that can be accommodated.

4.2.4.1 SNF

The producer of the packaged SNF must certify that multiple fuel elements in a single waste package (if allowable by criticality calculations for the repository) will not be affected by a heat buildup within the waste package to unacceptable levels, e.g. cladding damage, fission product migration while in storage at the producer site.

4.2.4.2 HLW

The producer of glass 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/convection, heat capacity, canister spacing.

4.2.5 Temperature Limits on Waste Forms

4.2.5.1 SNF

SNF should be packaged such that when the fuel package and its thermal output, taken in conjunction with the MPC, any overpack, and the characteristics of the geological environment, shall not allow contents of an MPC to exceed mean temperatures for the following listed fuels:

aluminum clad	150°C [200°C max]
zirconium clad	340-380°C
stainless steel clad	350°C
graphite	<800°C

4.2.5.2 HLW

HLW [either as borosilicate glass or glass- ceramic] should be packaged such that when the glass canister and its thermal output, taken in conjunction with the MPC, any overpack, and the characteristics of the geological environment, shall not allow the centerline temperature of an HLW canister in an MPC to exceed 400°C.

4.2.6 Allowable Void Space

4.2.6.1 SNF

Salt Repository

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

Granite Repository

No void space filler is required in a granite type repository unless the material is need for criticality safety, either through water exclusion or neutron adsorption.

Tuff Repository

Use of materials to fill void spaces in the spent fuel packages is generally not prescribed unless such materials are needed for assurance of criticality safety and will remain uniformly distributed through the fissile mass within the waste package.

4.2.6.2 HLW

The producer shall fill the canister to a minimum of 80% (by volume) of the empty canister and the producer shall report the actual percentage in the production records.

4.2.7 Package Labeling

4.2.7.1 Waste Package Labeling

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

4.2.7.2 Label Information

Each waste package 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.

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 waste package.

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

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

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

g) The label must be an integral part of the waste package, remaining legible for a period of 50 years under the anticipated conditions for interim storage prior to repository emplacement.

4.2.8 Waste Package Handling Features

Salt Repository **Granite Repository**

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 containers.

b) The producer shall supply the repository with a working duplicate of the pintle grappling 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.

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

Tuff Repository

Design features of any waste package are intended to provide a simple, standardized method for movement of the package during shipping and storage/repository operations. The package design shall utilize the MPCs identified for use in the disposal of commercial SNF and HLW.

4.3 Form Criteria

4.3.1 Solids

All radioactive waste shall be in a solid form.

4.3.1.1 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 and 10 CFR 60, 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 0.90 mm minimum wall thickness.

- or -

Fuel elements that are relatively small compared to larger PWR-type elements may use single cans to package multiple elements to simplify handling.

4.3.1.2 HLW

a) standard form

Material treatment/processing will convert all HLW materials into non-dispersible 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 waste package, for any package(s) shipped to the repository.

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 contributing to internal corrosion of the waste package.

4.3.2.1 SNF

SNF that was formerly stored and/or loaded into a waste package within the confines of a wet-storage environment must qualify the fuel loading procedure to demonstrate the ability to provide a sealed containment of the fuels with a residual liquid content of less than **[TBD]** % in the package at time of closure.

4.3.2.2 HLW

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 **[TBD]** % exists within the canister at time of closure.

4.3.3 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 waste package may be pyrophoric forms of radionuclides, and these shall generally be dispersed in the waste package.

4.3.4 Chemically Reactive Species

Waste form shall not contain chemically reactive materials which can create phase volume changes in an amount that could compromise the waste package or the repository's ability to satisfy the performance objectives.

4.3.4.1 General - All Waste Forms

a) Chemical Composition

The producer shall provide records indicating the chemical composition and crystalline phase projections for the waste form.

b) Chemical Compatibility

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

c) Waste Form - Container Compatibility

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

4.3.4.2 SNF

Acceptance of SNF in a repository requires identification of specific materials integral to the fuel elements or assemblies/subassemblies. Characteristics such as cladding (Zircaloy®, aluminum, stainless steel), fuel metal matrix (carbide, oxide, hydride, metal), or others (sodium, cadmium, asbestos) are needed for waste characterization in PA analysis and potential retrieval concerns.

4.3.4.3 HLW

Acceptance of HLW forms from any producer shall be contingent on reporting the composition of the waste form for oxides of elements present in concentrations greater than 0.5% by weight, and estimating the error bounds of the composition.

4.3.5 Neutron Absorbers

Salt Repository

Neutron absorbers are not required in a salt repository environment unless the fissile material loading per waste package exceeds the prescribed limit identified in Section 4.3.6.1.

Granite Repository

Neutron absorbers are not required in a granite repository environment unless the fissile material loading per waste package exceeds the prescribed limit identified in Section 4.3.6.1.

Tuff Repository

Use of neutron absorbers within SNF packages will be allowed to the extent it is 'fixed' in a matrix that: (1) assures uniform distribution throughout the fuel array within the MPC, (2) prevents or protects against redistribution within the MPC, and (3) meets regulatory requirements with respect to RCRA.

4.3.6 Criticality Safety

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

The waste package content shall remain subcritical under all credible conditions likely to be encountered at the producer's site, including any interim storage array, where two independent barrier failures must occur before a criticality can be achieved. The calculated effective neutron multiplication factor, k_{eff}, must be shown to be less than 0.95 (at initial package loading) 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.

4.3.6.1 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 no greater than 10.0 kg FGE U-235. This restriction is based on water exclusion as one of two barriers against criticality (the other being spacing).

Granite Repository

Canister packages may contain no greater than 700 grams FGE U-235. This restriction is based on mass limit as one of two barriers against criticality (the other being spacing).

Tuff Repository

It must be proven that the waste package will remain critically safe for **[TBD]** years by accepted methods such as Probablistic Risk Assessment (PRA) and established computer codes. This requirement is based on the presumption that water cannot be excluded from the repository.

4.3.6.2 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 HLW package, to an equivalent mass of U-235 for purposes of criticality calculations.

4.3.7 Safeguards and Material Accountability

SNF materials with greater than 20% U-235 enrichment that is packaged for disposal in a geologic repository must include documented accountability of fissile materials. Packaging such materials must provide for tamper resistant seals and security controls (including possible inspection) up until the time of emplacement in a repository.

International Atomic Energy Authority (IAEA) safeguards may be invoked commensurate with the amount, form, and enrichment of materials destined for geologic disposal.

4.3.8 Solubilities

4.3.8.1 SNF

Fuels need not typically be (re)packaged before insertion into the waste package unless it is a designed portion of the package into which the fuels will be placed.

4.3.8.2 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.

4.3.9 Leach Rates

Wastes containing any metallic radionuclides are to be treated with a validated process that either renders the material less leachable or disperses and binds it within an inert matrix.

4.3.9.1 SNF

Allowable specific leach rates for radionuclides from SNF are based on the combined barriers provided by the assumed fuel element matrix itself leachrate, along with any cladding and waste package barrier failures.

4.3.9.2 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, currently established @ 1.0 gm/m^2-day.

The measured or calculated mean results for cationic leachate from 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.

4.3.10 Corrosion

304L stainless steel will be used extensively for waste package and components construction as corrosion models indicate that material will resist damage within a typical repository environment necessary to achieve the 50 year retrievability limit. Special situations may suggest the use of materials with greater corrosion resistance such as Incoloy® 825.

4.3.10.1 SNF

Credit for corrosion resistance of spent fuels may be granted based on the type or condition (intact) of the fuel cladding; this condition may obviate the need to perform additional canning.

4.3.10.2 HLW

Corrosion resistance of the HLW canister is more to meet the 50-year retrievability requirement than the protection of the BDAT waste form against leaching.

4.3.11 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 waste package and/or its overpack, or due to the radiolysis of water, are acceptable where it can be demonstrated that neither explosive conditions nor accelerated transport of materials are promoted within the repository.

4.3.12 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] Canister design will protect against collapse for full immersion pressures up to 3.5 MPa.

Tuff Repository

The repository will be at atmospheric pressure due to the porous nature of the rock, to the extent that barometric pressure fluctuations are expected to affect the flow and transport. Waste package design will protect against collapse for full immersion pressures up to **[TBD]** MPa.

4.3.13 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.

4.3.14 Surface Dose Limits

The waste package 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.

4.3.15 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 (by either mass or curies) 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 waste package, 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 waste package and each type of waste. The error associated with these individual estimates will be reported in the WQR.

4.3.16 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.

4.3.17 Inert Gases

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

4.4 Waste Container/Transportation

[NOTE: Development of details relative to container 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]

4.4.2 Container 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 Characteristics

[NOTE: much of the information to be included in Section 4.5 will be dependent on the results of the calculations associated with the performance assessment specific to the repository.]

4.5.1 Total MTIHM

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

[NOTE: the capacity of the repository will be determined at some point in the future based on more current estimates of the quantity 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 (e.g. borosilicate glass, encapsulated SNF), waste package type (e.g. material, thickness, overpack), and container 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 vertical boreholes in the drift.

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

Tuff Repository

Waste package disposal will consist of horizontal emplacement within the various drifts. Package density within the repository is set at **[TBD]** MTU/acre.

4.5.4 Ground Water Releases

The containment requirements (40 CFR § 191.13) set probabalistic limits on cumulative releases of radionuclides beyond the "controlled area" (defined in the regulations as a surface location that encompasses no more than 100 km^2 and extends no more than a 5-km radius from the outer boundary of a radio-active waste disposal system, plus the underlying subsurface for 10,000 years after disposal).

Typically, these release limits apply to all forms of radionuclide release; here they are limited to discussions relative to ground water transport only.

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 (intermittent) ground water flows shall should not be capable of reaching the defined repository boundary within 10,000 years with radionuclides in excess of the prescribed release limits.

Tuff Repository

While water exclusion for the selected site is a primary siting criteria for a nuclear waste repository, the presence of water is a considered variable that at some time in the future may affect breach of a waste package and transport of material from the repository. The primary source of water will likely occur from climatological (wetter) changes, and the resultant water percolation from above.

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 suitable for a salt environment may be utilized to identify specific canister locations at time of placement in the repository.

Granite Repository

Shield plugs installed in the individual bore holes will be number-indexed against a plan drawing of the drift.

Tuff Repository

Repository drawings will reflect surveyed placement points for all drift emplaced packages.

4.5.6 300-1000 Year Waste Package Integrity (10 CFR 60)

Salt Repository

[NOTE: Accelerated corrosion rates in a salt repository will breach 304L stainless steel within a 1000 year time frame. However, retarded radionuclide transport behavior in a characteristic salt repository obviates the need for a more robust waste package design.]

Granite Repository

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

Tuff Repository

The layered design of the MPC is intended to assure waste package integrity through the first 1000 years in a post-closure repository environment.

4.5.7 10,000 Year Releases (40 CFR 191)

Salt Repository

Performance assessment indicates radionuclide transport will fall below current regulatory limits in the hypothetical salt repository for the forms and materials specified within this document.

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 prior to defining actual criteria.]

Tuff Repository

Performance assessment indicates radionuclide transport will fall below current regulatory limits in the tuff repository for the forms and materials specified within this document.

4.6 Other Criteria

4.6.1 Waste Package Fabrication Reporting

[TBD]

4.6.2 Waste Package After Closure

After closure, the waste 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. Any cover gas shall be argon or helium.

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

4.6.3 (HLW) 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, cylindrical cavity (64 -0.5+1.0 cm in diameter and 310 ± 3.0 cm in length).

4.6.4 Surface Contamination on Waste Package

The levels of removable (smearable) radioactive contamination of all external surfaces of each waste package shall not exceed 220 dpm/100 cm^2 for alpha radiation and 2200 dpm/100 cm^2 for beta and gamma radiation.

The producer shall inspect each waste package and remove visible debris from the exterior surface prior to shipment.

4.6.5 Consistency Test

4.6.5.1 SNF

The producer shall demonstrate control of waste package 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 m from the exposed fuel element.

4.6.5.2 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.

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 waste form using "Toxicity Characteristic Leaching Procedure" (TCLP) described in 55 Federal Register 26986, 6/29/90 or other approved test. 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 Performance

The canister package shall be tested and qualified to 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 Supporting Documentation

5.1 Records

5.1.1 Waste Form Compliance Plan (WCP)

The WCP shall describe the producer's plan for demonstrating compliance with each requirement in the Waste Acceptance - System Requirements Document (WA-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.

5.1.2 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.

5.1.3 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.

5.1.4 Storage and Shipping Records

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

5.1.5 Waste Package Annual Report

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

5.1.6 Product Specification

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

5.2 Certification & Waste Form Approval

It shall be the responsibility of the producer to qualify the waste form generated in the 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].

5.3 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
DOE 5820.2A I.3.b(7)(a)
40 CFR 262.41(u)(6)(b)(7)
40 CFR 262 Appendix
40 CFR 264.75(h)
40 CFR 264.75(i)
40 CFR 264.73(b)(9)
40 CFR 265.75(h)
40 CFR 265.75(i)

6.0 Qualification/Quality Assurance

6.1 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 producer 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.

6.2 Operations and Safety Criteria QA Requirements

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

6.3 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.

6.4 Waste Characterization Quality Assurance Requirements

The QA requirements for the waste characterization efforts at the producer 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.

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 wastes from fuel reprocessing 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.

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.

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

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

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

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

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

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

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

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

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

Engineered barrier consists of backfill material and plugs in the boreholes, overpack, the waste package, and waste form itself.

Engineered barrier system (EBS) means the waste packages and the underground facility. [§ 10 CFR 60.2]

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

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

Fissile gram equivalent is the number of grams of fissile material of a given fissile species that it takes, on an equivalent basis comparison to U-235, to form a critical mass.

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

Free liquids are those liquids which would form a pooled collection of solution (by visual observation) of that which might drain from an inverted package.

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

Glass-ceramic material formed with a combination of calcine and flux material in the Hot Isostatic Press (HIP) or other processes. It consists of merging crystalline and intergranular amorphous phases.

Glass transition temperature is the temperature above which a glass crytalizes. Below this temperature, the viscous flow or molecular rearrangement in glass is negligible.

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

Heavy Metal encompasses all uranium, plutonium, or thorium placed into a nuclear reactor. [§ 40 CFR 191.12]

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

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

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

Legal Weight Truck Canister (LWT) is an engineered structure containing multiple fuel elements (up to 4 PWR), and is comprised of guide sleeves, spacer discs, and top and bottom shield plugs (optional) formed into a corrosion resistant stainless steel container. The container is intended for use by facilities that do not have railhead capability.

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

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

Multiple-Purpose Canister (MPC) is an engineered structure containing multiple fuel elements (up to 21 PWR) or HLW in canisters (4),and is comprised of guide sleeves, spacer discs, and top and bottom shield plugs (optional) formed into a corrosion resistant stainless steel container.

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

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

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

Overpack is that portion of the engineered barrier system installed on the waste package at the repository to complement the geologic conditions in the repository.

Performance Assessment (PA) means an analysis that: 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. These estimates shall be incorporated into an overall probability distribution of cumulative release to the extent practicable [40 CFR 191.12].

Producer is any operator of a treatment or packaging facility of high-level radioactive waste or SNF resulting from atomic energy defense activities, or any producer of vitrified commercial HLW.

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

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

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

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

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 waste packages.

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 containerized 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 waste packages 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, or the phase compositions 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 Product Specification (WAPS) is prepared by the waste form(s) producer, and it identifies the specifications that a given waste form provides to be acceptable in a repository.

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.

Waste Acceptance Criteria identifies the specific characteristics a waste must exhibit to qualify the waste for disposal in a given geologic environment.

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

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

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

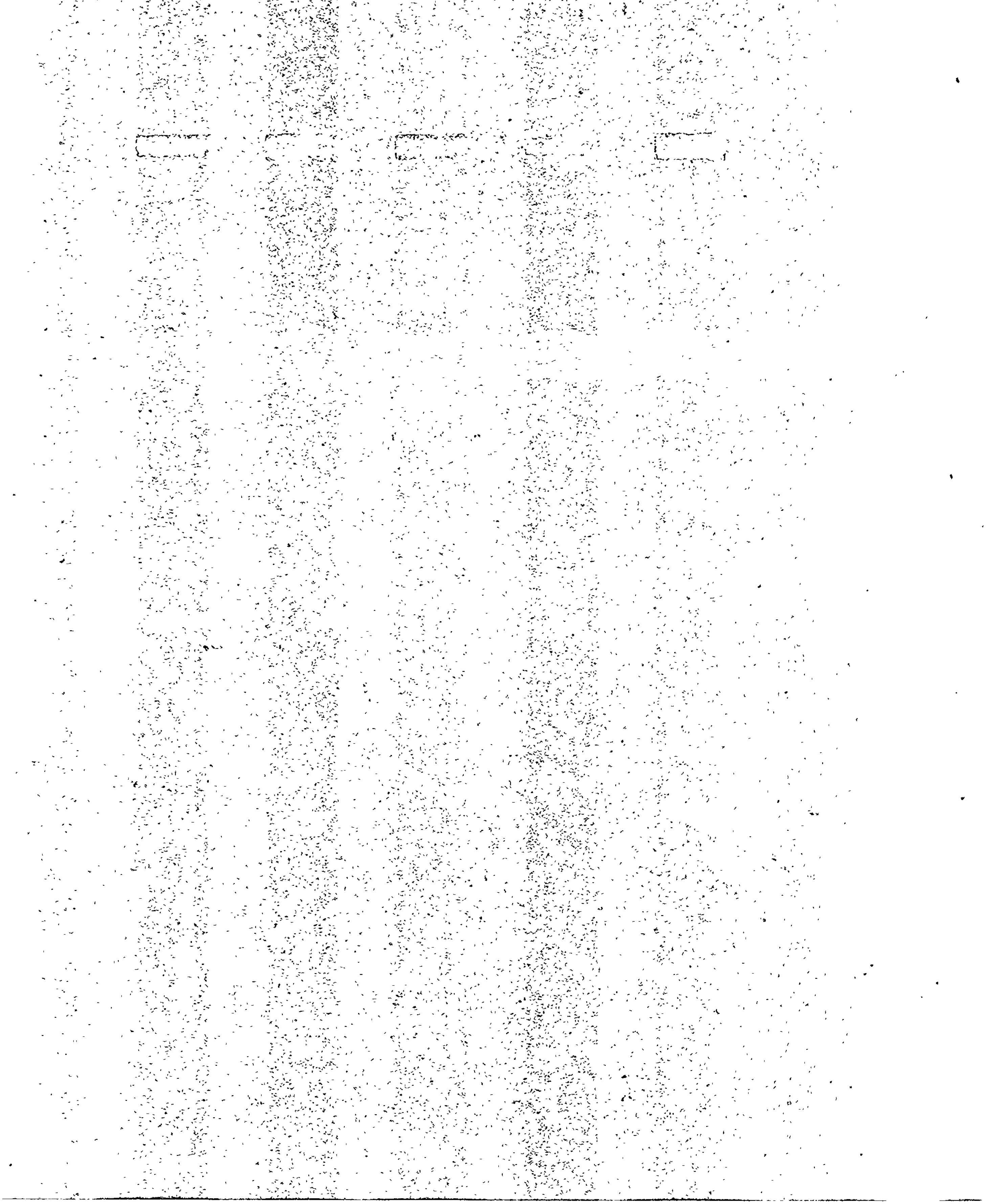
Waste Package is the waste form itself (canistered SNF or HLW) and any canisters, shielding, packaging and other absorbent materials immediately surrounding an individual waste container. [Ref. 10 CFR 60.2]

ACRONYMS AND ABBREVIATIONS

ADP	Automatic Data Processing
AEA	Atomic Energy Act
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
ASME	American Society of Mechanical Engineers
BDAT	Best Demonstrated Available Technology
BWR	Boiling Water Reactor
CCDF	complementary cumulative distribution functions
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CRWMP	Civilian Radioactive Waste Management Program
CRWMS	Civilian Radioactive Waste Management System
DCS	Delivery Commitment Schedule
DOE	Department of Energy
DOT	Department of Transportation
DP	Office of Defense Programs (DOE)
DWPF	Defense Waste Production Facility (Savannah River)
EA	Environmental Assessment
EBS	Engineered Barrier System
EM	Office of Environmental Restoration and Waste Management (DOE)
EPA	Environmental Protection Agency
FDS	Final Delivery Schedule

FGE	fissile gram equivalent
HANF	Hanford Site
HEU	highly enriched uranium (>20% U-235)
HIP	Hot Isostatic Press
HTGR	High Temperature Gas Reactor
HLW	High Level Waste
IAEA	International Atomic Energy Agency
ICPP	Idaho Chemical Processing Plant
INEL	Idaho National Engineering Laboratory
LDR	land disposal restriction
LEU	low-enriched uranium (<20% U-235)
LWT	Legal Weight Truck (canister)
MGDS	Mined Geologic Disposal System
MPC	Multi-Purpose Canister
MRS	Monitored Retrievable Storage
NRC	Nuclear Regulatory Commission
NWCF	New Waste Calcining Facility
NWPA	Nuclear Waste Policy Act of 1982
NWPAA	Nuclear Waste Policy Amendments Act of 1987
OCRWM	Office of Civilian Radioactive Waste Management (DOE)
OSTS	On-site Storage and Transfer System
PA	Performance Assessment
PCT	Product Consistency Test

PR	Production Records
PWAC	Preliminary Waste Acceptance Criteria
PWR	Pressurized Water Reactor
QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QAPjP	Quality Assurance Project Plan
QARD	Quality Assurance Requirements Document
RCRA	Resource Conservation and Recovery Act
RW	Office of Civilian Radioactive Waste Management (DOE)
SARP	safety analysis report for packaging
SF&WMTDP	Spent Fuel and Waste Management Technology Development Program
SNF	spent nuclear fuels
SRS	Savannah River Site
SDWA	Safe Drinking Water Act
TBD	to be determined
TBP	to be published
TBR	to be resolved
WAC	Waste Acceptance Criteria
WAPS	Waste Acceptance Product Specification
WASRD	Waste Acceptance Systems Requirement Document
WCP	Waste Form Compliance Plan
WFPC	Waste Form Product Characteristics
WIPP	Waste Isolation Pilot Plant



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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.

APPENDIX A

Table A-1

Cross Reference Requirements by Supporting Documents

WFPC Criteria		
SPECIFIC CRITERIA	**REFERENCE SECTION**	**SUPPORTING DOCUMENTATION**
Waste Package		
Materials Considerations	4.2.1	10 CFR 60.135(a)(1) EM-WAPS 2.1 WASRD 3.7.1.2.1.2.7
Waste Package Weight	4.2.2	WA-SRD 3.7.1.2.1.2.1 EM-WAPS 3.11.2 DOE/RW-0184
Waste Package Configurations	4.2.3	WA-SRD 3.7.1.2.1.1.2.1 EM-WAPS 3.11.2 & 2.4 DOE/RW-0184
Heat Generation	4.2.4	WA-SRD 3.7.1.2.1.2.1 EM-WAPS 3.8 49 CFR 173.442(a) 49 CFR 173.416(d&f)
Temperature Limits on Waste Forms	4.2.5	EM-WAPS 1.4.2 WA-SRD 3.7.1.2.1.2.1
Allowable Void Space	4.2.6	WA-SRD 3.7.1.2.1.2.1 EM-WAPS 3.6 DOE/RW-0184
Package Labeling	4.2.7	10 CFR 60.135(b)(4) WA-SRD 3.7.1.2.1.2.15 EM-WAPS 2.3.2
Waste Package Handling Features	4.2.8	WA-SRD 3.7.1.2.1.2.16 EM-WAPS 3.13 10 CFR 60.135(B)(3) 10 CFR 71.45 49 CFR 173.411(a-d)
Waste Forms		
Solids	4.3.1	10 CFR 60.135(C)(1) WASRD 3.7.1.2.1(A)(1)
Liquids	4.3.2	10 CFR 60.135(b)(2) WASRD 3.7.1.2.1(B) EM-WAPS 3.1 DOE/RW-0184

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Cross Reference Requirements by Supporting Documents

WFPC Criteria		
SPECIFIC CRITERIA	**REFERENCE SECTION**	**SUPPORTING DOCUMENTATION**
Explosiveness, Pyrophoricity Combustibility	4.3.3	10 CFR 60.135 (b)(1),(C)(3) 49 CFR 173(c)(d)(g)(e) 40 CFR 261 (c)(d) 49 CFR 173.418 EM-WAPS 3.3 WASRD 3.7.1.2.1(A)(3)
Chemically Reactive Species	4.3.4	40 CFR 261.23 10 CFR 60.135(c)(1) WASRD 3.7.1.2.1.2.5 & 6 WASRD 3.7.1.2.1 (C)
Neutron Absorbers	4.3.5	DOE-ID 5480.5a
Criticality Safety	4.3.6	10 CFR 71.55 10 CFR 60.131(b)(7) WASRD 3.7.1.2.1.4 EM-WAPS 3.5 DOE 5820.2A [3(b)(2)(i)]
Safeguards and Material Accountability	4.3.7	10 CFR 71.55
Solubilities	4.3.8	10 CFR 60.135(a)(2)
Leach Rates	4.3.9	10 CFR 60.135(a)(2) WASRD 3.7.1.2.1.2.13(b) DOE/EA-0179
Corrosion	4.3.10	10 CFR 60.135(a)(2) 40 CFR 261.22 EM-WAPS 3.5 WASRD 3.7.1.2.1.5
Gas Generation	4.3.11	10 CFR 60.135(a)(2) EM-WAPS 3.2 WASRD 3.7.1.2.1.2.9A
Mechanical Properties	4.3.12	10 CFR 60.135(a)(2)
Radiolysis	4.3.13	10 CFR 60.135(a)(2)
Surface Dose Limits	4.3.14	DOE/WIPP 88-020 49 CFR 173.441 WASRD 3.7.1.2.1.2.17 EM-WAPS 3.9 DOE/RW-0184

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Cross Reference Requirements by Supporting Documents

WFPC Criteria		
SPECIFIC CRITERIA	**REFERENCE SECTION**	**SUPPORTING DOCUMENTATION**
Radionuclide Inventory	4.3.15	40 CFR 191 10 CFR 60.113 WASRD 3.7.1.2.1.2.8 EM-WAPS 1.2
Organics	4.3.16	10 CFR 60.135(a)(2) EM-WAPS 3.4 WASRD 3.7.1.2.1.2.9B
Inert Gases	4.3.17	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
Waste Cask/Transportation		10 CFR 71 49 CFR 173 49 CFR 174
DOT Standards	4.4.1	49 CFR 173 Subpart I 49 CFR 174
Container Configuration		
-weight	4.4.2.1	49 CFR 173.411(b)(c)
-dimensions	4.4.2.2	49 CFR 173 Subpart I (Type A or B Cask)
-allowable dose rates	4.4.2.3	49 CFR 173.441
-surface contamination'	4.4.2.4	49 CFR 173.411(e)
Accident Criteria	4.4.3	10 CFR 71.73 DOE ORDER 5480.3 Subpart 12
Handling Criteria	4.4.4	49 CFR 174 Subpart D
Mtl's of Construction	4.4.5	49 CFR 178
Identification	4.4.6	49 CFR 172 Subpart E
Security	4.4.7	49 CFR 174.84 10 CFR 60.31(b)

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Cross Reference Requirements by Supporting Documents

WFPC Criteria		
SPECIFIC CRITERIA	**REFERENCE SECTION**	**SUPPORTING DOCUMENTATION**
Repository Criteria		
Total MTIHM	4.5.1	[TBD]
Natural Barrier	4.5.2	10 CFR 60.133(a) 10 CFR 60.133
Engineered Barrier Design	4.5.3	10 CFR 60.113(a)(1) 10 CFR 60.133(b)
Ground Water Releases	4.5.4	10 CFR 60.113(B)(2) 10 CFR 60.133(f) 40 CFR 191.16
50 Year Retrieval	4.5.5	10 CFR 60.111(a)(1)
300-1000 Yr Can Integrity	4.5.6	10 CFR 60.113(a)(1)(ii)(A)
10,000 Year Releases	4.5.7	40 CFR 960.4-1 (b)
Other Criteria		
Waste Package 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
Waste Package After Closure	4.6.2	10 CFR 60.135(c)(1) 49 CFR 173.412 WASRD 3.7.1.2.1.2.9
Waste Package at Delivery	4.6.3	WASRD 3.7.1.2.1.2.18 DOE/RW-0184
Surface Contamination	4.6.4	49 CFR 173.411(e) 10 CFR 71.87 49 CFR 173.443 WASRD 3.7.1.2.1.2.10 EM-WAPS 3.7
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

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Cross Reference Requirements by Supporting Documents

WFPC Criteria		
SPECIFIC CRITERIA	**REFERENCE SECTION**	**SUPPORTING DOCUMENTATION**
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
Can. Impact Characteristics	4.6.7	10 CFR 60.134(c)(1), (c)(2) EM-WAPS 3.12 10 CFR 71.73 C(1) WASRD 3.7.1.2.1.2.14
Supporting Documentation		
Records	5.1	EM-WAPS 5.1 & 5.8 WASRD 3.7.1.2.1.2.19 & 20 DOE/RW-0214
Cert. & Waste Form Apprv'l	5.2	[TBD]
Waste Volume Minimization	5.3	40 CFR 265.75(h & i) 40 CFR 262.41(a)(6) 40 CFR 264.75(h & i) 40 CFR 264.73(b)(9) DOE 5480.2A[3b(7)(A)]

Table A-2
Requirements Cross Reference by Other Documents

Description (Outline from WFPC)	SRS WAPS For Vitrified HLW Forms 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 Responsiblities	N/A	N/A	2.0
3.1 Interim Storage	N/A	Fig.1.1	2.6
3.2 Transportation	N/A	3.2.3.2.3	3.1.2
3.3 Geological Disposal Sit	N/A	N/A	N/A
3.4 Waste Generation Site(s)	N/A	N/A	2.6
3.5 Waste Acceptance Overview	N/A	N/A	N/A
3.5.1 WA Background	N/A	N/A	N/A
3.5.2 Major Considerations and Assumptions	N/A		
3.5.3 Radioactive Material Inventory	N/A	3.1	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	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 Material Considerations	2.1	3.7.1.2.1.2.5	3.2.1
4.2.2 Waste Package Weight	3.11.1	3.7.1.2.1.2.1 B(3)	3.4.1
4.2.3 Waste Package Configurations	3.11.2	3.7.1.2.1.2.1 B	3.2.2
4.2.4 Heat Generation	3.8	3.7.1.2.1.2.1 B(5)	3.4.6
4.2.5 Temperature Limits on Waste Forms	1.4.2	3.7.1.2.1.2.1 B(6)	N/A
4.2.6 Allowable Void Space	3.5	3.7.1.2.1.2.1 B(4)	N/A
4.2.7 Package Labeling	2.3.2	3.7.1.2.1.2.15	3.4.8
4.2.8 Waste Package Handling Features	3.13	3.7.1.2.1.2.16	3.2.3

Table A-2
Requirements Cross Reference by Other Documents

Description (Outline from WFPC)	SRS WAPS For Vitrified HLW Forms Section No.	WASRD Section No. Doc. No. WBS: 9.2.1.1	WIPP Section No. Doc. No. WIPP/DOE-069
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)	3.3.1.1
4.3.2 Liquids	3.1	3.7.1.2.1(B)	3.3.2
4.3.3 Explosiveness, Pyrophoricity, & Combustibility	3.3	3.7.1.2.1(A)(3) & (C)	3.3.3 3.3.4
4.3.4 Chemically Reactive Species	3.5	3.7.1.2.1(C) 3.7.1.2.1.2.5 3.7.1.2.1.2.6	N/A
4.3.5 Neutron Absorbers	N/A	[TBD]	N/A
4.3.6 Criticality Safety	3.10	3.7.1.2.1.2.4	3.4.2
4.3.7 Safeguards and Material Accountability	N/A	3.3.8.2.1 (C)	N/A
4.3.8 Solubilities	1.3	3.7.1.2.1.2.13(B)	N/A
4.3.9 Leach Rates	1.3	3.7.1.2.1.2.13(B)	N/A
4.3.10 Corrosion	N/A	N/A	N/A
4.3.11 Gas Generation	N/A	N/A	3.4.7
4.3.12 Mechanical Properties	N/A	N/A	N/A
4.3.13 Radiolysis	N/A	N/A	N/A
4.3.14 Surface Dose Limits	3.9	3.7.1.2.1.2.17	3.4.4
4.3.15 Radionuclide Inventory	1.2	3.7.1.2.1.2.8	N/A
4.3.16 Organics	3.4	3.7.1.2.1.1.5 C(2)	N/A
4.3.17 Inert Gases	3.2	3.7.1.2.1.1.5 C(1)	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 Container 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

Table A-2
Requirements Cross Reference by Other Documents

Description (Outline from WFPC)	SRS WAPS For Vitrified HLW Forms Section No.	WASRD Section No. Doc. No. WBS: 9.2.1.1	WIPP Section No. Doc. No. WIPP/DOE-069
4.5 Repository Criteria	N/A	N/A	N/A
4.5.1 Geological Barrier	N/A	N/A	N/A
4.5.2 Total MTIHM	N/A	N/A	N/A
4.5.3 Engineered Barrier Design	Sandia PA	N/A	N/A
4.5.4 Ground Water Releases	N/A	N/A	N/A
4.5.5 50 Year Retrieval	N/A	N/A	N/A
4.5.6 300-1000 Year Waste Package Integrity	N/A	N/A	N/A
4.5.7 10,000 yr Releases	N/A	N/A	N/A
4.6 Other Criteria	N/A	N/A	3.6
4.6.1 Waste Package 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	3.7.1.2.1.2.1	3.2.2
4.6.4 Surface Contamination on Waste Package	3.7	3.7.1.2.1.2.10	3.4.5
4.6.5 Consistency Test	N/A	3.7.1.2.1.2.13	N/A
4.6.6 Hazardous Waste Determination	1.5	3.7.1.2.1.2.12	3.13 3.5.1.3
4.6.7 Canister Impact Characteristics	3.12	3.7.1.2.1.2.14	N/A
5.0 Supporting Documentation	N/A	N/A	N/A
5.1 Records	N/A	3.7.1.2.1.2.19	N/A
5.1.1 Waste Form Compliance Plan (WCP)	5.1.1	3.7.1.2.1.2.19.1	N/A
5.1.2 Waste Form Qualification Report (WQR)	5.1.2	3.7.1.2.1.2.19.2	N/A
5.1.3 Production Record	5.1.3	3.7.1.2.1.2.19.3	3.5.1
5.1.4 Storage and Shipping Record	5.1.4	3.7.1.2.1.2.19.4	N/A
5.1.5 Waste Package Annual Report	N/A	3.7.1.2.1.2.20	N/A
5.1.5 Product Specification	1.3	N/A	N/A
5.2 Certification & Waste Form Approval	N/A	N/A	N/A
5.3 Waste Volume Minimization	N/A	N/A	N/A

Table A-2
Requirements Cross Reference by Other Documents

Description (Outline from WFPC)	SRS WAPS For Vitrified HLW Forms Section No.	WASRD Section No. Doc. No. WBS: 9.2.1.1	WIPP Section No. Doc. No. WIPP/DOE-069
6.0 Qualification/Quality Assurance	4.0	N/A	4.0
6.1 Quality Assurance Activities	N/A	N/A	4.0
6.2 Operations and Safety Criteria QA Requirements	N/A	N/A	4.1
6.3 Transportation Packaging QA Requirements	N/A	N/A	4.2
6.4 Waste Characterization Quality Assurance Requirements	N/A	N/A	4.3

APPENDIX B

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

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

INTRODUCTION

At the INEL, DOE has about 4,634,000 kg total mass of spent 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 Spent Fuel & Waste Management Technology Development Program (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 System (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.

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

Sufficient chemical and structural data shall be provided, in production records, to characterize the elemental composition for all elements present in the SNF 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).

The SNF 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 SNF 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. The method used to make these projections shall be described in the production records.

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 40 CFR 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 SNF 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.

1.5 Radionuclide Releases

The SNF 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 developed.

2.0 <u>Canister Specifications</u>

2.1 Material of Construction

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 WQR.

2.2 Fabrication and Closure

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 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 form the top and one visible form 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. 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 WCP. 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 a convex bottom and a top which contains an attached grapple (lifting flange) feature that will allow vertical lifting or horizontal pulling.

2.4.1 Length

The canister length may vary from 160 to 477 cm.

2.4.2 Diameter

The canister diameter may vary from 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. The method of compliance shall be described in the WCP and the results shall be reported in the WQR.

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 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 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 provided that this material is well dispersed throughout the canister. An evaluation shall be presented of the canistered waste form to demonstrate that the waste meets this requirement. The method of evaluation shall be described in the WCP, and the evaluation results shall be documented in the WQR.

3.4 Organic Materials

At canister closure, the waste shall not contain detectable organic materials. The potential to generate acetylene and other organics from water reaction with heavy metal carbides shall be addressed in the WCP.

3.5 External Contamination

The level of removable contamination on all external surfaces of each canister shall not exceed 220 dpm/100 cm^2 alpha or 2200 dpm/100 cm^2 beta/gamma. 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.

3.6 Heat Generation

The heat generation rate at the time of shipment and its accuracy to ±15% shall be supplied for the special fuel canistered waste forms, and the plan for compliance shall 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. This information is available as a product of the characterization program and shall be reported in the WQR.

3.7 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 in the WQR.

3.8 Chemical Compatibility

The contents of the canistered waste 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 WCP. Corrosion interactions, capable of occurring until repository closure, shall be evaluated and reported in the WQR.

3.9 Subcriticality

The producer shall ensure that the canistered material will 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 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. Compliance with this requirement will entail detailed safety analysis and the results will be reported in the WQR. Depending on requirements of the repository, criticality prevention could have significant impact on the conditioning requirements.

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

3.10 Weight and Overall Dimensions

3.10.1 Weight

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

3.10.2 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.

3.11 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.

3.12 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 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 repository.

4.3 Safety Assessment Report

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

5.0 Implications on Special Fuel Disposal

5.1 General

Various options for disposing of Spent Nuclear Fuel (SNF) 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 SNF 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.

5.2 Description of SNF

Information gathering for the SNF is continuing; of the information gathered thus far, the SNF varies widely in characteristics. There are individual rods stored in buckets, fuel assembles, 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 phase consists of obtaining all of the known information about each of the SNF 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.

5.3 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.

5.4 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.

5.5 Chemical Processing For Disposal

Chemical processing would consist of chemical treatment to separate fissile and radioactive waste portions of the fuel; 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.

5.6 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.

5.7 Canister Size

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

5.8 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.

5.9 Fuel Characterization

Detailed characterization of both the chemical and nuclear properties of the SNF 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.

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APPENDIX C

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

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 long-term (50 - 100 years) interim storage at the INEL of HLW immobilized in a glass-ceramic waste form. Based on the results of initial performance assessments of the INEL glass-ceramic waste form in geologic repositories, it is anticipated that any waste form suitable for long-term interim storage will also meet the requirements for acceptance 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, performance assessments of proposed on-site interim storage facilities, 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, anticipated requirements for safe, long-term interim storage, 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),

(2) the Waste Form Qualification Report (WQR),

(3) Production Records, and

(4) Storage and Shipping Records.

The WCP is the producer's plan for qualifying the waste form production process. The production process is qualified by 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, thereby demonstrating qualification of the production process. 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. Production records serve to qualify each individual waste form for acceptance into the CRWMS. 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 is reacted with the additives and densified 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 phase compositions for all phases >10 volume % for each waste type. The anticipated phase composition ranges shall also be reported for each waste type, with the phase composition being reported so as to identify the principle stoichiometry of the host phase. Waste elements incorporated into the host phase as interstitial or substitutional defects in concentrations >0.5 weight % (based on total waste form composition) shall be reported in terms of elemental concentration in the host phase. The method(s) 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 composition for production runs of the waste form. The reported composition shall include elements present in concentrations >0.5 weight % (based on total waste form composition). The phase composition of the waste form shall be estimated for all phases >10 volume % based on known elemental composition and phase composition ranges reported in the WQR. 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 in the Environmental Assessment (EA) for the Defense Waste Production Facility (DWPF) 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 DWPF 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 MCC-1 static leach 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, for each projected waste type, a time-temperature-transformation (TTT) diagram that identifies the duration of exposure at temperatures that cause 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 time and temperature conditions identified in 1.4.1 that result in significant changes in the phase composition. 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 listed hazardous materials in the waste as defined in 40 CFR 261.31 through 40 CFR 261.33.

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.

If de-listing is obtained for the waste form, this requirement is waived.

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 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.

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 X 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.

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 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.

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 cm^2
Beta and Gamma radiation: 2200 dpm/100 cm^2

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.

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.

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 X 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.

4 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 RW-0333P 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 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. The specifications described in this document are also expected to satisfy anticipated long-term interim storage requirements. 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, and to identify the host phases for those waste elements incorporated as impurities in host phases.

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 time-temperature-transformation relationship for the glass-ceramic waste form that results in any significant changes to the phase composition, and references storage conditions to the measured time-temperature-transformation behavior. 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, 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.

APPENDIX D

Discussion of Waste Form / Package Criteria

Discussion of Waste Form / Package Criteria

The following material references the latest revision of the *Preliminary Waste Acceptance Criteria for the ICPP Spent Fuel and Waste Management Technology Development Program* (now the *Waste Form Product Characteristics* document). This document details the basic waste criteria that, through computer simulations done in support of the performance assessment, will allow the waste forms to meet existing regulatory requirements for purposes of geologic disposal.

The additional document references of how the same criteria described other nuclear waste treatment applications attempts to comply with the body of regulatory documents governing radioactive waste disposal in all forms, e.g. transuranic (TRU) wastes as well as spent nuclear fuel (SNF) and high-level waste (HLW).

Canister Material:

The selection of 304L is suggested as the basic material for nuclear waste packages.

"Material thickness will be such that canister integrity is guaranteed to meet the 50-year retrievability requirement once the package is placed in the Mined Geologic Disposal System (MGDS)."

"Typical canister materials will consist of 304L stainless steel. This also applies to structural internals (for fuel compartments) within larger canisters. Allowances for other materials will be considered on a case-by-case evaluation and approval by the repository."

Referenced Document(s):

Characteristics of Potential Repository Wastes, DOE/RW-0184-R1, Vol 1, Sec 3.3.3, July 1992 - "The main body of the canister is made of schedule 20 type 304L stainless steel pipe . . . ."

Waste Acceptance Product Specifications for Vitrified High Level Waste Forms, (EM-WAPS) Office of Environmental Restoration and Waste Management (draft), December 1992 - "The waste form canister, the canister label, and any secondary canister applied by the producer, shall be fabricated from austenitic stainless steel."

Technical Justification:

300 series (austenitic) stainless steels offer a good combination of corrosion resistance, fabrication, weldability (304L), availability, and favorable costs. Other barriers, e.g. overpacks, bentonite, and the geology of the repository, should allow 304L containers to meet the retrievability requirements, and the waste forms to meet the release limits for the prescribed lifetime of the repository.

Both West Valley and Savannah River have standardized on the 304L material for their HLW canister. Ongoing research to utilize 'recycled' stainless materials throughout the DOE complex (predominantly 304) also suggest a cost savings and efficiency through the combined disposal with already contaminated metals.

Canister Weight:

This requirement is expected to apply only to HLW canisters as it represents the upper bound of an individual mass that would be loaded into an MPC at any one time.

"An individual waste (HLW) canister w/o overpack or super-canister construction shall not exceed a weight of 6 metric tons."

Referenced Document(s):

WASRD, Sec 3.7.1.2.1.2.1 B(3), DOE/RW-0351P, March 1994 - "(Producer) Weight shall not exceed 2500 kilograms."

Characteristics of Potential Repository Wastes, DOE/RW-0184-R1, Vol 1, Sec 3.3.3, July 1992 - "The total weight of a loaded canister is therefore about 2,180 kg (4,810 lb) (Baxter 1988, Plodinec 1990)."

EM-WAPS 3.11.1 - "The weight of the canistered waste shall not exceed 2,500 kg. The measured weight and estimated error shall be reported in the Storage and Shipping Records."

Technical Justification:

Physical size of cranes and other remote handling equipment in the confines of a shielded cell very likely will preclude use of equipment with extensive weight-handling capabilities.

The physical weight of a filled HLW canister is essentially a function of the glass density and the makeup of the empty canister itself. In the case of the larger canister weight cited in the PWAC, it reflects the longer size of a canister to better utilize the volume in the standard (proposed) MPC.

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Dimensions:

NOTE: dimensional information for individual canisters relates solely to HLW packages.

> ***"The recommended size of a standard canister size is 61 cm (+1.5 cm, -1.0 cm) O.D. and 300 (+5.0 cm, - 20 cm) in length."***

Referenced Document(s):

> *Waste Acceptance Requirements Document* (WASRD), Sec 3.7.1.2.1.2.1, B(1) & (2) DOE/RW-0351P, March 1994 - "(Producer) Total length shall be 3.000 meters (+0.05, -0.020 m)." and "(Producer) Diameter shall be 61.0 centimeters (+1.5, - 1.0 cm)."

> *Characteristics of Potential Repository Wastes*, DOE/RW-0184-R1, Vol 1, Sec. 3.3.3, July 1992 - ". . . with an outside diameter of 61 cm and a nominal wall thickness of about 0.95 cm. The overall length of the canister is 300 cm (9 ft 10 in.)."

Technical Justification:

Physical size limitations on HLW canisters are determined by: (1) the diameters that a combination HLW canisters takes up inside an MPC, and (2) the ability to maintain the canister centerline temperature < 400 °C. It is generally recognized that typical glasses should be maintained some 50°C below the phase transition temperature of any glass form, which typically starts about 450°C.

Lengths of the HLW canisters are dictated more by the overhead space requirements to move and maintain the canisters in a vertical orientation while within the processing cell. Current, proposed designs for HLW canister storage inside an MPC will leave a significant amount of void (head space) within the proposed MPC design.

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Heat Generation:

Heat generation rates are currently quoted at ~1500 watts/canister (~6 kW/MPC) for HLW packages. Current design for YMP (if a 'hot' repository concept is approved) will allow ~14kW/MPC with a commercial nuclear fuel load. Temperatures relative to the various waste packages that could end up in a geologic repository will be heavily dependent on the nature of the repository itself.

"The thermal power generated by the waste materials in any single canister shall be calculated based on the known contents and shall not exceed 1500 watts without approval from the repository operators . . ."

Referenced Document(s):

10 CFR 60.135(a).2 - "The design shall include consideration of thermal loads and thermal effects."

10 CFR 60.133(i) - "Thermal Loads: The underground facility shall be designed so that the performance objectives will be met taking into account the predicted thermal and thermomechanical response of the host rock, and surrounding strata, groundwater system."

WASRD, Sec 3.7.1.2.1.2.1.B(5), DOE/RW-0351P, March 1994 - "(Producer) Total heat generation rate shall not exceed 1500 watts per canister at the year of shipment."

Waste Acceptance Product Specifications for Vitrified High Level Waste Forms, (EM-WAPS 3.8) Office of Environmental Restoration and Waste Management (draft), February 1993 - "The heat generation rate for each waste form shall not exceed 1500 watts per canister at the year of shipment."

Waste Acceptance Criteria for the Waste Isolation Pilot Plant (WIPP WAC) 3.4.6 - "THERMAL POWER - CONTACT HANDLED WASTE: Individual CH-TRU waste packages in which the average thermal power density exceeds 0.1 W/ft^3 (3.5 W/m^3) shall have the thermal power recorded in the data package; REMOTE HANDLED WASTE: The thermal power generated by waste materials in any RH-TRU waste package shall not exceed 300 watts. The thermal power shall be recorded in the data package."

Heat Generation: (cont'd)

Technical Justification:

The limitation on allowable heat generation for any canister or any MPC in the repository will be a function of the ability of the geologic media to dissipate the heat, i.e. heat transfer away from any canister will be a function of the repository conditions. MPC / overpack construction will affect heat retention within the canister, which in turn will affect centerline or skin temperatures of HLW glass and spent fuels respectively.

In all cases, the controlling item will be the internal heat generation of either the fuel or glass waste form itself. Design will necessarily require an iterative approach to allowable heat generation based on known characteristics of the waste form, the package for the waste form, and the ambient conditions found in a specific repository.

Temperature Limits on Waste Forms:

"SNF should be packaged such that when the fuel package, taken in conjunction with the MPC, any overpack, and the characteristics of the geological environment, shall not allow contents of an MPC to exceed mean temperatures for the following listed fuels:"

aluminum clad	*150°C [200°C max]*
zirconium clad	*340°C*
stainless steel clad	*350°C*
graphite	*<800°C*

"HLW [either as borosilicate glass or glass- ceramic] should be packaged such that when the glass canister, taken in conjunction with the MPC, any overpack, and the characteristics of the geological environment, shall not allow contents of an MPC to exceed 400°C."

Referenced Document(s):

WASRD, Sec 3.7.1.2.1.2.1 B(6), DOE/RW-0351P, March 1994 - "(Producer) Temperature shall not have exceeded 400°C during storage to ensure the glass transition temperature has not been exceeded. [Derived]"

Waste Acceptance Product Specifications for Vitrified High Level Waste Forms, (EM-WAPS 1.4.2) Office of Environmental Restoration and Waste Management (draft), February 1993 - "Control of Temperature for Phase Stability At the time of shipment, the producer shall certify that after the initial cool-down, the waste form temperature has not exceeded 400°C. The producer shall describe the method of compliance in the WCP."

Multi-Purpose Canister (MPC) Implementation Program Conceptual Design Phase Report: Vol 1 - MPC Conceptual Design Summary Report, DOC ID A20000000-00811-5705-00001, September 30, 1993. "The spent fuel cladding temperature limit of 340°C is adopted as the design limit for thermal analyses to ensure that storage limits would be met in the transportation cask. Thus, the licensing of the MPC transportation cask itself for storage is not precluded. Applying the 340°C storage limit to transportation also avoids exceeding MRS and repository temperature limits during transportation from a Purchaser site. The MPC fuel baskets have temperatures less than those previously licensed transportation cask baskets because of the use of aluminum panels."

Temperature Limits on Waste Forms: (cont'd)

Feasibility Study for a DOE-Fuel Multipurpose Canister (Draft), EGG-WM-11011, September 1993 -

> " The following are the parameter value assumptions that were made for the ATR [aluminum] fuel:
>
> . . . .
>
> Fuel clad temperature limits 380°C @ 5 years
> 340°C @ 10 years."

EG&G company internal study, "MPC Quantities and Costs for Complex-Wide EIS", May 1994 - "All aluminum-clad fuel will be placed in sealed [gas-]inerted cans prior to being placed in the MPCs. In these inerted cans, the aluminum cladding will be allowed to reach 350°C."

Technical Justification:

There are three basic concerns that potentially impact the temperature or thermal limits imposed on the waste packages destined for storage/disposal. They are: (1) fuel cladding temperature limitations, (2) phase changes in HLW borosilicate glass, and (3) collective temperature effects on the repository media itself.

Originally, fuel cladding design was based on temperatures in operating, moderated reactors. The ability to quickly carry heat away from the fuels thereby allowed higher temperatures in the controlled environment of the reactor. Ambient conditions expected for fuels stored in dry conditions associated with MPC/geologic disposal will generally be more restrictive because of the thermal resistances encountered in the canister design and implied conservatism needed to establish or meet waste acceptance criteria. Of the typical fuel cladding encountered in DOE-owned fuels, zirconium and aluminum predominate. Burnup and cooling time (time-out-of-reactor) for each of the individual fuel types, along with criticality safety concerns, will determine the allowable fuel loading in each canister to avoid over-temperature conditions for the cladding or repository limits.

Phase changes in the borosilicate glass structure are predicted to occur at temperatures as low as 450°C. To avoid these structural changes, upon which glass leach resistance is predicated, the centerline temperatures of the glass 'logs' are limited to ~400°C in either storage or disposal environments.

Temperature Limits on Waste Forms: (cont'd)

Collectively, each waste package destined for the repository will have a calculated rate of thermal output. Any given waste package, when combined with the repository environment, will result in a steady state or equilibrium temperature both inside the package and within the geologic medium. Hence, the thermal output limits imposed on any package destined for the repository will be determined by the conditions in the repository itself, e.g. host rock temperature, predominant mechanism(s) of heat transport, package density within the repository, thermal output of each package, whether the individual waste packages are backfilled. Until the actual, detailed characteristics of the repository are identified can the waste package loadings (both thermal and fissile) be finalized.

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Allowable Void Space:

Salt 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."

Tuff Repository

"Use of materials to fill void spaces in the spent fuel packages is generally not prescribed unless such materials are needed for assurance of criticality safety and will remain uniformly distributed through the fissile mass within the canister."

Referenced Document(s):

WASRD 3.7.1.2.1.2.1.B(4) - "Fill height shall be equivalent to at least 80% of the volume of the empty canister."

EM-WAPS 3.6 - "The producer shall fill the canister to a height at least 80% of the volume of the empty canister."

Technical Justification:

The void space limitation was intended to encourage producers to maximize packing efficiency in canisters. Costs associated with 'excess quantities' of canisters (both production and storage/disposal) created by inefficient packing should ensure optimal packing.

At least in the case of spent fuels to be disposed of in salt, void volumes should be filled with inert materials so that the canister emulates a solid body that can better withstand the crushing pressures experienced with salt creep over time.

Other considerations favoring addition of other inert materials to a fuel cask with its significant void space might be to: (1) enhance heat transfer, (2) *in situ* stabilization of fuels, and/or (3) retardation of fuel 'reconfiguration' inside the MPC over time.

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Package Labeling:

"The shipper shall be responsible for installing a metal etched bar code and visible, alphanumeric identifier on each canister waste package that might require individual handling. 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."

Referenced Document(s):

10 CFR 60.135(b)4 - "A label or other means of identification that will not impair the integrity of the waste package, will be legible to end of retrievable period, and will be consistent with permanent records shall be applied to each waste package."

WASRD 3.7.1.2.1.2.15 - "Each canistered waste form label shall meet the following criteria: The label must have a unique alphanumeric identifier and this identifier must appear on all documentation pertinent to that particular canistered waste form; The label must not impair canister integrity; The label material must be compatible w/canister material; The label must be visible from the top and side of the canister; the label must not cause dimensional limits to be exceeded; the label must be an integral part of the canister to assist in remaining legible at least to the end of the period of retrievability at the MGDS."

EM-WAPS 2.3.2 - "Each canister shall be labeled in two locations: one visible from the top and one visible from the side of the canister. The identification code shall be printed in a type size of at least 92 points using a sans serif type face. A proposed layout shall be provided in the WCP. Labels shall be applied to the exterior of the outermost canister and shall not cause the dimensional limits (Specification 3.11) to be exceeded."

WIPP 3.4.8 - "A unique identification barcode label reasonably expected to last 10 years shall be affixed. Each package shall have appropriate DOT labels. Each package shall be marked with the shipping category."

Package Labeling: (cont'd)

Technical Justification:

Issues relative to waste package placement within the repository may be dependent on the content of the package (SNF or HLW) and/or the thermal considerations in terms of balancing or even concentrating heat loads for a 'hot' repository configuration. The ability to stage/position waste packages within the repository will be dependent on traceability of data back to the original packages and knowledge of their contents.

Subsequent retrieval within the 50-year time frame, should that prove necessary, would also rely heavily on traceability back to a data package and the linkage with any given waste package.

Waste Package 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.

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

d) 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.

e) 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.

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

Referenced Document(s):

10 CFR 60.135(B)3 - "Handling: Waste packages shall be designed to maintain waste containment during transportation, emplacement, and retrieval."

WASRD 3.7.1.2.1.2.16 - "The following requirements apply the grapple used in the handling of the standard HLW canister that includes a concentric neck and lifting flange: The producer shall provide a grapple design suitable for sue in loading or unloading a transportation cask w/ a standard HLW canister; The grapple, when attached to the hoist and engaged w/ the flange, shall be capable of moving the canistered waste form in the vertical direction; The grapple shall be capable of being remotely engaged with and remotely disengaged from the HLW canister flange; The grapple shall be capable of being engaged or disengaged while remaining w/in the projected diameter of the waste form canister; The grapple shall include features that prevent inadvertent release of a suspended canistered waste form."

EM-WAPS 3.13 - "The canistered waste form shall have a concentric neck and lifting flange. The lifting flange geometry and maximum loading capacity shall be described in the WCP. The producer shall design a grapple, suitable for use at the repository which satisfies the following: Grapple capable of being remotely engaged and disengaged from the flange; Grapple, when attached to a suitable hoist, and when engaged with the flange, shall be capable of raising and lowering a canistered waste form in a vertical direction; Grapple shall be capable of engaging and disengaging the canister flange within a right-circular cylindrical cavity with a maximum diameter of 62.5 cm. The grapple shall be designed to prevent an inadvertent release of a suspected canistered waste form when the grapple is engaged with the flange. The producer shall describe the grapple in the WCP and provide the designs in the WQR."

WIPP 3.2.3.1 - "CONTACT HANDLED WASTES: All waste packages shall be provided with cleats, offsets, chimes, skids of 7-pack handling fixture for handling by means of fork trucks, cranes, or similar handling devices. Lifting rings and other auxiliary lifting devices on the waste packages, if provided, shall be recessed, offset, or hinged in a manner which does not inhibit stacking the waste packages.
REMOTE HANDLED WASTE: RH-TRU waste packages shall be equipped with an axial lifting pintle of a design acceptable to the WIPP. The waste packages shall have no other lifting devices."

Technical Justification:

As described in the current PWAC, reference to canister handling features is limited exclusively to the HLW waste canister. In the salt and granite environment described in the '93 PWAC, limited fuel (fissile) loadings per package made adoption of the standard HLW design reasonably practical.

Use of MPC's tend to negate these requirements as stated, and a new set of requirements will be needed to describe MPC requirements as they are more fully developed.

Solids:

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 0.90 mm minimum wall thickness

- or -

Fuel elements that are relatively small compared to larger PWR-type elements may use single cans to package multiple elements to simplify handling.

Referenced Document(s):

10 CFR 60.135(c)1 - "All such radioactive waste shall be in solid form and placed in sealed canisters."

10 CFR 60.135(c)2 - "Particulate waste forms shall be consolidated (i.e., encapsulation in matrix) to eliminate availability and generation of particulates."

WASRD 3.7.1.2.1.A(1) - Statement of 10 CFR 60.135(c)1

WIPP 3.3.1 - "Waste shall be immobilized if > 1 wt% is particulate material < 10 microns in diameter, or if > 15 wt% is particulate material < 200 microns in diameter."

<u>Solids</u>: (cont'd)

<u>Technical Justification:</u>

Prohibition of particulate solids is intended to minimize the spread of contamination, either through a handling accident (canister rupture), or subsequent leaching of materials due to the much greater surface area exposed to leachate upon canister failure. The need to consolidate particulate material is also dictated by the adoption of BDAT technology as a treatment path for nuclear wastes.

Consolidation of scrap materials, i.e. TMI fuel debris, may not justify treatment beyond the canisterization already done. Similarly, fuels with breached cladding (whether through destructive testing or corrosion failure due to wet storage) will likely be 'canned' prior to packaging in an MPC.

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."

Referenced Document(s):

10 CFR 60.135(b)2 - "No free liquid in amount which will compromise package containment or result in spillage & spread of contamination during period through permanent closure."

WASRD 3.7.1.2.1.B - Statement of 10 CFR 60.135(b)2

EM-WAPS 3.1 - "The producer shall ensure that the canistered waste form does not contain detectable amounts of free liquids. The producer shall describe the method of compliance in the WCP and provide documentation of the ability to comply, and of detection limits, in the WQR."

WIPP WAC 3.3.2.1 - "TRU waste for emplacement in the WIPP shall contain as little residual liquid as is reasonably achievable. All internal containers (eg., bottles, cans, etc) must be well-drained, but may contain residual liquids. As a guideline, residual liquid in well drained containers will be restricted to approximately 1 % of the volume of the internal container. In no cases shall the total liquid equal or exceed one volume percent of the waste container (eg., drum or SWB)."

WIPP Definitions:
-Residual liquid: Liquids in quantities of less than one volume percent of the waste container that result from : liquid residues remaining in well-drained internal containers; condensation of moisture; and liquid separation resulting from sludge-resin settling.

<u>Liquids</u>: (cont'd)

-Well-Drained Container: An internal rigid container, such as a bottle or can, in which liquid has been removed by pouring, pumping, or otherwise removing as much liquid as possible. The actual quantity of liquid remaining in well-drained containers will vary depending upon the viscosity of the liquid and the type and size of the internal rigid container. As a guideline, residual liquid in well-drained containers will be restricted to approximately one percent of the volume of the internal container. Plastic bags that contain individual waste items (eg., combustibles, filters, metal, etc.), are not considered to be rigid containers. The total volume of residual liquid in a non-rigid container is considered to be contained by the waste container (eg., 55-gallon drum, SWB). The sum of all liquids will be less than one percent of the volume of the waste container.

<u>Technical Justification:</u>

Liquids are prohibited from wastes stored in geological repositories for several reasons. Internal corrosion of the waste packages is certainly an overriding concern. The combination of internal corrosion, gas generation, and leaching of the waste form(s) prior to canister breach can all contribute to an accelerated failure of the waste package.

Current requirements are ill-defined and totally arbitrary at this time, i.e. no technical basis. These same assumptions may be totally inappropriate to glass ceramic logs and certain spent fuels because of either the nature of packaging, processing, or preceding storage conditions. HLW canisters will experience temperatures in excess of 400°C during their loading under process conditions. It is difficult to postulate conditions or events that could lead to an accumulation of any liquids, free or otherwise, in an HLW package.

As an example, the WIPP WAC standards are based on certain assumptions associated with essentially undocumented packaging of materials in 55-gallon drums; these assumptions relative to typical residues that could remain in containers led to a 1 % by volume limit. It would be preferable to address allowable liquids for SNF packages based on weight percentages rather than by volume. For fuels being loaded directly from 'wet storage' into an MPC, this may require a drying step that invokes some form of testing. Testing may consist of a combination of vacuum containers with water vapor sampling, weighing/treatment/weighing steps, etc.

Liquids: (cont'd)

There is a greater degree (opportunity) of liquid availability in waste packages associated with spent fuels. Fuels formerly stored wet and then dried while in interim 'dry' storage have a chance to dry out due to self- heating; canned fuels (formerly stored wet) may or may not dry out in dry storage, depending on both the can and storage conditions. Fuels stored wet and loaded wet into an MPC offer the greatest chance of water introduction and retention in an MPC.

One way to establish these limits may center on an allowable weight % based on the waste mass, and that in turn may be dependent on the type of waste under consideration. This method of developing an acceptance criteria must be technically based on something like an allowable wt% (liquid) of waste loading that might result in: (1) a canister overpressurization [steam generation?], (2) internal corrosion [allowable mils thickness degradation of the canister], (3) gas generation [H_2 formation], or (4) some other definable, quantifiable amount.

A reasonable first approach (for purposes of calculation) may assume/allow the equivalent of a 100% saturated volume of any empty MPC in the form of water vapor. As condensed moisture (~385 gm), it would likely be visible were physical inspection possible. With this amount selected as an upper limit, it would be possible to calculate: (1) maximum pressurization that could occur, given bounding conditions for temperature and pressure, (2) estimates of total metal mass reaction and gas production ($M + H_2O \dashrightarrow MO + H_2$), (3) estimates of uniform or perhaps localized corrosion amounts. Most of the conceivable events involving water in an enclosed MPC should be scalar over the time frame of interest, so application of multiples of the allowable water mass should be relatively predictable.

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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 disperses and binds it within an inert matrix."

Referenced Document(s):

10 CFR 60.135(b)1 - "No explosive or pyrophoric materials in an amount that will compromise the ability of the repository to isolate waste or satisfy performance objectives."

10 CFR 60.135(c)3 - "All combustible waste shall be reduced to noncombustible form unless it can be demonstrated that a fire involving the waste package w/ combustibles will not compromise the integrity of other waste packages or damage repository components, systems, or structures important to safety."

WASRD 3.7.1.2.1A.(3) - Same as 10 CFR 60.135(c)3

WIPP WAC 3.3.3 - "Pyrophoric Materials: No nonradioactive pyrophorics permitted. Radionuclides in pyrophoric form are limited to < 1 wt% in each waste package."

WIPP WAC 3.3.4 - "Explosives: No explosives as defined by 49 CFR 173, Subpart C, are permitted."

EM-WAPS 3.3 - "The producer shall ensure that the canistered waste form does not contain detectable amounts of explosive, pyrophoric, or combustible materials. The producer shall describe the method of compliance in the WCP and provide documentation of, the detection limits, and the ability to comply with this specification for the range of waste types, in the WQR. The producer shall document in the WQR that the canistered waste forms remain nonexplosive, nonpyrophoric, and noncombustible after having been subjected to temperatures up to 500°C."

Explosiveness, Pyrophoricity, Combustibility: (cont'd)

Technical Justification:

Restriction on pyrophorics is to minimize potential for creating an ignition source in a waste package. Studies at the Rocky Flats Plant have shown that small quantities of pyrophoric plutonium can be accommodated in other nonpyrophoric materials without an unacceptable hazard. A 1% limit has been established in the criteria for the WIPP as an acceptable level of pyrophoric material in a transuranic waste package. The 1% is used instead of 3% (demonstrated acceptable at Rocky Flats) since TRU waste forms may not be as uniform or homogeneous as the materials in the Rocky Flats Plant study.

This 1% limit on pyrophorics has been adopted in the PWAC for HLW because any pyrophorics present in the HLW forms will be dispersed throughout the waste package. Analysis as to the applicability of this limit to SNF will have to be further addressed. The presence of pyrophorics actually does not present a problem in most packages, where the amount of free oxygen would be limited. At best, exposed pyrophoric material at elevated temperatures might act as an oxygen scavenger in the repository environment, with a fast but controlled rate of oxidation.

Explosives, if contained in a waste package, present a potential hazard to operating personnel during shipment and handling and provide a source for failure of the waste container. Explosive materials would consist primarily of gaseous species (hydrogen) and/or nitrated organics. Through the exclusion of organics and chemically reactive species (nitric acid), and nitrated organics themselves, the issue of explosives should be adequately addressed. In the case of HLW treatment, much of the treatment occurs at temperatures which would destroy any explosive materials or components which might recombine over time. Therefore, hydrogen generation, whether through corrosion reactions with metal in a package or by radiolysis, becomes the single, most significant source of a potentially explosive condition. However, this situation would also require an ignition source and a source of oxygen.

Carbon in the graphite fuels is in itself combustible, but in a monolithic form, limited oxygen, and lack of a significant ignition source would qualify it as non-combustible. NOTE: cardboard, polyethylene bottles, ethanol, Tyvek® anti-C's, all constitute material typically thought of as 'combustible' because of their high specific surface area.

Chemically Reactive Species:

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

a) Chemical Composition

The Producer shall provide records indicating the chemical composition and crystalline phase projections for the waste form.

b) Chemical Compatibility

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

c) Waste Form - Container Compatibility

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

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

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."

Referenced Document(s):

10 CFR 60.135(b)1 - "No chemically reactive species in amount that will compromise ability of repository to isolate waste or satisfy performance objectives."

<u>Chemically Reactive Species</u>: (cont'd)

WASRD 3.7.1.2.1.2.6.A - "The Producer shall report to DOE/OCRWM the chemical composition and crystalline phase projections for the waste form."

WASRD 3.7.1.2.1.2.6.B - "The producer shall report to DOE/OCRWM the oxide composition of the waste form for the oxides of elements present in concentrations greater than 0.5% by weight and the estimate of the error of the composition."

WASRD 3.7.1.2.1.2.5 - "The contents of the canistered waste form shall not lead to internal corrosion of the canister such that there are will be an adverse effect on normal handling, during storage, and on abnormal occurrence such as a canister drop accident after exposure to temperatures up to the glass transition temperature."

WASRD 3.7.1.2.1(C) - "The waste form shall not contain explosive, pyrophoric, or chemically reactive species in amount that could compromise ability of repository to isolate waste or satisfy performance objectives."

EM-WAPS 3.5 - "The producer shall ensure that the contents of the canistered waste form do not cause internal corrosion of the canister which could adversely affect normal handling during storage, or during abnormal occurrence such as a canister drop accident. The producer shall describe the method of compliance in the WCP. Interactions between the canister and its contents, including any reaction products generated w/in the canistered waste form after exposure to temperatures up to 500 °C shall be discussed in the WQR."

<u>Technical Justification:</u>

The intention of excluding chemically reactive materials from any waste package is intended to: (1) prevent formation or new reactive materials in the package over time, and (2) avoidance of reactions that lead to degradation of the waste form or the containment package.

In the first case, reactive materials could generate new compounds or species within waste form or package that were not considered or analyzed in the performance assessment. These new species might alter the characteristics of the waste package in terms of solubilities or breakdown of the form itself, leading to accelerated leaching. Abnormal gas generation rates due to something like elemental sodium/water reaction or uranium carbide/water reactions could accelerate transport away from the package.

Chemically Reactive Species: (cont'd)

In the second case, acidic wastes and/or salt (halides, nitrates, phosphates, sulphates, carbonates) compounds that can generate ions in solution (usually through immersion in water) need to be excluded unless they can be shown to be stable in some natural analog form. Most wastes, to stand a chance of being acceptable in a geologic repository, will have a predominant amount of oxides associated with them. In most all conditions, the oxides themselves are stable. Although subject to some leaching, in general low solubilities of the oxide waste forms provide retardation against transport in a groundwater environment.

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Neutron Absorbers:

"Use of neutron absorbers within SNF packages will be allowed to the extent it is 'fixed' in a matrix that: (1) assures uniform distribution throughout the fuel matrix, (2) prevents or protects against redistribution within the fuel package, and (3) meets regulatory requirements with respect to RCRA/CERCLA."

Referenced Document(s):

Multi-Purpose Canister (MPC) Implementation Program Conceptual Design Phase Report: Vol 1 - MPC Conceptual Design Summary Report, DOC ID A20000000-00811-5705-00001, September 30, 1993. "A significant factor that affects the capacity of transportation cask systems is the requirement for neutron absorbers to ensure subcriticality. PWR storage cask design may take credit for dissolved boron present in the spent fuel pool during loading and unloading operations, and the fuel baskets of storage-only systems may dispense with materials provided specifically to absorb neutrons. The MPC design incorporates neutron absorber (the B-10 isotope of boron) into the aluminum heat conductor sheets through the use of borated aluminum alloy. This metal is a two-phase alloy, which provides an even dispersion of B-10 without substantially degrading the material properties (fabricability and thermal conductivity) of the aluminum. The addition of B-10 (as natural or enriched boron) to the aluminum does not incur an additional space requirement. The borated aluminum is clad with a stainless steel outer tube to protect it and to maintain the position of the aluminum sheets surrounding a fuel assembly in the transportation drop accident scenarios."

Technical Justification:

Use of neutron absorbers are applicable only to the tuff media. Earlier studies ('93 PA) addressed criticality safety through employment of either fissile mass limits (granite) or water exclusion (salt) as one of two contingencies required in fissile material facilities. Since neither water exclusion nor mass limits are in place for the tuff environment, neutron absorbers must be added as one of the contingencies.

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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 (at initial package loading) 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."

Referenced Document(s):

10 CFR 60.131(b)7 - "All systems for radioactive waste isolation (waste form) shall be designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, cocurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. The waste form shall be designed for criticality safety under normal and accident conditions. The calculated effective multiplication factor, k_{eff}, must be sufficiently below unity to show at least a 5% margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation."

WASRD 3.7.1.2.1.2.4 - "The Producer shall design a waste form to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and cocurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. The waste form shall be designed for criticality safety under normal and accident conditions. The calculated effective multiplication factor (k_{eff}) shall 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."

Criticality Safety: (cont'd)

EM-WAPS 3.10 - "The Producer shall design a waste form to ensure that, under normal and accident conditions, a nuclear criticality accident is not possible unless at least two unlikely, independent, and cocurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. The calculated effective multiplication factor, k_{eff}, must be shown to less than 0.90 after allowing for the 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 in the WQR. The WQR shall also include sufficient information on the nuclear characteristics, such as fissile density, of the canistered waste form to enable subcriticality to be confirmed under transportation, storage and disposal conditions."

WIPP WAC 3.4.2 - "Contact Handled Waste. The fissile or fissionable radionuclide contents of the CH-TRU waste package shall be no greater than the following values , in Pu-239 fissile gram-equivalent:

- 200 g per 55-gallon (0.21 m^3) drum
- 500 g per DOT 6M container
- 5 g per ft^3 (0.028 m^3) in boxes, up to 350 g maximum

. . . .

Remote-Handled Waste: The fissile or fissionable radionuclide content of RH-TRU waste packages shall not exceed 600 g total (in Pu-239 FGE)."

Technical Justification:

The issue of criticality safety in any repository is more likely a political issue than a technical one. In PA for the salt and granite repositories, design of the waste package was such that the potential for a near-field (single package) criticality is literally impossible. The adoption of this approach, while assuring against criticality, creates an inordinate number of waste packages to deal with all the spent fuels in the DOE complex.

Subsequent studies associated with tuff media was to allow for a criticality at some small probability to determine the probability and the effects on the repository if it did occur.

Safeguards and Material Accountability:

"SNF materials with greater than 20% U-235 enrichment that is packaged for disposal in a geologic repository must include documented accountability of fissile materials. Packaging such materials must provide for tamper resistant seals and security controls (including possible inspection) up until the time of emplacement in a repository."

Referenced Document(s):

10 CFR - Energy Section 70.51 Material balance, inventory, and records requirements: "(a) As used in this section: (1) Additions to material in process means receipts that are opened except for receipts opened only for sampling and subsequently maintained under tamper-safing, and opened sealed sources. (2) Enrichment category for uranium-235 means high-enriched uranium-that uranium whose isotope content is 20 percent or more uranium-235 by weight, and low-enriched uranium-that uranium whose isotope content is less than 20 percent uranium-235 by weight."

Section 70.58 Fundamental nuclear material controls: "(d) Material Balance Areas (MBA) or Item Control Areas (ICA) shall be established for physical and administrative control of nuclear material."

"(e) A system must be established, maintained, and followed for the measurement of all special nuclear material received, produced, or transferred between MBAs, transferred from MBAs to ICAs, on inventory, or shipped, discarded, or otherwise removed from inventory and for the determination of the limit of error associated with each such measured quantity except for plutonium-beryllium sources; samples that have been determined by other means to contain less than 10 grams U-235, U-233, or plutonium each; and reactor-irradiated fuels involved in research, development, and evaluation programs in facilities other than irradiated-fuel reprocessing plants. The system must be described in writing and provide for sufficient measurements to substantiate the quantities of element and isotope measured and the associated limits or error. The licensee shall record the required measurements and associated limits of error and shall retain any record associated with this system for three years after the record is made."

Safeguards and Material Accountability: (cont'd)

Technical Justification:

In accordance with International Atomic Energy Agency (IAEA) policies and treaties to which the United States government is a signatory, we have a compliance responsibility regarding materials contained in many of the DOE-owned SNF packages intended for repository disposal.

Interpretation of current documents directs one to the conclusion there will be reporting requirements at least up to the time the material is disposed of in a geologic repository, if not beyond that point unless modifications or reinterpretation of controlling documents are made.

Solubilities:

"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."

"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."

Referenced Document(s):

10 CFR 60.135(a)2 - "The design shall include consideration of solubility."

Technical Justification:

Performance assessment analyses take into account the solubilities of the various constituents comprising the waste package. The materials selected for analysis in the PA are based on their predominance in the waste, their 'mobility' under normal conditions, and the expected effects on the biosphere should they transport past the repository boundary.

Waste treatment issues relative to HLW should in most cases either fix materials of interest in an essentially non-leachable form, or the treatment process, e.g. conversion from a nitrate to an oxide, significantly reduces the soluble properties of the material.

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Leach Rates:

"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."

"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."

Referenced Document(s):

10 CFR 60.135(a)2 - "The design shall include consideration of leaching."

WASRD 3.7.1.2.1.2.13(B) - "For acceptance, the concentrations of lithium, sodium, and boron in the leachate, after normalization for the concentrations in the glass, shall be less than those of the benchmark glass."

Technical Justification:

Adoption of a standard for determining leach rates, most specifically HLW waste forms, is an ongoing effort. There is currently a general lack of agreement on which currently identified leach test best represents material behavior when in the HLW form.

Certainly acceptability of any waste form will depend on its ability to meet or exceed the demonstrated leach resistance of some glass standard tested with some yet-to-be standardized leach test.

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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."

Referenced Document(s):

10 CFR 60.135(a)2 - "The design shall include consideration of corrosion."

EM-WAPS 3.5 - "The producer shall ensure that the contents of the canistered waste form do not cause internal corrosion of the canister which could adversely affect normal handling during storage, or during abnormal occurrence such as a canister drop accident. The producer shall describe the method of compliance in the WCP. Interactions between the canister and its contents, including any reaction products generated w/in the canistered waste form after exposure to temperatures up to 500 °C shall be discussed in the WQR."

Technical Justification:

Corrosion performance of any waste package will be pure conjecture until the actual repository is identified, along with the characteristic makeup of the ground water in that area.

Predicting corrosion behavior of materials 10-20 years into the future in ground water environments encounters enough uncertainties to make predictions 1000 to 10,000 years into the future purely speculative. Extrapolation techniques and statistical sampling for corrosion rate ranges are used to estimate probable times to package failure given current knowledge about failure mechanisms.

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

Referenced Document(s):

10 CFR 60.135(a)2 - "The design shall include consideration of gas generation."

WASRD 3.7.1.2.1.2.9.A - "After closure, the canistered waste form shall not contain free gas other than air, cover, and radiogenic gases with an immediate internal gas pressure not to exceed 150 kPa (22 psia) at 25 °C. Cover gases shall be helium, argon, or other inert gases."

EM-WAPS 3.2 - "The producer shall ensure that the canistered waste form does not contain detectable amounts of free gases other than air, the residuals of air, nobel and radiogenic gases. The internal gas pressure immediately after closure shall not exceed 150 kPa (22 psia) at 25 °C. The Producer shall describe the method of compliance in the WCP and provide documentation of the ability to comply with this specification, and of detection limits, in the WQR. The producer shall also document in the WQR the quantities and compositions of any gases that might accumulate inside the canister from radiogenic decay or after the canister has been subjected to temperatures up to 500 °C."

WIPP 3.4.7 - "Waste packages emplaced in WIPP during the experimental period shall not exceed 50% of the lower explosive limit in any layer of confinement for hydrogen and methane. Total flammable VOCs are limited to 500 ppm in the headspace gas of the waste package. All chemicals > 1 wt% must be evaluated for compatibility w/in the waste form and with TRUPACT-II materials of construction. Trace chemicals < 1 wt% limit must total < 5 wt % of the waste in any package. Total alpha activity of waste on a container basis using methodology listed in QAPP."

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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."

Referenced Document(s):

10 CFR 60.135(a)2 - The design shall include consideration of radiolysis.

Technical Justification:

Consideration of radiolysis in a repository was intended to focus on how water chemistries external to the waste package might be affected by the radiation fields created in a repository.

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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."

Referenced Document(s):

10 CFR 71.47 - External radiation standards for all packages - A package must be designed and prepared for shipment so that the radiation level does not exceed 200 mrem/hr ar any point on the external surface of the package of the package and the transport index does not exceed 10 .

For a package transported as exclusive use by rail, highway, or water, radiation levels external to the package may exceed those limits, but must not exceed any of the following:

a.) 200 mrem/hr on the accessible external surface of the package unless the following conditions are met, in which case the limit is 1000 mrem/hr:

1) The shipment is made in a closed transport vehicle;

2) Provisions are made to secure the package so that its position within the vehicle remains fixed during transportation; and

3) There are no loading or unloading operations between the beginning and end of the transportation;

b.) 200 mrem/hr at any point on the outer surface of the vehicle, including upper and lower surface;

c.) 10 mrem/hr at any point two meters from the vertical planes represented by the outer lateral surfaces of the vehicle;

d.) 2 mrem/hr in any normally occupied positions of the vehicle.

Surface Dose Limits: (cont'd)

WASRD 3.7.1.2.1.2.17 - "Canistered waste not exceed max surface gamma dose rate of 10^5 rem/hr or max neutron dose rate of 10 rem/hr, at the year of shipment to the MGDS."

EM-WAPS 3.9 - "Canistered waste not exceed max surface (on contact) gamma dose rate of 10^5 rem/hr or max neutron dose rate of 10 rem/hr."

EM-WAPS 3.9.1 - "Projections of Dose Rates: The producer shall report in the WQR the expected values and the range of expected variation for both gamma and neutron dose rates indexed to the year 2015. The producer shall describe the method for demonstrating compliance in the WCP."

EM-WAPS 3.9.2 - "Dose rates at time of shipment: The producer shall provide in the storage and Shipping Records either the calculated or measured values for both gamma and neutron dose rates at the time of shipment for each canistered waste form. The producer shall describe the method of compliance in the WCP."

Technical Justification:

Adoption of Rad/hr dose rates in the PWAC attempted to be consistent with the Rem doses used in other areas. However, most of the concern in the 0-10,000 year time frame will be with radiolysis and material damage rather than biological effects (as the Rem figure is intended to reflect).

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 (by mass/curie)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."

Referenced Document(s):

WASRD 3.7.1.2.1.2.8 - "The producer shall report to the DOE/OCRWM the estimated total and individual canister inventory of radionuclides (in Curies) that have half-lives longer than 10 years and that are, or will be, present in concentrations greater than 0.05% of the total radioactive inventory. The estimates shall be indexed to the year 2015 and 3115."

EM-WAPS 1.2 - "The producer shall report the inventory of radionuclides (in Curies) that have half-lives longer than 10 years and that are, or will be, present in concentrations greater than 0.05% of the total radioactive inventory for each type of waste, indexed to the year 2015."

EM-WAPS 1.2.1 - "Radionuclide Inventory Projections: 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. The producer shall also report the upper limit of these radionuclides for any canistered waste form, an average calculated radionuclide inventory per canister for each waste type. The method to be used to obtain the required data shall be described by the producer in the WCP. The data shall be provided in the WQR. Radionuclide inventory estimates not available for reporting in the initial WQR shall be included in an addendum to the WQR."

<u>Radionuclide Inventory</u>: (cont'd)

EM-WAPS 1.2.3 - "The producer shall provide in the production records estimates of the inventories of the individual reportable radionuclides for each canister and for each waste type. The producer shall also report the estimates of error of these estimates in the WQR."

<u>Technical Justification:</u>

The total curie inventory is merely divided on an average basis among the number of canisters. Use of calculational methods in the PA do account for a range of values, both higher and lower than the calculated mean value.

<u>Organics</u>:

"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."

<u>Referenced Document(s):</u>

WASRD 3.7.1.2.1.2.9(B) - "After closure, the canistered waste form shall not contain detectable amounts of organic materials."

EM-WAPS 3.4 - "The Producer shall ensure that the canistered waste form does not contain detectable amounts of organic materials. The producer shall describe the method of complying with this specification in the WCP and provide documentation of the ability to comply, and the detection limits in the WQR."

WIPP WAC 3.3.5.3 - "NONFLAMMABLE VOCs (COMPARABILITY): The NMD mandates that any waste package that is sent to the WIPP must meet the requirement that the headspace concentration within a package does not exceed two times the maximum concentration for five nonflammable VOCs: carbon Tetrachloride, Methylene Chloride, 1,1,1-Trichloroethane, Trichloroethylene, 1,1,2-Trichloro-1,2,3-trifloroethane. This requirement is designed to ensure that the wastes to be emplaced in the WIPP are similar to the wastes described in the NMVP. The 5 nonflammable compounds and their 2X maximum concentration limits are reported in the NMD and the WAP in the WIPP RCRA Part B Permit Application, and the methodology for demonstrating compliance is presented in the QAPP; NONFLAMMABLE VOCs (NO-MIGRATION DEMONSTRATION): The NMD mandates that any waste package that is sent to the WIPP must meet the requirement that the headspace concentration /win a package does not exceed 10X the average concentration of the three nonflammable VOCs. (Two of the above 5 do not meet this requirement). The 3 nonflammable VOCs that must meet the requirement are: Carbon Tetrachloride, Methylene Chloride, Trichloroethylene."

<u>Technical Justification:</u>

The basis originally assumed for organics was the result of numbers contained in the WIP WAC. Those waste packages were projected to contain organics, both as liquids and solids, that originated as a result of the materials used at the processing facilities that generated the TRU wasted destined for WIPP.

<u>Organics</u>: (cont'd)

Organics associated with SNF and HLW materials is much less likely based on the known properties of both types of waste. Much of the processing HLW experiences is at conditions that virtually precludes the presence of anything more than negligible concentrations of organics. It was the intention in writing the exclusion requirement to prevent the addition of any organics in the treatment or preparation of the waste packages. The exclusion of organics and reactive materials, i.e. nitrates, is also intended to preclude the formation of explosive materials within the waste packages.

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."

Referenced Document(s):

WASRD 3.7.1.2.1.2.9.A - "After closure, the canistered waste form shall not contain free gas other than air, cover, and radiogenic gases with an immediate internal gas pressure not to exceed 150 kPa (22 psia) at 25 °C. Cover gases shall be helium, argon, or other inert gases."

EM-WAPS 3.2 - "The producer shall ensure that the canistered waste form does not contain detectable amounts of free gases other than air, the residuals of air, nobel and radiogenic gases. The internal gas pressure immediately after closure shall not exceed 150 kPa (22 psia) at 25 °C. The Producer shall describe the method of compliance in the WCP and provide documentation of the ability to comply with this specification, and of detection limits, in the WQR. The producer shall also document in the WQR the quantities and compositions of any gases that might accumulate inside the canister from radiogenic decay or after the canister has been subjected to temperatures up to 500 °C."

Technical Justification:

The allowable use of inert gases is to facilitate the welding procedure(s) that may be used to close the various waste canisters as they are produced. Of some concern may be the ambient temperature of the waste canister at the time of closure, and whether trapped gases may increase in pressure. While in a remote cell with a controlled temperature environment, pressures inside the canister might well be less than in a repository environment where heat retention in the surrounding geological structure can increase the canister temperature above what was experienced in the remote cell at canister closure.

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