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Office of Civilian Radioactive Waste Management

Waste Acceptance Preliminary Specifications for the Defense Waste Processing Facility High-Level Waste Form

(OGR/B-8)

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FOREWORD

This is the initial issue of the baselined document Waste Acceptance Preliminary Specifications for the Defense Waste Processing Facility High-Level Waste Form. During the development and review of the various drafts of this document it was identified as OGR/B-8. At initial baseline issue the document number DOE/RW-OXXX has been added to the cover. This document will continue to be identified as OGR/B-8.

WASTE ACCEPTANCE

PRELIMINARY SPECIFICATIONS

for the

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Defense Waste Processing Facility

High-Level Waste Form

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Introduction

These Waste Acceptance Preliminary Specifications (WAPS) specify the properties and requirements for the high-level waste (HLW) forms to be produced by the Defense Waste Processing Facility (DWPF) at the Savannah River Plant, South Carolina. The WAPS establish the minimum requirements which the DWPF waste form must meet in order to be compatible with any of the three geologic media (i.e., basalt, salt, or tuff) under consideration for the first geologic repository.

The WAPS has been developed by the Waste Acceptance Committee (WAC), which is responsible for the preparation of the various site-specific and generic documents identified in the Waste Acceptance Process (WAP). The development and the approval of the WAPS have been carried out in accordance with procedures outlined in the WAC charter. The WAPS specify technical requirements that the waste form must meet and documentation that the producer must provide in order to fulfill the producer's role in the repository licensing process. The WAPS also provide the bases for developing design specifications for the repository and the waste package. The rationale for each specification is presented in Appendix A.

It is recognized that some individual canistered waste forms may not comply in every respect with these specifications. For these cases, the producer will identify nonconformities and propose a remedy for evaluation by the receiving repository on a case-by-case basis. The repository will evaluate the proposed remedy, and a final disposition of the nonconforming waste form will be determined in accordance with the repository license.

Within the waste acceptance process, the WAPS follow the repository-site-specific, waste-form-specific Waste Acceptance Specifications. Where possible, the WAPS reflect generic requirements; however, in one case (i.e., Specification 1.3, Specification for Radionuclide Release Properties), it is not possible to set a single specification that is adequate for all repositories. In this case, producers must demonstrate compliance with repository-specific requirements, at least until the site for the first repository is chosen. The required release properties for the waste form will be based on the overall performance allocation for different parts of the engineered barrier system since containment and isolation requirements are to be met by the total engineered barrier system and not necessarily by the waste form alone. The WAPS require demonstration of compliance via three different documents, each prepared by the producer and concurred with by the repository projects through the waste acceptance process: (1) the Waste Form Compliance Plan (WCP), (2) the Waste Form Qualification Report (WQR), and (3) Production Records.

The Waste Form Compliance Plan (WCP) is the producer's plan for demonstrating compliance with each specification in the WAPS. The WCP is to include detailed descriptions of the testing (including detailed test

procedures), analyses, and process controls to be performed by the producer, including the identification of production records to be provided, to demonstrate compliance with the specifications. The plan for compliance with each specification is to be concurred with by each of the repository projects. To meet schedule demands, it may be necessary for WCP preparation and concurrence to proceed specification by specification, and such an approach is permissible, with the agreement of the WAC Chairman. Concurrence by repository projects means that the producer's proposed method of compliance will satisfactorily meet the intent of the specification, acceptance criteria (as applicable), and support requirements for licensing arguments.

The WQR is a compilation of all results from testing and analysis that presents detailed evidence of compliance with each specification. This document is also prepared by the producer and concurred with by each repository project. Concurrence by the repository projects will be required for each specification and will mean that the testing and analysis as described and documented provide a satisfactory demonstration of compliance with the specification and are adequate for the intended use in repository licensing. Again, consideration of the basis of individual specifications is permissible if the WAC Chairman concurs.

Production Records refers to documentation, provided by the producer, that describes the actual canistered waste forms for review by the repository operator before the waste is shipped. The format and the content of the production records will be specified in the WCP. Concurrence means that the canistered waste forms described are in compliance with the specifications and are therefore acceptable for disposal.

The WAPS are based on the best available information current as of the date of issue. They are likely to be revised as the repository program proceeds through design and licensing. Eventually the WAPS will evolve into the Updated Waste Acceptance Specifications (WAS), which will be used for the License Application, and ultimately into the Final WAS, after the incorporation of applicable NRC licensing technical specifications. All changes will be made in accordance with the Waste Acceptance Process, through the WAC.

When these WAPS were prepared, there was insufficient information available to firmly fix some of the specifications. These specifications remain reserved and are denoted by [R#] in the text of the specification. An explanation of all reserved items is found in Appendix B.

1. WASTE FORM SPECIFICATIONS

1.1 CHEMICAL SPECIFICATION

The waste form for DWPF is borosilicate waste glass.

1.1.1 Chemical Composition Projections

The producer shall include in the Waste Form Qualification Report (WQR), sufficient chemical and microstructural data to characterize the elemental composition and crystalline phases for the product of the waste production facility and expected variations in the product due to process variations during the life of the facility. The method to be used to make these projections shall be described by the producer in the Waste Form Compliance Plan (WCP).

1.1.2 Chemical Composition During Production

For the canistered waste forms the producer shall include in the production records the elemental composition of the glass waste form for all elements, excluding oxygen, present in concentrations greater than 0.5 percent by weight. The producer shall describe the method to be used for compliance in the WCP. An estimate of the precision, accuracy and the basis for the estimate of the precision shall be reported in the WCP.

1.2 RADIONUCLIDE INVENTORY SPECIFICATION

For all radionuclide inventory estimates required by this specification, the producer shall report all radioisotopes that have half-lives longer than 10 years and are present in concentrations greater than 0.05% [R1] of the total radioactive inventory in curies (in the aggregate or in the canistered waste form, as applicable) at any time up to 1100 years after production.

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 and of the uncertainties in the expected values. The producer shall also provide in the WQR estimates of the inventories of individual radionuclides expected to be present in each canistered waste form produced at the facility and the expected range of variations due to process variations during the life of the facility. These estimates shall be calculated for the year 2025. The method used to make these projections shall be described by the producer in the WCP.

1.2.2 Radionuclide Inventory During Production

At the time of shipment, the producer shall provide in the production records estimates of inventories of individual radionuclides in each canistered waste form. The producer shall also report the expected precision and accuracy of these estimates in the WCP.

1.3 SPECIFICATION FOR RADIONUCLIDE RELEASE PROPERTIES

1.3.1 Control of Radionuclide Release Properties

The producer shall demonstrate that the radionuclide release properties of the waste form can be controlled during production. The producer shall relate the method of control to the repository-site-specific tests TBD* [R2] or perform the repository-site-specific tests TBD* [R2]. The producer shall describe the intended method for demonstrating compliance in the WCP. Supporting technical documentation for the selected method of control shall be included in the WQR.

1.3.2 Verification of Radionuclide Release Properties

The producer shall document that the canistered waste form at the time of production met the limits of Specification 1.3.1. The producer shall describe the method for demonstrating compliance in the WCP. Documentation supporting the selected method of verification and the verification results shall be included in the production records.

1.4 SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

The producer shall provide the following data on the borosilicate glass waste form:

(a) The transition temperature where the slope of the thermal expansion vs. temperature curve shows a sharp increase.

(b) A time-temperature transformation (TTT) diagram that identifies temperatures and the duration of exposure at the temperature that causes significant changes in either the phase structure or the phase compositions of the borosilicate glass waste form. The producer shall provide TTT diagrams characteristic of the expected range of waste form composition. The waste form radionuclide release properties called for under Specification 1.3 shall also be provided for representative samples covering the same ranges of temperature, duration of exposure, and waste form composition.

The requested data, analysis, and appropriate technical support shall be provided in the WQR. The method used to produce these data shall be described in the WCP.

At the time of shipment, the producer shall certify that the maximum waste form temperature is at least 100°C below the transition temperature of 1.4(a) above. In addition, the producer shall certify that after the initial cooldown, the canistered waste forms to be shipped have been handled and stored in a manner such that the maximum temperature of the waste form has not exceeded the transition temperature specified in Specification 1.4(a). The producer shall also describe the method of certification in the WCP. The canistered waste forms shall be transported under conditions that ensure that the transition temperature of Specification 1.4(a) above is not exceeded; certification that this has been accomplished will be required on receipt at the repository.

* TBD - to be determined.

2. CANISTER SPECIFICATIONS

2.1 MATERIAL SPECIFICATION

The waste form canister and any secondary canisters applied by the producer shall be fabricated from austenitic stainless steel. The ASTM alloy specification and the composition of the canister material, the secondary canister material, and any filler material used in welding shall be included in the WCP.

2.2 FABRICATION AND CLOSURE SPECIFICATION

The canister fabrication methods, as well as those for any secondary canister applied by the producer, shall be identified in the WCP and documented in the WQR. The outermost closure shall be leaktight in accordance with the definition of "leaktightness" in ANSI N14.5-1977, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials." The method for demonstrating compliance shall be described by the producer in the WCP and documented in the WQR.

2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

2.3.1 Identification

The producer shall assign an alphanumeric code to each canister or secondary canister, if one is used, that is produced. This alphanumeric code shall appear on the labels of the canistered waste form and on all documentation pertinent to that particular canistered waste form.

2.3.2 Labeling

Each canister shall be labeled with the identification code specified above. Two labels shall be firmly affixed, with one visible from the top and one from the side of the canister. The identification code shall be printed in a type size of at least 92 point using a sans serif type face (Megaron Bold Condensed or equivalent). A proposed layout shall be provided in the WCP. Labels, meeting the requirements above, shall be applied to the exterior of the outermost canister. Labels affixed to the outside of the outermost canister shall not cause dimensional limits of Specification 3.11 to be exceeded. The label materials and method of attachment shall be selected to be compatible with the canister material. The label shall be designed to withstand filling and storage at the producer's facility, shipment to the repository, and possible lag storage at the repository prior to final packaging. The producer shall describe the label materials and method of attachment in the WCP. The producer shall estimate the service life of the label and provide a basis for meeting that estimate in the WCP.

3. CANISTERED WASTE FORM SPECIFICATIONS

3.1 FREE-LIQUID SPECIFICATION

After closure the canistered waste form shall not contain free-liquids that could be drained from the canister either initially or after having been subjected to the transition temperature of Specification 1.4(a). The producer shall describe the method of compliance in the WCP and provide documentation in the WQR.

3.2 GAS SPECIFICATION

After closure, the canistered waste form shall not contain free-gas other than cover and radiogenic gases. Cover gases shall be helium, argon, other inert gases, or air, or combinations thereof. The maximum internal gas pressure immediately after closure shall be 7 psig at 25°C. The producer shall describe the method of compliance in the WCP and shall document in the WQR the quantities and compositions of any gases that might accumulate inside the canister after the canister has been subjected to temperatures up to the transition temperature of Specification 1.4(a).

The producer shall also document in the WQR the quantities and compositions of any gases that might accumulate inside the canisters as a result of radioactive decay.

3.3 SPECIFICATION FOR EXPLOSIVENESS, PYROPHORICITY, AND COMBUSTIBILITY

After closure the canistered waste form shall not contain explosive, pyrophoric, and combustible materials. The producer shall describe in the WCP those administrative controls and other factors that prevent the introduction of explosive, pyrophoric, or combustible materials into canistered waste form. The producer shall present in the WQR an evaluation of the canistered waste form to demonstrate that, for the range of material compositions, it remains nonexplosive, nonpyrophoric, and noncombustible after having been subjected to temperatures up to the transition temperature of Specification 1.4(a).

3.4 ORGANIC MATERIALS SPECIFICATION

After closure the canistered waste form shall not contain organic materials. The producer shall describe the method for complying with this specification in the WCP and document the detection limit for organic materials in the WQR.

3.5 FREE-VOLUME SPECIFICATION

After closure, the free-volume within the canistered waste form shall not exceed 20 percent of the total internal volume of an empty canister. The producer shall identify the nominal free-volume and expected range of variation in the WCP and describe the method of compliance in the WCP. The producer shall also provide in the WCP the expected frequency distribution of free-volumes in the canistered waste forms. The free-volume within the canistered waste form shall be reported in the production records.

3.6 SPECIFICATION FOR 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:

Alpha radiation: 220 dpm/100 cm^2

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

In addition, the producer shall visually inspect the canistered waste forms and remove visible waste glass on the exterior of the canistered waste form before shipment. The producer shall also provide in the WCP an estimate of the amount of canister material that is removed during the decontamination and the basis for that estimate. The producer shall describe the method of compliance in the WCP and provide supporting documentation in the WQR.

3.7 HEAT GENERATION SPECIFICATION

The canistered waste form shall not exceed a total heat generation rate of 800 watts per canister at the time of shipment to the repository.

3.7.1 Heat Generation Projections

The producer shall document in the WQR the expected thermal output and the range of expected variation due to process variation during the life of the production facility. The method to be used in making these projections shall be described by the producer in the WCP.

3.7.2 Heat Generation During Production

The producer shall specify in the production records the heat generation rate and its accuracy to $\pm$ 15% for canistered waste forms at time of shipment. The expected accuracy of the heat generation rates shall be supplied in the WCP. The producer shall describe the plan for compliance in the WCP.

3.8 SPECIFICATION FOR MAXIMUM DOSE RATES

At the time of shipment the canistered waste form shall not exceed a maximum surface gamma dose rate of 10^5 rem/hr and a maximum neutron dose rate of 10^3 rem/hr.

3.8.1 Projections of Dose Rates

The producer shall specify in the WQR the expected values and the range of expected variation for both gamma and neutron dose rates. The producer shall describe in the WCP the method to be used in making these projections.

3.8.2 Dose Rates at Time of Shipment

The producer shall provide in the production records the gamma and neutron dose rates for the canistered waste forms at the time of shipment. The producer shall describe the method of compliance in the WCP.

3.9 CHEMICAL COMPATIBILITY SPECIFICATION

The contents of the canistered waste form shall not lead to internal corrosion of the canister such that there will be an adverse effect on normal

handling during storage, transportation, and repository operation. The producer shall describe the method of compliance in the WCP and document in the WQR the extent of corrosiveness and chemical reactivity among the waste form, the canister, and any filler materials. Corrosion, chemical interactions, and any reaction products generated within the canistered waste forms after exposure to temperatures up to the transition temperature of Specification 1.4(a) shall be evaluated in the WQR.

3.10 SUBCRITICALITY SPECIFICATION

The producer shall ensure that the canistered waste form will remain subcritical under all credible conditions likely to be encountered from production through receipt at the repository. The calculated effective neutron 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. The producer shall describe the method of compliance in the WCP and provide supporting documentation in the WQR. The WQR shall also include sufficient information on the nuclear characteristics of the canistered waste form to enable the repository designer to confirm subcriticality under repository storage and disposal conditions.

3.11 SPECIFICATIONS FOR WEIGHT, LENGTH, DIAMETER, AND OVERALL DIMENSIONS

The configuration, dimensions, and weights of the canistered waste form shall be controlled as indicated below, and the following parameters of the canistered waste form shall be documented at the time of shipment.

3.11.1 Weight Specification

The weight of the canistered waste form shall not exceed 3,000 kg. The measured weight shall be reported in the production records, accurate to within ±5%.

3.11.2 Length Specification

The overall length of the final canistered waste form at the time of shipment shall be 3.000 m (+ 0.005 m, - 0.020 m)

3.11.3 Diameter Specification

The outer diameter of the canistered waste form shall be 61.0 cm (+ 1.5 cm, - 1.0 cm). The minimum wall thickness of the empty canister shall be 0.85 cm. The producer shall state in the WCP the minimum canister wall thickness of the filled canister, and the thickness of any secondary canisters, along with their technical bases.

3.11.4 Specification for Overall Dimensions

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

3.12 DROP TEST SPECIFICATION

The canistered waste form at time of shipment shall be capable of withstanding a drop of 7 m onto a flat, essentially unyielding surface without breaching. The producer shall describe the method of compliance in the WCP and present the 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 test.

3.13 HANDLING FEATURES SPECIFICATION

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

The producer shall design the lifting flange and a suitable grapple, which could be used at the repository, that meets applicable codes and standards for use at the repository.* The grapple and the flange shall be designed to satisfy the following requirements:

(a) The grapple shall be capable of being remotely engaged and disengaged from the flange.

(b) The grapple, when attached to a suitable hoist (to be supplied by the repository), and when engaged with the flange, shall be capable of raising and lowering a canistered waste form in a vertical direction.

(c) The grapple, in the disengaged position, shall be capable of being inserted into and withdrawn in a vertical direction from a right-circular cylindrical cavity with a diameter equal to that of the canistered waste form.

The design of the flange and grapple shall be capable of fulfilling the requirements of Specification 3.13(a) through 3.13(c) without contacting or penetrating the walls of an imaginary right-circular, cylindrical cavity with a diameter equal to that of the canistered waste form, coaxial with the canistered waste form, and extending for a height of 0.7 m above the highest point on the canistered waste form. The design of the grapple shall include features that will prevent an inadvertant release of a suspended canistered waste form when the grapple is engaged with the flange. The producer shall describe the grapple and the flange design concepts in the WCP and provide the designs in the WQR.

*The applicable codes and standards will be identified in the site-specific Repository Subsystem Design Requirements documents, which are scheduled to be issued early FY 1987, and will be added to the WAPS when the WAPS are updated.

4. QUALITY ASSURANCE SPECIFICATION

The producer shall establish, maintain, and execute a quality assurance (QA) program that complies with OGR/B-3 as augmented by Supplement No. 11. The quality assurance program shall be applied to all testing and analysis activities that provide information to be included in WQRs. The WCPs shall be prepared in accordance with the QA program; however, existing data generated prior to the inception of the subject QA program may be included in the WCP so long as the specific QA measures that were in effect when the data were generated are described. 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. The producer shall describe his QA program in the WCP and certify compliance with it in the WQR, and in production records.

Borosilicate waste glass - glass typically containing approximately 20 to 35 wt% waste oxides, 40 to 50 wt% silicas, 5 to 10 wt% boron oxides, and 10 to 20 wt% alkali oxides, plus additives.

Canister - the metal vessel into which borosilicate waste glass is poured during waste form fabrication.

Canister breach - loss of canister leaktightness.

Canistered waste form - the waste form and the surrounding canister as well as any secondary canisters applied by the producer.

Combustible material - any material that can be ignited readily, and, when ignited, burns rapidly, and is therefore liable to cause fires.

Corrosiveness - the tendency of a substance to wear away or alter a material by a chemical or electrochemical (essentially oxidizing) process.

Explosive material - a substance that, in its normal condition, is characterized by chemical stability, but may be made to undergo rapid chemical change without an outside source of oxygen, whereupon it produces a large quantity of energy generally accompanied by the evolution of hot gases. These substances include those specified in 40 CFR Part 173, Subpart C, Classes A and B.

Free-gas - any gas, including radiogenic gases and cover gases like helium, argon, or air, that could contribute to the pressurization of the canister at temperatures below the glass transition temperature. This includes gases mechanically trapped in the waste form and those generated by chemical reaction and radiolytic decomposition.

Free-liquid - liquid that could be drained from the canister either initially or after having been subjected to the transition temperature of Specification 1.4(a); free-liquid includes liquid that is mechanically trapped in the waste form.

Free-volume - volume inside the sealed canister that is not occupied by the borosilicate waste glass, including voids within the glass itself.

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

Leaktightness - a leakage rate of 10^{-7} atm-cm^3/s or less based on dry air at 25°C and for a pressure differential of 1 atm against a vacuum of 10^{-2} atm or less (ANSI N14.5-1977, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials.").

Lifting flange - a protruding rim, edge, rib or collar used to handle the canister.

Organic material - any material based on carbon chains or rings, generally containing hydrogen with or without oxygen, nitrogen, or other elements, whether or not derived from living organisms. Carbon monoxide, carbon dioxide, and cyanide compounds are excluded.

Production records - the documentation, provided by the producer, that describes the actual canistered waste forms.

Pyrophoric material - any liquid that will ignite spontaneously in air below 54.4°C. Any solid material, other than one classed as an explosive, which under normal conditions is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation, handling, or disposal hazard. Included are spontaneously combustible and water-reactive materials, and especially the materials specified in 49 CFR Part 173, Subpart E.

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

Removable radioactive contamination - radioactive material not fixed to a surface. The level of this contamination is determined by wiping an area of 300 cm^2 with an absorbent material, using moderate pressure, and measuring the activity on the wiping material.

Secondary canister - a sealed metal vessel that is applied by the producer and completely surrounds the waste form and its canister.

Transition temperature - the dilatometric softening point where the slope of the thermal expansion versus temperature curve shows a sharp increase.

Waste form - the radioactive waste materials and any encapsulating or stabilizing matrix (10 CFR 60.2).

Waste Form Compliance Plan (WCP) - the document that describes the producer's plan for demonstrating compliance with each waste acceptance specification in the WAPS. The WCP includes descriptions of the tests, analyses, and process controls to be performed by producer.

Waste Form Qualification Report (WQR) - a compilation of results from waste form testing and analysis which develops in detail the case for compliance with each waste acceptance specification.

APPENDIX A

RATIONALE FOR DEFENSE WASTE PROCESSING FACILITY HIGH-LEVEL WASTE FORM WASTE ACCEPTANCE PRELIMINARY SPECIFICATIONS

1. WASTE FORM SPECIFICATIONS

1.1 RATIONALE FOR THE CHEMICAL SPECIFICATION

The regulatory requirements outlined in 10 CFR 60.135(c)(1) state that, "All such radioactive wastes shall be in solid form and placed in sealed containers". The chemical specification addresses two repository information needs. Information on the planned production is required to allow testing of material that is representative of what is to be produced. Secondly, information on canistered waste forms confirms that actual product is within the range of materials tested.

Oxygen is excluded from the requirements for analysis for the following reasons:

(a) The measurement of oxygen would not provide any data relevant to determination of the valence state of radionuclides in the glass. A direct measurement of oxygen would have an uncertainty of $\pm$ 1% of the measured value. The elements for which release rate control is required are present in concentrations that are collectively less than 0.5%; of these, only a small number, such as Tc and Pu, are redox sensitive. Since other, non-radioactive oxides are present in much greater concentrations, a measurement of the oxygen concentration with an uncertainty of more than 1% would provide no information on the valence state of the radionuclides of interest.

(b) For radionuclide release to occur in the repository, the surface of the glass must be in communication with the repository environment. This environment includes the host rock, the metal container, packing material (if present), and fluids. The environment will control the redox state of the solutions produced by reaction of fluids with the glass because of the much larger abundance of redox sensitive species in the environment. Since it is the redox state of the fluid that will determine the concentration of radionuclides available for transport, and since the glass redox state will not control the fluid redox state, it is not necessary to know the glass redox state.

Expected accuracy of measurement of canistered waste form compositions is necessary to allow adequate evaluation of uncertainties in waste form composition for repository performance assessment.

1.2 RATIONALE FOR THE RADIONUCLIDE INVENTORY SPECIFICATION

The total radionuclide inventory is required for a determination of the producer's contribution to the repository source term for calculations to show compliance with 40 CFR 191 total release standards. A year was needed for indexing radionuclide inventory values. The year 2025 was chosen as a reasonable date for completion of emplacement operations in the first repository. Inventory estimates for each canistered waste form are required to confirm that each canistered waste form falls within ranges considered in licensing, safety, and isolation assessments, and for estimates of releases under unanticipated processes and events, and accident scenario conditions. Expected variations in radionuclide inventories are necessary to adequately quantify uncertainties in radionuclide release estimates for repository

performance assessments. The minimum concentration of 0.05% [R1] is needed to ensure that all isotopes of possible consequence to safety and isolation analyses are included, assuming that congruent dissolution of all nuclides occurs upon contact with an aqueous environment. It provides a factor of 2 reduction with respect to the 0.1% limit on isotopes which must be considered in meeting the 10 CFR 60.113 release rate criterion; it also provides a reasonable lower bound for assessment of releases during accidents. The half-life criterion needs to be as low as 10 years so that "pre-closure" exposure and accident concerns can be addressed.

The 1100 years is based on 1000 year containment period plus 100 years after production for storage, transportation, and operation prior to repository closure, and will be used as the basis for calculating the inventory for the 10 CFR 60.113 release rate criterion.

1.3 RATIONALE FOR THE SPECIFICATION FOR RADIONUCLIDE RELEASE PROPERTIES

The justification for this specification is based on the need for the control of the waste form release properties during production and the need for information concerning the release of radionuclides from the waste form based on repository-site-specific release tests TBD* [R2]. The test procedure to demonstrate control of the radionuclide release properties during production is being developed by the producer. The producer shall relate the production control test to the repository-site-specific release tests TBD* [R2] or shall perform the repository-site-specific release tests TBD* [R2]. The repository-site-specific test procedures and correlation of these data with release properties under repository conditions are being developed by the repository projects to satisfy regulatory criteria. Both the NRC criteria (10 CFR 60) and the EPA criteria (40 CFR 191) have defined long-term radionuclide release in terms of the engineered barrier system and the mined geologic disposal system respectively. As a component part of these systems, the waste form may be required to contribute to the compliance with these requirements. The preliminary allocation of performance requirements among the various components of the engineered barrier system and the repository system is to be described in the Site Characterization Plans being developed for each candidate repository site. Therefore, site-specific tests and acceptance specifications are required.

1.4 RATIONALE FOR THE SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

Specifications 1.4.(a) and 1.4.(b) will provide data useful to the repository project for establishment of repository and waste package design limits. The certifications required will provide assurance that producers and transporters have not handled or stored the wastes in such a way as to cause significant changes in the phase structure.

The available evidence indicates that the borosilicate glass waste forms will retain release properties similar to those obtained under Specification 1.3 so long as the phase structures and compositions of the glass are unchanged from those provided under Specification 1.1. The evidence also indicates that:

*TBD - to be determined

- Neither energy input nor radioactive decay significantly affect radionuclide release from waste glass, as long as the temperature of the glass does not exceed the glass transition temperature (approximately 500°C). Above this temperature, significant changes in phase composition can occur.
- For glasses of the type which will be produced in the DWPF, even changes in phase composition due to devitrification do not greatly alter the rate of release of material from the glass.

A program has been and continues to be in place to ensure that the effects of energy input and radioactive decay on glass properties are well-understood. A report reviewing relevant literature and thoroughly documenting recently-performed tests will be published in early 1987. This report will be referenced in the rationale for Specification 1.4.

The requirement for certification of conditions during transportation has been included herein to identify the need for consideration of these requirements during design of the transportation system.

2. CANISTER SPECIFICATIONS

2.1 RATIONALE FOR THE MATERIAL SPECIFICATION

The repository must have a complete materials inventory to evaluate long term performance under repository conditions. Austenitic stainless steel has been selected as the container material for DWPF. This specification acknowledges that fact and establishes the repository's interest in this interface. The current role of the canister as part of the engineered barrier system does not require the canister to act as a post-closure engineered barrier; therefore, the primary requirement of the canister material specification is to ensure that the canister material does not have an adverse impact on waste package performance. By specifying austenitic stainless steel which is manufactured to the ASTM specification, this requirement is met. Additionally, identification of the materials is necessary to assure that the canister material, and the material of any other component present in significant quantities (i.e., secondary canisters and welding fillers), are compatible with other materials in the repository.

2.2 RATIONALE FOR THE FABRICATION AND CLOSURE SPECIFICATION

The canister is designed to provide containment of the waste during handling up to packaging in a repository container to prevent escape of waste, liquids, gases, and particulates. Additionally, the canister must provide protection of the waste form from contact with externally derived liquids and gases until the canister is sealed in a repository container.

2.3 RATIONALE FOR THE IDENTIFICATION AND LABELING SPECIFICATIONS

The regulatory requirements in 10 CFR 60.135(b)(4) state that "A label or other means of identification shall be provided for each waste package. The identification shall not impair the integrity of the waste package and shall be applied in such a way that the information shall be legible at least to the end of the period of retrievability. Each waste package identification shall be consistent with the waste package's permanent written records."

This specification provides a means of tying the waste package and the waste form together through placement in the repository disposal container. The 92 point sans serif type face (Megaron Bold Condensed or equivalent) results in a letter height of approximately 3 cm and width of approximately 2 cm which has been judged to be adequate dimensions for visibility. The canister label is needed to identify the canistered waste form through storage at the producer's facility, shipment to the repository, and possible lag storage at the repository prior to final packaging. Once the canistered waste form is enclosed in the repository waste package, the burden of maintaining the identity of the contents shifts to the waste package.

3. CANISTERED WASTE FORM SPECIFICATIONS

3.1 RATIONALE FOR THE FREE-LIQUID SPECIFICATION

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

3.2 RATIONALE FOR THE GAS SPECIFICATION

The regulatory requirements in 10 CFR 60.135(a) require that "packages for HLW shall be designed so that in-situ chemical, physical, and nuclear properties of the waste package...do not compromise the function of the waste package..." and "The design shall include...consideration of... oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects...mechanical stress, radiolysis radiation damage...." In order to demonstrate compliance with the regulations, waste package designers require information on gas generation potential of the waste form.

The intent of this specification is to ensure that gas pressure will not build up inside the container and contribute to loss of containment and dispersion of radionuclides. This specification provides a limit to initial gas pressure and information from which to index the calculation of gas pressure build-up with time due to nuclear decay and temperature changes.

The value for the maximum initial gas pressure, 7 psig, was chosen because it has the following attributes: it is low enough to preclude significant stresses in the canister wall arising from internal pressurization, both initially and after the anticipated helium production from alpha decay over the containment period; plus, it is to avoid introducing unnecessary restrictions that will not materially contribute to the overall function of the canistered waste form in the repository.

In general, an internal pressure P in a cylindrical vessel of diameter D and wall thickness t produces a tensile hoop stress of $o_H = PD/2t$ and a tensile longitudinal stress of $o_l = PD/4t$ in the wall of the vessel (Popov, 1959). For a vessel made from Type 304L stainless steel, the yield strength at 500°C would be at least 14,000 psi (ASM, 1980). The more rapid cooling of the canister wall than the bulk of the glass after pouring as well

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Popov, E. P., Mechanics of Materials, Prentice-Hall, Englewood Cliffs, New Jersey (1959), pp. 225-5.

ASM (American Society for Metals), Metals Handbook Ninth Edition, Vol. 3, American Society for Metals, Metals Park, Ohio (1980), p. 192.

as differences in the coefficients of thermal expansion of the two materials are expected to lead to tensile thermal stresses approaching or exceeding the yield strength of the stainless steel (Baxter, 1983). In order for the stresses due to internal pressurization to be insignificant in comparison, it would be sufficient to limit them to a small percentage of the yield strength. If the hoop stress is limited to 10% of the yield strength at 500°C or 1400 psi, the maximum internal pressure would be 44 psi at 500°C, which is equivalent to 17 psi at 25°C.

The maximum pressure due to helium release from alpha decay after 1000 years has been calculated to be less than 1 psi (Baxter, 1983); therefore, an initial pressure less than about 16 psi would therefore appear to be conservative. With these guidelines, a value of nearly half an atmosphere, or 7 psig was chosen as conservative and practicable. In actual fact, the pressure (evaluated at 25°C) immediately after canister sealing is expected to be much less than 7 psig, and may actually be slightly negative, due to cooling after sealing.

3.3 RATIONALE FOR THE SPECIFICATION FOR EXPLOSIVENESS, PYROPHORICITY, AND COMBUSTIBILITY

This specification is needed to ensure that after closure, the canistered waste form does not explode or burn during normal repository operations and accident conditions.

The regulatory requirements as outlined in 10 CFR 60.135(b)(1) state that, "The waste package shall not contain explosive or pyrophoric 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."

The regulatory requirements on the waste package as outlined in 10 CFR 60.135(a)(2) state that, "The design shall include but not be limited to consideration of...fire and explosion hazards." The waste form, as a component of the waste packages must comply with this requirement.

3.4 RATIONALE FOR THE ORGANIC MATERIALS SPECIFICATION

This specification is needed to ensure that organic materials that tend to mobilize radionuclides by formation of complexes, etc., or generate gases due to radiolysis are not present in the canistered waste form.

The regulatory requirements on the waste package as outlined in 10 CFR 60.135(a)(2) state that, "The design shall include but not be limited to consideration of the following factors: ...gas generation; radiolysis, radionuclide retardation, leaching...." The waste form, as a component of the waste package must be assessed for compliance.

Baxter, R. G., "Description of Defense Waste Processing Facility Reference Waste Form and Canister," DP-1606, Rev. 1, E. I. du Pont de Nemours and Co. Savannah River Plant, Aiken, SC (1983), p. 16.

3.5 RATIONALE FOR THE FREE-VOLUME SPECIFICATION

In general, free-volume is to be minimized for the following reasons: 1) repository design; 2) economical use of repository space; and 3) less volume of water in contact with waste form after breach of containment. Specifically, BWIP has a concern about collapse of the packing into the void, resulting in less than desired density and creating preferential flow paths for radionuclide release; therefore, the effects of void volume elements for the case of the emplaced waste package and the void volume existing in the canisters filled with the borosilicate glass waste forms from DWPF and WVDP were analyzed with respect to the density of the waste package packing needed to achieve diffusional control of radionuclides released from the waste form. (The density of the waste package packing is related to its swelling behavior.) The void volume within the canister was treated as a variable in the analysis. It was determined that the free-volume in the canister could be as large as 20% and still be acceptable relative to the minimum acceptable bulk density as specified in the current design requirements for the BWIP. (The void volume analyses will be fully documented in the BWIP Waste Package Advanced Conceptual Design Report.)

Although it is desirable to have the vast majority of canistered waste forms to have free-volume less than 20 percent, it is recognized that a small fraction of canisters may have free-volumes in excess of this due to operational occurrences at the producer's facility. The specification, as drafted, is intended to allow for these cases, to provide the information necessary for assessment of their impact on performance, and to provide the canister-by-canister certifications necessary to demonstrate compliance with likely repository license conditions.

3.6 RATIONALE FOR THE SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

This specification is necessary to protect personnel, prevent uncontrolled spread of contamination in repository facilities, minimize need for remote maintenance of facility equipment, and minimize need for cleanup of contamination during normal operations.

The specification limits chosen are used extensively in the nuclear industry practice (e.g., for compliance with 10 CFR 71.87) to indicate surfaces are free of removable contamination.

3.7 RATIONALE FOR THE HEAT GENERATION SPECIFICATION

A heat generation rate limit must be set to ensure that the temperatures reached in other disposal package components or the host rock do not significantly reduce their performance capabilities.

Repository designers need a number with which to work to ensure that repository thermal load limits are not violated. The value of 800 watts was chosen as an expected upper bound for production from DWPF facilities. (Previously published heat generation design valves were substantially lower; however, they were based on initial calculations and do not reflect current design valves.)

An accuracy of $\pm$15% is judged to be a reasonable working value, acceptable to both repositories and to DWPF. The variation in normal expected

heat generation rates is necessary to allow assessment of uncertainties in repository performance.

3.8 RATIONALE FOR THE SPECIFICATION FOR MAXIMUM DOSE RATES

The repository projects need the maximum gamma and neutron dose rates in order to design shielding for the receipt and handling facilities. The value of 10^5 rem/hr for maximum gamma dose rate and 10^3 rem/hr for maximum neutron dose rate provide a reasonable basis for repository design and operation and are judged to be sufficiently above the expected dose rates for DWPF wastes to provide reasonable flexibility for normal operations.

3.9 RATIONALE FOR THE CHEMICAL COMPATIBILITY SPECIFICATION

The specification is required to assure that the canister can be safely handled during storage, transportation, and repository operational periods, and to provide needed data for assessment of long term performance of the waste package components.

3.10 RATIONALE FOR THE SUBCRITICALITY SPECIFICATION

The regulatory requirements as outlined in 10 CFR 60.131(b)(7) state that, "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 evaluate the method of calculation."

Subcriticality of multiple canister arrays at the repository is the responsibility of the repository designer.

3.11 RATIONALE FOR THE SPECIFICATIONS FOR WEIGHT, LENGTH, DIAMETER, AND OVERALL DIMENSIONS

The specifications on weight, length, diameter and wall thickness of the canistered waste form are needed for the repository design of handling requirements and waste packages. The overall dimensions of the canistered waste form must be such that (1) no forcing is required to place it in the disposal package container to prevent damage to the inside of the container and (2) there is compatibility with container geometry.

3.12 RATIONALE FOR THE DROP TEST SPECIFICATION

This specification is necessary to ensure that the canistered waste form is not breached after a drop. The height of 7 m was chosen as representative of the maximum drop height under normal operating conditions. Repository facilities will be designed to ensure that larger drops of bare canisters are not possible. The surface which is characteristic of repository conditions has been defined as a "flat, essentially unyielding" surface.

3.13 RATIONALE FOR THE HANDLING FEATURES SPECIFICATION

This specification reflects the lifting and handling requirements necessary for compatibility with current waste package concepts. The specification is drafted to allow the waste producer maximum flexibility in design of the canister handling arrangements.

4.0 RATIONALE FOR THE QUALITY ASSURANCE SPECIFICATION

All activities relevant to licensing of a repository must be conducted in accordance with appropriate quality assurance controls. OCRWM quality assurance policies and requirements are described in the referenced document. Producer activities must be conducted to comply with the program established by OCRWM.

APPENDIX B

EXPLANATION OF RESERVED ITEMS

R1 - Radionuclide Inventory Specification

Specification 1.2 establishes a numerical concentration of 0.05% of the total inventory (in curies) for the reporting of radionuclides. This value is considered to be adequate based on a preliminary analysis by one of the repository projects alone; consequently, 0.05% is being held on reserve pending final analysis by repository projects.

R2 - Specification for Radionuclide Release Properties

At the time of publication of the WAPS, the test procedures and acceptance criteria for Specification 1.3, Specification for Radionuclide Release Properties, are not available. These procedures and criteria are being developed along with each project's Site Characterization Plan and depend upon site-specific performance allocations for the waste form. These procedures and acceptance criteria will be added to the specifications when they become available.

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